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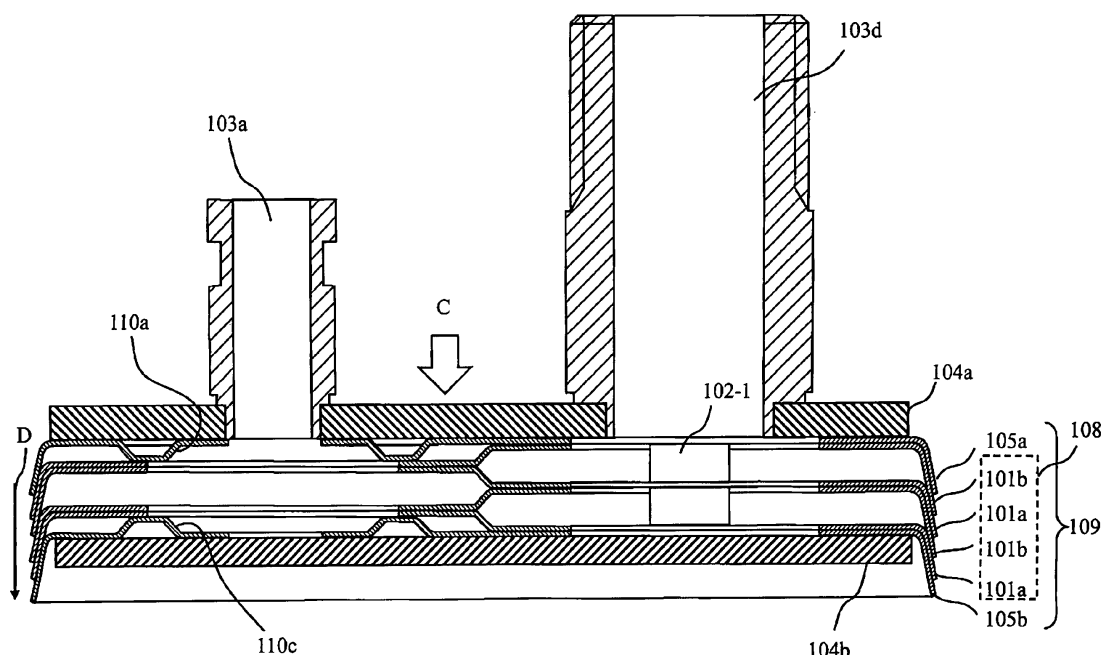
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(54) **Plate heat exchanger and heat pump device**

(57) One of the purpose is to improve a yield ratio of members to be used for a plate heat exchanger and a yield ratio of the plate heat exchanger itself, and to improve a strength of the plate heat exchanger. Each heat transfer plate 101 in the plate heat exchanger has a rectangular shape with a long side and a short side, in which two flow channel holes that are openings through which any of the first fluid and the second fluid passes are

formed respectively on one side of the short sides and another side of the short sides. Each heat transfer plate 101 includes a structure 102 which protrudes from a part of a periphery of any flow channel hole of four flow channel holes, and bends and extends in a direction to be distanced from an opening. The structure 102 is attached firmly to a vicinity of a periphery of a corresponding flow channel hole in a lamination direction of the heat transfer plate that is adjacent on the other side.

Fig. 6



Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims the benefit of priority from Japanese Patent Application No. 2011-028106, filed in Japan on February 14, 2011, the content of which is incorporated herein by reference in its entirety.

Technical Field

[0002] The present invention relates to a plate heat exchanger to perform heat exchange between refrigerant and a fluid to be heated, and a heat pump device using the plate heat exchanger.

Background Art

[0003] Generally, it is known a plate heat exchanger for performing heat exchange between two types of flow channels by laminating and brazing plural pieces of plates to form the flow channels. Since each element in the plate heat exchanger is joined by brazing, there is a characteristic that the main body of the heat exchanger can be downsized.

[0004] However, since the plate heat exchanger is joined semipermanently by brazing filler metal, when a lamination error of the heat transfer plates occurs at the time of manufacturing, it is impossible to exchange only the plates, and the members used for manufacturing need to be discarded. The lamination error of the heat transfer plates causes functional failure of the plate heat exchanger itself.

Further, the lamination error means that water and refrigerant, represented by R410A, are mixed. This leads to an adverse effect on a human body and environment should a product of lamination error is leaked to the market. Therefore, to detect a lamination error of the heat transfer plates before brazing is important also to improve the yield ratio and the reliability of the product.

[0005] The lamination error of the heat transfer plates occurs because of the similarity of each heat transfer plate. In a general plate heat exchanger, a method to laminate one type of heat transfer plates by alternately inverting the heat transfer plates 180 degrees, or to laminate two types of heat transfer plates alternately. Regardless of the type of the heat transfer plate, it is difficult to understand whether the heat transfer plates are inverted 180 degrees or not, and the difference between two types of the heat transfer plates from the outer shape after lamination.

[0006] In the conventional plate heat exchanger, for the above-mentioned lamination error, the lamination error is detected by applying an irregular shape to one side of the heat transfer plate, which is not applied in the other three sides, by a surplus member, and by making the surplus members be arranged alternately after lamination

(for example, see Patent literature 1).

[0007] However, the use of the surplus member has no influence on heat transfer performance, strength reliability, etc., but is used only for detecting a lamination error, and is unnecessary for the product. Thus, the yield ratio of the materials is lowered. It is desired a method of detecting the lamination error without lowering the yield ratio.

10 Citation List

Patent Literature

[0008] Patent literature 1: JP 1997-89484 A

15 Summary of Invention

Technical Problem

20 **[0009]** The present invention aims to improve the yield ratio of the members used for the plate heat exchanger, the yield ratio of the plate heat exchanger itself, and the strength of the plate heat exchanger.

25 Solution to Problem

[0010] The plate heat exchanger according to the present invention is a plate heat exchanger in which, by joining each plate of a plurality of plates that are laminated from one side to another side with another plate, which is adjacent to the each plate of the plurality of plates on both sides, a first flow channel wherein a first fluid flows, and a second flow channel wherein a second fluid that exchanges heat with the first fluid flows are alternately formed in a lamination direction, the plate heat exchanger, wherein the each plate of the plurality of plates has a rectangular shape with a long side and a short side, in which two flow channel holes that are openings through which any of the first fluid and the second fluid passes are formed respectively on one side of short sides and another side of the short sides, and wherein the each plate includes a bend portion which protrudes from a part of a periphery of any flow channel hole of four flow channel holes, and bends and extends in a direction to be distanced from an opening, and which is attached firmly to a vicinity of a periphery of a flow channel hole that corresponds in the lamination direction of the each plate that is adjacent on the other side.

50 Advantageous Effects of Invention

[0011] It is possible to improve the yield ratio of the members used for the plate heat exchanger, and the yield ratio of the plate heat exchanger.

55 Brief Description of Drawings

[0012] The present invention will become fully under-

stood from the detailed description given hereinafter in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagram describing a usage pattern of a plate heat exchanger 100 according to the first embodiment;

Fig. 2 is an exploded perspective view describing the plate heat exchanger 100 according to the first embodiment;

Fig. 3 is a side view of the plate heat exchanger 100 according to the first embodiment;

Fig. 4 is a front view describing the plate heat exchanger 100 according to the first embodiment (an arrow A in Fig. 3);

Fig. 5 is a back view describing the plate heat exchanger 100 according to the first embodiment (an arrow B in Fig. 3);

Fig. 6 is an X-X cross-sectional view of Fig. 4;

Fig. 7 is a diagram describing heat transfer plates 101a and 101b according to the first embodiment;

Fig. 8 is a diagram describing a "U-shaped structure 102" formed in a heat transfer plate 101 according to first embodiment;

Fig. 9 is a diagram describing an effect of the "U-shaped structure 102" according to the first embodiment;

Fig. 10 is a diagram describing a drawing shape part in side plates 105a and 105b according to the first embodiment; and

Fig. 11 is a diagram describing a peripheral structure of a nozzle 103 in Fig. 6.

Description of Embodiment

[0013] In describing preferred embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of the present invention is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.

Embodiment 1

[0014] In the first embodiment below, the plate heat exchanger 100 will be described.

Fig. 1 is a diagram describing a usage pattern of the plate heat exchanger 100 according to the first embodiment. The usage pattern of the plate heat exchanger 100 will be described with reference to Fig. 1. A heat pump unit 2 (heat pump device) includes a compressor 3, a condenser 4 (the first heat exchanger), an electronic expansion valve 5 and an evaporator 6 (the second heat exchanger).

(1) The compressor 3 compresses refrigerant 7 by use of electric power, and increases the enthalpy and the pressure of the refrigerant 7.

(2) The condenser 4 performs heat exchange between the compressed refrigerant 7 (the first fluid) and a fluid to be heated (the second fluid).

(3) The electronic expansion valve 5 adiabatically-expands the refrigerant 7 ejected from the condenser 4.

(4) The evaporator 6 exchanges heat between the refrigerant 7 ejected from the electronic expansion valve 5 and an external heating source. Here, the heat pump unit 2 may additionally include an ancillary part such as a receiver, etc. to accumulate surplus refrigerant 7, which is not described in the diagrams.

[0015] The compressor 3 through the evaporator 6 make up a refrigeration cycle mechanism where the refrigerant 7 circulates. For example, the plate heat exchanger 100 is used for the condenser 4. In this way, water flowing into the plate heat exchanger 100 is heated by dissipating heat (heat absorbed by the evaporator 6) of the external heating source by the plate heat exchanger 100. Although there is another type of medium, such as air, geothermal heat, etc., to be used as the external heating source (counterpart of heat exchange with the evaporator 6), the plate heat exchanger 100 can be used in any hot-water supplying heat pump units that use external heat sources. Further, the plate heat exchanger 100 may be used, not only as the condenser 4 (the first heat exchanger), but as the evaporator 6 (the second heat exchanger).

[0016] Runoff hot-water 9 (may be referred to as water 9) circulates in a water circuit 8. Fig. 1 describes an indirect heating method. The water 9 (the second fluid) flows in the plate heat exchanger 100 being the condenser 4, is heated by the refrigerant 7, and flows out from the plate heat exchanger 100. When the runoff hot-water 9 flows out from the plate heat exchanger 100, the runoff hot-water 9 flows in a heating appliance 12, such as a radiator, a floor heating appliance, etc. that is connected by a pipe that makes up a clean water 10, to be used for an indoor temperature control. Further, by allocating a water-water heat exchanging tank 11 for exchanging heat between the runoff hot-water 9 and the clean water 10 halfway in the water circuit 8, the clean water 10 heated by the runoff hot-water 9 can be used for daily life water, such as for a bath, a shower, etc.

[0017] Figs. 2 through 5 are diagrams for describing an appearance configuration of the plate heat exchanger 100.

Fig. 2 is an exploded perspective view describing the plate heat exchanger 100.

Fig. 3 is a side view of the plate heat exchanger 100.

Fig. 4 is a front view describing the plate heat exchanger 100 (an arrow A in Fig. 3).

Fig. 5 is a back view describing the plate heat exchanger 100 (an arrow B in Fig. 3).

[0018] The appearance of the plate heat exchanger 100 will be specifically described blow. As shown in Fig.

2, a refrigerant flow channel, from which the refrigerant 7 that has flowed in from a nozzle 103a being a refrigerant inflow port flows out from a nozzle 103b being a refrigerant outflow port, is formed in the plate heat exchanger 100. Further, a water flow channel where the water 9 flowing in from a nozzle 103c, which is a water inflow port, flows out from a nozzle 103d, which is a water outflow port, is formed.

[0019] As shown in Fig. 3, in the plate heat exchanger 100, a reinforcing plate 104a where the nozzle 103 is attached, a side plate 105a, a heat transfer plate 101a, a heat transfer plate 101b and so on, a heat transfer plate 101a, the heat transfer plate 101b, a side plate 105b, and a reinforcing plate 104b are laminated in this order. Here, the reinforcing plate 104b is in a covered state by the side plate 105b, hence the reinforcing plate 104b is not shown in Fig. 3.

[0020] As shown in Fig. 4, four nozzles 103a through 103d attached to the reinforcing plate 104a are shown in the front view (the arrow A in Fig. 3).

[0021] As shown in Fig. 5, the surface of the reinforcing plate 104b is shown in the back side view (the arrow B in Fig. 3).

[0022] The structure of the plate heat exchanger 100 will be described next with reference to Figs. 6 and 7. Fig. 6 is a cross-sectional surface corresponding to X-X cross section in Fig. 4. The reason why "corresponding" is used is as follows. In Fig. 6, the heat transfer plates 101a and the heat transfer plates 101b are used only four pieces in total for ease of explanation. Then, the order of lamination is in the order of the reinforcing plate 104a, the side plate 105a, the heat transfer plates 101b, 101a, 101b and 101a, the side plate 105b, and the reinforcing plate 104b. As just described, Fig. 6 is not the same as Fig. 4, hence "corresponding" is used.

(Heat transfer plate 101a, heat transfer plate 101b)

[0023] (a) and (b) of Fig. 7 are diagrams describing the heat transfer plate 101a and the heat transfer plate 101b, respectively. The heat transfer plates 101a and 101b are plates both having the same shape. Thus, the size and the thickness of the heat transfer plates 101a and 101b shown in (a) and (b) of Fig. 7 are the same. When there is no necessity to distinguish between two of them, they are simply called as heat transfer plates 101. The heat transfer plate 101b is the heat transfer plate 101a shown in (a) of Fig. 7 rotated 180 degrees about a point P. Thus, the heat transfer plate 101a and the heat transfer plates 101b have the same shape (approximately the same). In the explanation for the first embodiment, a heat transfer plate wherein apexes of the alphabet V in the V-shaped wave patterns in Fig. 2 are directed to the direction of the nozzles 103a and 103d is the heat transfer plate 101a, and a heat transfer plate wherein apexes of the alphabet V are directed to the 180 degrees opposite direction is the heat transfer plate 101b. The heat transfer plate 101b shown in (b) of Fig. 7 is the heat transfer plate 101a in

(a) of Fig. 7 rotated 180 degrees about the point P where-to signs of channel holes are attached. The heat transfer plates 101a and 101b have channel holes 106a through 106d at the four corners. Each heat transfer plate has wave patterns 107a and 107b for stirring a fluid between the channel holes 106a and 106b, and between the channel holes 106c and 106d, in the length direction. The wave patterns 107a and 107b have shapes that are directed upward and downward with respect to a lamination direction when the heat transfer plates 101a and 101b are laminated. The wave pattern 107a of the heat transfer plate 101a has an inverted shape of the wave pattern 107b of the heat transfer plate 101b for 180 degrees. As described above, the wave pattern 107b has a relation to the wave pattern 107a that the wave pattern 107b is the wave pattern 107a rotated 180 degrees in the arrow direction about the point P.

[0024] As shown in Fig. 6, the heat transfer plate 101b is located below the side plate 105a, and the heat transfer plate 101a is located below the heat transfer plate 101b. In the laminated state, the channel holes 106a through 106d created in the heat transfer plate 101b overlap the channel holes 106a through 106d created in the heat transfer plate 101a, which compose channels. The heat transfer plate 101a shown in (a) of Fig. 7 is assumed to be the heat transfer plate 101a next to the side plate 105a in Fig. 2. The channel holes 106a, 106b, 106c and 106d created in the heat transfer plate 101a in (a) of Fig. 7 correspond to the nozzles 103a, 103b, 103c and 103d, respectively. In the channel hole 106b, a U-shaped structure 102-1, which will be explained later, is formed in the rear side of the plate.

(Heat transfer part 108, major part 109)

[0025] The plate heat exchanger 100 in the first embodiment is structured mainly by a heat transfer part 108 which forms channels for performing heat exchange between the first fluid and the second fluid, by laminating the heat transfer plates 101a and the heat transfer plates 101b. A plate heat exchanger major part 109 (major part 109, hereinafter) is structured by arranging the side plate 105a above the heat transfer part 108, and the side plate 105b below the heat transfer part 108. That is, the heat transfer part 108 means a structure that is formed by plural pieces of the heat transfer plates 101, and the major part 109 means a structure wherein the side plates on the both sides are added to the heat transfer part 108. By arranging the reinforcing plate 104a above the major part 109, and arranging the reinforcing plate 104b below the major part 109, the major part 109 is interleaved between the reinforcing plates 104a and 104b. As mentioned above, nozzle mounting slots (nozzle corresponding holes) are created in the reinforcing plate 104a. The nozzles 103a through 103d are mounted to the nozzle mounting holes.

(Formation of the channels by the heat transfer plates 101)

[0026] By laminating the heat transfer plates 101a and 101b, the wave pattern 107a and the wave pattern 107b are brought into point contact. The parts of the point contact become "columns" that form channels by being brazed. For example, the heat transfer plate 101a forms a channel of water (pure water, tap water, or water wherein antifreeze liquid is mixed), and the heat transfer plate 101b forms a refrigerant channel of the refrigerant 7 (for example, refrigerant used for an air conditioner, represented by R410A). The water channels are formed by laminating the heat transfer plates 101a and 101b layer by layer, and a layer of "water - refrigerant" is formed by laminating the heat transfer plate 101a further. Below, by increasing the number of lamination of the heat transfer plates 101, the channels are formed alternately, like "water-refrigerant-water-refrigerant..." (see Fig. 2). The heat transfer part 108 as shown in Fig. 6 is structured by the laminated plural heat transfer plates.

(Characteristic of the plate heat exchanger 100)

[0027] The characteristic of the plate heat exchanger 100 according to the first embodiment will be explained. The plate heat exchanger 100 of the first embodiment is a heat exchanger in a method where each component is joined by brazing.

Fig. 8 is a diagram describing a "U-shaped structure 102" (also referred to as a structure 102 hereinafter) formed in the heat transfer plates 101. (a) of Fig. 8 is a diagram describing the heat transfer plate 101a in (a) of Fig. 7 in more detail. (b) of Fig. 8 is a Y-Y cross-sectional view of (a). Here, in (a) of Fig. 8, a case wherein three structures 102 (structures 102-1, 102-2 and 102-3) are formed in the channel hole 106b is shown. As in (a) of Fig. 8, the heat transfer plate 101a has three U-shaped structures 102 at intervals of 45 degrees on the circumference of circle of the hole of the channel hole 106b on the opposite side of the wave pattern 107. The characteristic of the plate heat exchanger 100 is that the U-shaped structures 102 are included in one of the channel holes 106a, 106b, 106c and 106d created in four directions as shown in Fig. 8. As described above, since the heat transfer plate 101b is the heat transfer plate 101a rotated 180 degrees, the heat transfer plates 101 in the plate heat exchanger 100 all have the "U-shaped structures 102." By the structures 102, columns 121 and a column 122, which will be explained later, are formed in the circumference of the channel holes where the structures 102 are formed.

(U-shaped structure 102)

[0028] The channel hole 106b of the heat transfer plate 101 in Fig. 8 has the U-shaped structures 102 which extend downward to the inner side, being curved, on the opposite side of the wave pattern (in a direction to be

distanced from the wave pattern). The structures 102 are formed by bending parts to be a discarded material at the time of punching out the channel holes. The structures 102 can be formed in any channel holes in the heat transfer plate 101. In Fig. 8, the structures 102 are provided to the channel hole 106b (the channel hole in a position corresponding to the nozzle 103b from which refrigerant flows out) of four holes in the heat transfer plate.

[0029] The U-shaped structures 102 will be explained further. As shown in Fig. 2, in the plate heat exchanger 100 using the heat transfer plates wherein the U-shaped structures 102 are formed, the first flow channel 301 where the refrigerant 7 (the first fluid) flows and the second flow channel 302 where the water 9 (the second fluid) which exchanges heat with the refrigerant 7 flows are alternately formed in a lamination direction D by joining each heat transfer plate of plural heat transfer plates 101a and 101b that are laminated from one side (the reinforcing plate 104a side having the nozzle 103) to the other side (the reinforcing plate 104b side) with other heat transfer plates that are adjacent on the both sides. Each heat transfer plate 101 has a rectangular shape with a long side and a short side, as shown in Fig. 2, where two channel holes being the openings through which either of the refrigerant 7 or the water 9 passes are formed, respectively, on one side of short sides and the other side of the short sides. The U-shaped structures 102 are described as follows.

As shown in Fig. 8, in each heat transfer plate 101, any channel hole (in (a) of Fig. 8, the channel hole 106b) of four channel holes includes the structure 102 (bending part) that protrudes from a part of the periphery of the channel hole, and extends toward the direction to be distanced from the opening that constitutes the channel hole. The structure 102 is attached firmly to the vicinity of the periphery of the corresponding channel hole in the lamination direction of the adjacent heat transfer plate on the other side (the side of the reinforcing plate 104b among the reinforcing plates 104a and 104b) (described later with reference to Fig. 9). Here, as shown in (a) of Fig. 8, in the heat transfer plate 101a, the wave pattern 107 that is directed upward and downward with respect to the lamination direction is formed in an area in a direction of a long side between two channel holes on the one side of the short sides and two channel holes on the other side of the short sides. Then, the structure 102 extends in an extending direction 123 to be distanced from the wave pattern 107, as in (b) that shows the Y-Y cross section of (a).

[0030] Fig. 9 is a diagram describing the effect of the structures 102. Here, since Fig. 9 is a descriptive view for explaining the effect of the structures 102, Fig. 9 is not an exact cross-sectional view. (a) of Fig. 9 shows a state wherein the heat transfer plates 101 are laminated in a correct lamination order. (b) of Fig. 9 shows a case wherein the lamination order of the heat transfer plates 101 is improper. (a-1) and (b-1) of Fig. 9 are cases seen

from the same direction as the Y-Y cross section in Fig. 8. (a-2) and (b-2) of Fig. 9 are comparable to a Z-Z cross section (after lamination) in Fig. 8, which correspond to (a-1) and (b-1), respectively. By laminating the heat transfer plates 101a and the heat transfer plates 101b, the U-shaped structures 102 of the heat transfer plates 101a contact with planar sections around the channel holes of the heat transfer plates 101b, and the columns 121 ((a-2) of Fig. 9) are formed. By increasing the number of lamination of the heat transfer plates 101 below, the columns 121 as a whole become the column 122 (repeated structure) that supports the refrigerant channel holes. The columns 121 are not formed in a case wherein the lamination of the heat transfer plates 101 is improper. Thus, there is an effect to confirm a lamination error by distinguishing whether the columns are present or not through visual contact of the channel holes. Namely, by looking into the channel holes from an oblique direction after lamination of the heat transfer plates 101, a lamination error can be detected.

[0031] As shown in (b-2) of Fig. 9, when the heat transfer plates 101 are not laminated in a normal order, a lack exists in the U-shaped structures 102 which are expected to align in a line, and a clearance is formed. By visually confirming the formed clearance, it is possible to determine whether a lamination error exists or not. Hence, since brazing is not performed in a state of lamination error, the yield ratio is improved. In addition, since the U-shaped structures 102 are joined with next heat transfer plates 101 by brazing filler metal when lamination is performed properly, it is possible to improve the strength by making the U-shaped structures 102 themselves the columns 121 to support the plate heat exchanger 100.

[0032] The portions likely to be broken in the plate heat exchanger 100 due to pressure break and pressure fatigue breakdown are portions around the channel holes necessary for supplying a fluid to the plate heat exchanger 100. In a general plate heat exchanger, a wave pattern is formed on a surface of the heat transfer plate for increasing a heat exchanging area. The parts where the wave patterns of both the upper and lower heat transfer plates contact (the contact portions of the peak of the wave of the lower side heat transfer plate and the bottom of the wave of the upper side heat transfer plate) are all brazed. Then, the brazed portions all exist as columns. Meanwhile, the peripheral portions of the channel holes are not heat transfer parts, where the wave patterns do not exist, or only exist in an extremely small number even when the wave patterns exist. Therefore, the columns to support are small in number in the surrounding parts of the channel holes in the conventional plate heat exchanger. For improving the strength, it is preferable that columns exist in a large number also in the surrounding parts of the channel holes. However, the area is limited, and a structure of forming columns without interrupting the channels is limited, in the surrounding parts of the channel holes.

[0033] Therefore, in the plate heat exchanger 100 of

the first embodiment, the U-shaped structures 102 provided for confirming a lamination error in the surrounding parts of the channel holes are brazed to be used as the columns 121 (the column 122 of repeated structure). In this way, it is possible to improve the reliability of the plate heat exchanger 100. As shown in Fig. 9, the U-shaped structures 102 contact with the portions where wave patterns are not formed in the surrounding parts of the channel holes in the lower side heat transfer plates 101, and by brazing the U-shaped structures 102, the columns 121 are formed. The columns 121 have an effect to improve the yield ratio, and to confirm a lamination error, and further, the columns 121 can be formed by conventionally used members. Thus, it is possible to improve the strength without adding new members. Further, since the formed columns 121 are formed in the periphery of the channel holes, i.e., on the opposite side (the short side) of the wave patterns being the heat transfer parts across the channel holes, it is possible to improve the strength without interrupting the channels of the refrigerant 7.

(Side plate 105)

[0034] Fig. 10 is a diagram describing the side plate 105a and the side plate 105b that interleave the upper and lower parts of the heat transfer part 108. (103a), etc. show what nozzles in Fig. 2 that parts correspond to. The side plates 105a and 105b have sizes and thicknesses equivalent to the heat transfer plates 101, including channel holes 105a-1 through 105a-4, and 105b-1 through 105b-4 at the four corners, and being a plate having a planar structure without the wave pattern 107. As shown in Fig. 6, the side plate 105a is located above the heat transfer part 108, and the side plate 105b is located below the heat transfer 108, which constitute the major part 109.

(Drawing shape part 110a)

[0035] As described in Figs. 6 and 10, the side plate 105a includes drawing shape parts 110a in concave shapes that are formed by a deep drawing around the channel holes 105a-1 and 105a-4. The drawing shape part 110a of the channel hole 105a-1 is formed to be a full circle along the edge of the circular channel hole 105a-1. This is also the same in the drawing shape part 110a of the channel hole 105a-4. Here, the concave shape means a concave shape that protrudes in the lamination direction D oriented in the direction from the side plate 105a to the side plate 105b, and the shape that protrudes in the opposite direction to the lamination direction D is called convex shape.

[0036] The side plate 105b includes a drawing shape part 110b in a convex shape that is formed by a deep drawing around the channel hole 105b-1, and a drawing shape part 110c in a convex shape that is formed by a deep drawing around the channel hole 105b-4. Each drawing shape part is brazed to channel holes (channel holes that exist in a center line direction of each nozzle

at the time of lamination) corresponding to the nozzles 103a and 103b at the time of lamination out of the channel holes in the heat transfer plates 101a and 101b that are adjacent to each side plate. In this way, the drawing shape parts 110a, 110b and 110c form columns around the channel holes between the heat transfer plates 101 and the side plates 105. Thus, it is possible to improve the strength of the plate heat exchanger 100.

(Drawing shape part 110c)

[0037] As shown in (b) of Fig. 10, the side plate 105b includes the drawing shape part 110c having a different shape from the drawing shape part 110b around the channel hole 105b-4. The drawing shape part 110c has a shape wherein the parts that contact with the U-shaped structures 102 in the drawing shape part 110b are kept flat. By providing these flat parts, the U-shaped structures 102 formed in the heat transfer plate 101a at a lowermost layer adjacent to the side plate 105b are prevented from being carried. As shown in (b) of Fig. 10, since the U-shaped structures 102-1 through 102-3 (a case of forming at three parts is shown corresponding to (a) of Fig. 8) are supported at the flat parts, it becomes possible to surely braze the side plate 105b.

[0038] Fig. 11 is an enlarged view on the nozzle 103a side in Fig. 6. As shown in Fig. 11, refrigerant is prevented from flowing into a non-heat transfer space 111 (a space where a fluid does not flow in) formed by the side plate 105a and the side plate 105b. The non-heat transfer space 111 is a space formed by a plane and the wave pattern 107, and is a space where effectiveness regarding heat transfer cannot be obtained. Therefore, by preventing refrigerant from flowing into the non-heat transfer space 111, it is possible to prevent surplus heat dissipation, and decrease in flow velocity of the refrigerant.

(Reinforcing plate 104)

[0039] As shown in Fig. 6, the reinforcing plate 104a (outside plate) is attached above the major part 109, and the reinforcing plate 104b is attached below the major part 109. The reinforcing plates 104 (also called pressure-resisting plates) have thicknesses around five times of the thickness of the heat transfer plates 101 and the side plates 105. In the plate heat exchanger 100, the reinforcing plate 104a includes four channel holes as shown in Figs. 2 and 4, etc. Further, the reinforcing plate 104b does not include the channel hole 106, as shown in Fig. 5. By the reinforcing plates 104a and 104b, the plate heat exchanger 100 is made possible to endure pressure fluctuation fatigue generated by a fluid flowing in the major part 109, and a force generated by a difference between the pressure in the plate heat exchanger 100 and the atmospheric pressure.

(Caulking process of nozzles)

[0040] As shown in Figs. 2, 4, 6, etc., the nozzles 103a through 103d for making refrigerant and water flow into the major part 109 are attached to four channel holes in the reinforcing plate 104a, respectively. The installation positions (installation parts) of the nozzles 103 are determined depending on the number of the channel holes in the reinforcing plates 104a and 104b. In the plate heat exchanger 100 of the first embodiment, four channel holes are formed in the reinforcing plate 104a, and a channel hole is not formed in the reinforcing plate 104b; however, if a maximum of four channel holes are formed in one piece of the reinforcing plate, a total of eight nozzles 103 are attached to one unit of the plate heat exchanger 100. As shown in Fig. 11, the nozzle 103a through which the refrigerant 7 flows in includes at its end part a push part 112 that engages with the channel hole in the reinforcing plate 104a. The tip end of the push part 112 is made to protrude from the bottom of the reinforcing plate 104a by at least 1 mm. The size H in Fig. 11 is at least 1 mm. Before the step of joining the plate heat exchanger 100 by brazing, the push part 112 of the nozzle 103a is inserted in the channel hole in the reinforcing plate 104a, and the push part 112 is applied a caulking process. In a state of temporarily fixing the reinforcing plate 104a and the nozzle 103a by the caulking process, the reinforcing plate 104a is laminated over the major part 109, the whole plate heat exchanger 100 is temporarily fitted, and the temporarily fitted plate heat exchanger 100 is sent to a brazing step.

(Brazing step)

[0041] In the plate heat exchanger 100 in a temporarily fitted state, copper strips are intervened as brazing filler metal between the heat transfer plates 101a and 101b, between the heat transfer part 108, the side plate 105a and the side plate 105b, and between the major part 109 and the reinforcing plates 104a and 104b. Additionally, copper being brazing filler metal is located also between the reinforcing plate 104a and the nozzles 103a through 103d. The plate heat exchanger 100 in a temporarily fitted state where to the brazing filler metal is located is fed in a vacuum heating furnace in a brazing step, and brazing is performed in a vacuum state. Copper is melted in the brazing step, and the copper penetrates in a joint area in each element. The elements are adhered semipermanently by the penetrated copper being cooled, thereby the plate heat exchanger 100 is formed.

[0042] In the first embodiment above, in a pair of heat transfer plates that are the heat transfer plates having the U-shaped structures 102 only in one of the channel holes at four corners, being an outlet and inlet of a fluid, rotated 180 degrees from one another and laminated, by making the U-shaped structure of the upper heat transfer plate contact with the lower heat transfer plate, the columns 121 connecting the channel holes in the upper and

lower heat transfer plates are formed. Then, by laminating plural pairs of heat transfer plates, the column 122 (repeated structure) connecting the channel holes of the plate heat exchanger is formed. By the column 122 (repeated structure), it is possible to confirm whether a lamination error occurs or not before brazing, though looking into the channel holes and visually confirming the formed column before brazing. Further, the strength is improved by brazing the column 122 (repeated structure). Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the disclosure of this patent specification may be practiced otherwise than as specifically described herein.

Reference Signs List

[0043] 100 Plate heat exchanger, 2 Heat pump unit, 3 Compressor, 4 Condenser, 5 Electronic expansion valve, 6 Evaporator, 7 Refrigerant, 8 Water circuit, 9 Hot-water, 10 Clean water, 11 Water-water heat exchanging tank, 12 Heating appliance, 13 Clean water using appliance, 100 Plate heat exchanger, 101, 101a and 101b Heat transfer plate, 121 Column, 102 U-shaped structure, 103 Nozzle, 104, 104a and 104b Reinforcing plate, 105, 105a and 105b Side plate, 106a, 106b, 106c and 106d Channel hole, 107 Wave pattern, 108 Heat transfer part, 109 Major part, 110 Drawing shape part, 111 Non-heat transfer space, 112 Push part.

Claims

1. A plate heat exchanger (100) in which, by joining each plate of a plurality of plates (101a, 101b,...) that are laminated from one side to another side with another plate, which is adjacent to the each plate of the plurality of plates on both sides, a first flow channel (301) wherein a first fluid (7) flows, and a second flow channel (302) wherein a second fluid (9) that exchanges heat with the first fluid (7) flows are alternately formed in a lamination direction (D), the plate heat exchanger (100), wherein the each plate of the plurality of plates (101a, 101b,...) has a rectangular shape with a long side and a short side, in which two flow channel holes that are openings through which any of the first fluid (7) and the second fluid (9) passes are formed respectively on one side of short sides and another side of the short sides, and wherein the each plate includes a bend portion (102) which protrudes from a part of a periphery of any flow channel hole of four flow channel holes (106a, 106b, 106c, 106d), and bends and extends in a direction to be distanced from an opening, and which is attached firmly to a vicinity of a periphery of a flow channel hole that corresponds in the lamination direction (D) of the each plate that is adjacent

on the other side.

2. The plate heat exchanger (100) according to claim 1, wherein, in the each plate of the plurality of plates, a wave pattern (107a, 107b) that is directed upward and downward with respect to the lamination direction is formed in an area in a direction of the long side between the two flow channel holes on the one side of the short sides and the two channel holes on the other side of the short sides, and wherein, in the each plate of the plurality of plates (101a, 101b,...), the bend portion extends in a direction to be distanced from the wave pattern (107a, 107b).
3. The plate heat exchanger (100) according to claim 2, wherein the plurality of plates (101a, 101b,...) are a plurality of plates (101a, 101b,...) having an approximately same shape, that are alternately reversed 180 degrees and laminated, and wherein the bend portion (102) of the each plate forms a repeated structure (122) that is directed from the one side to the other side by a set of plates that are adjacent to each other through making the bend portion (102) of the each plate be attached firmly to the vicinity of the periphery of the flow channel hole (106a, 106b, 106c, 106d) that corresponds in the lamination direction (D) of the each plate that is adjacent on the other side.
4. The plate heat exchanger (100) according to any of claims 1 through 3, wherein a plurality of bend portions (102-1, 102-2, 102-3) are formed in a same flow channel hole.
5. A heat pump device (2) in which a compressor (3), a first heat exchanger (4), an expansion mechanism (5) and a second heat exchanger (6) are connected by a pipe, the heat pump device (2) comprising a plate heat exchanger (100) as at least any of the first heat exchanger (4) and the second heat exchanger (5), in which, by joining each plate of a plurality of plates (101a, 101b,...) that are laminated from one side to another side with another plate, which is adjacent to the each plate of the plurality of plates (101a, 101b,...) on both sides, a first flow channel (301) wherein a first fluid (7) flows, and a second flow channel (302) wherein a second fluid (9) that exchanges heat with the first fluid (7) flows are alternately formed in a lamination direction, wherein the each plate of the plurality of plates (101a, 101b,...) has a rectangular shape with a long side and a short side, in which two flow channel holes that are openings through which any of the first fluid (7) and the second fluid (9) passes are formed respectively on one side of short sides and another side of the short sides, and wherein the each plate includes a bend portion

(102) which protrudes from a part of a periphery of any flow channel hole of four flow channel holes (106a, 106b, 106c, 106d), and bends and extends in a direction to be distanced from an opening, and which is attached firmly to a vicinity of a periphery of a flow channel hole that corresponds in the lamination direction (D) of the each plate that is adjacent on the other side.

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Fig. 1

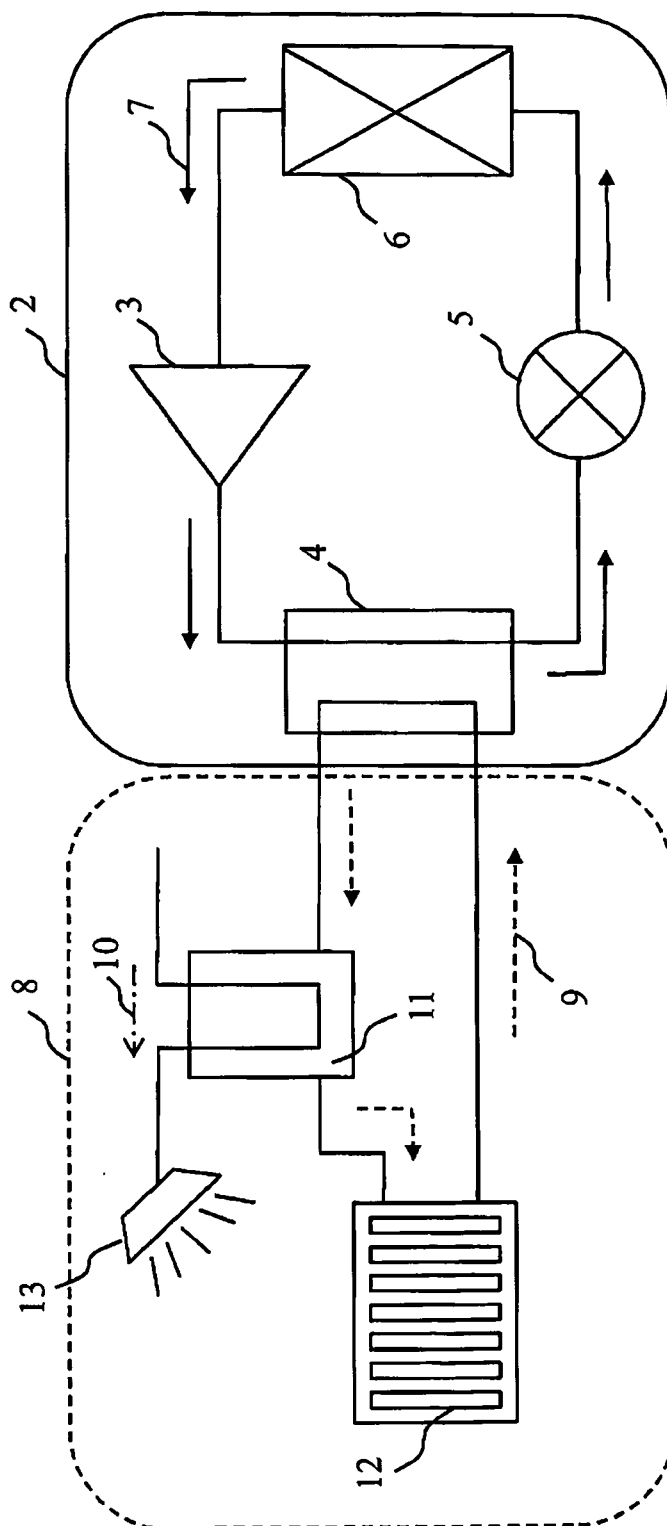


Fig. 2

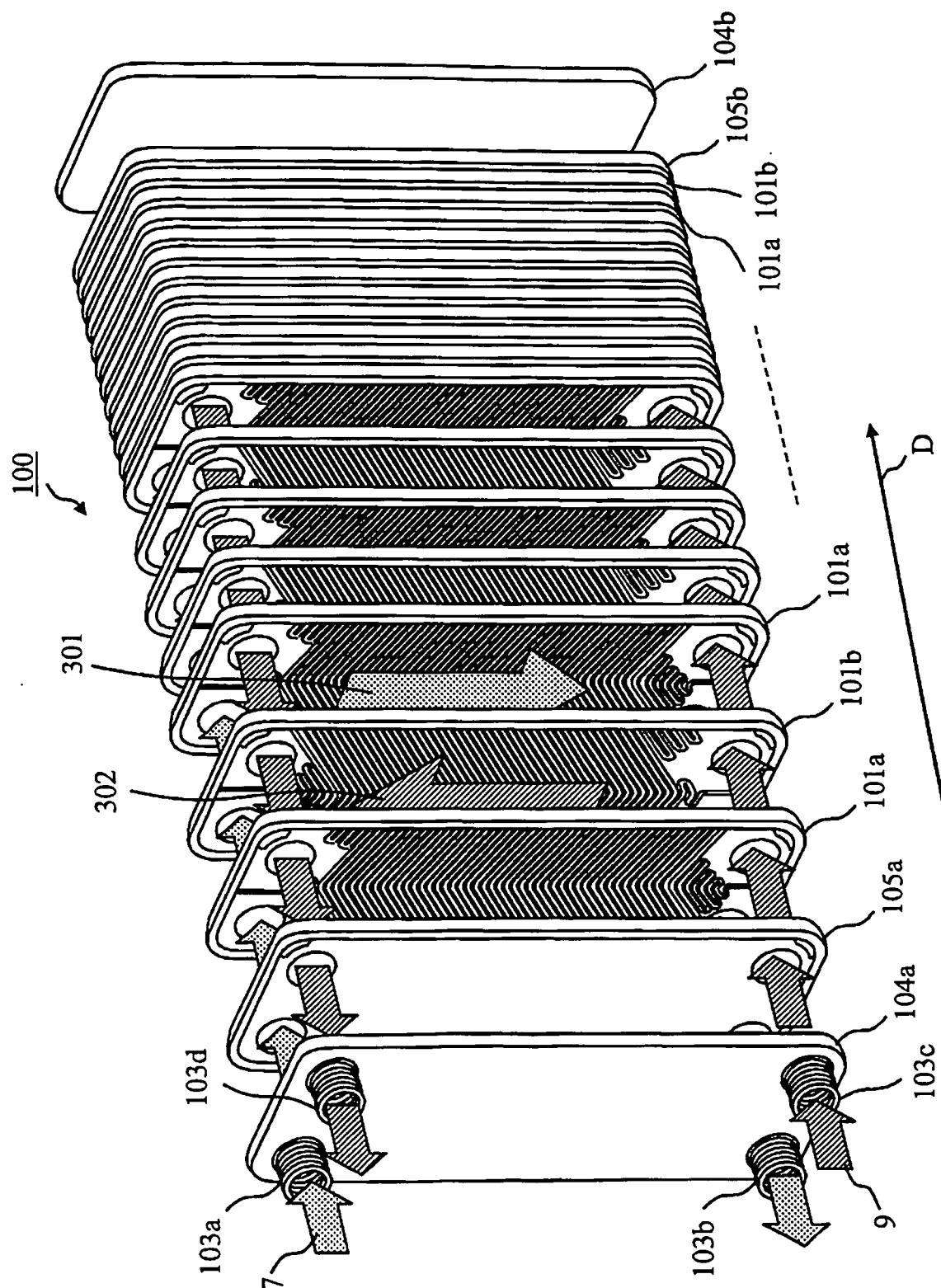


Fig. 3

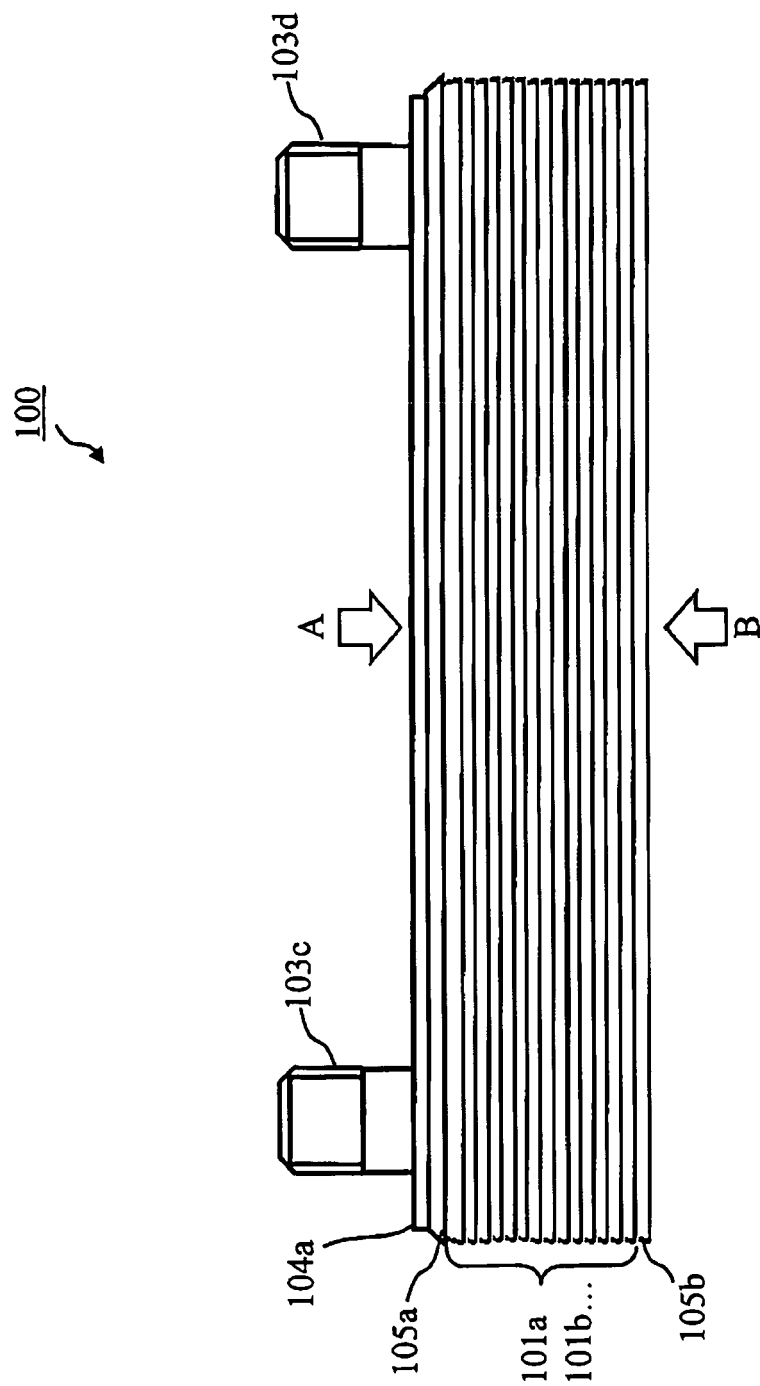


Fig.4

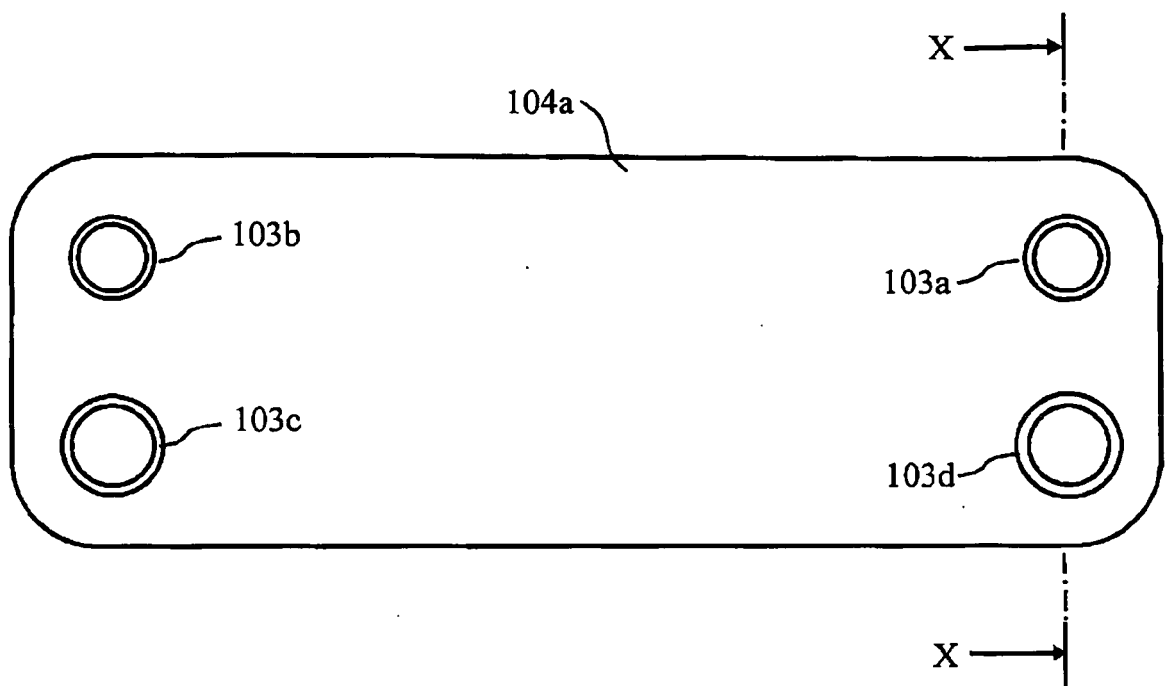


Fig.5

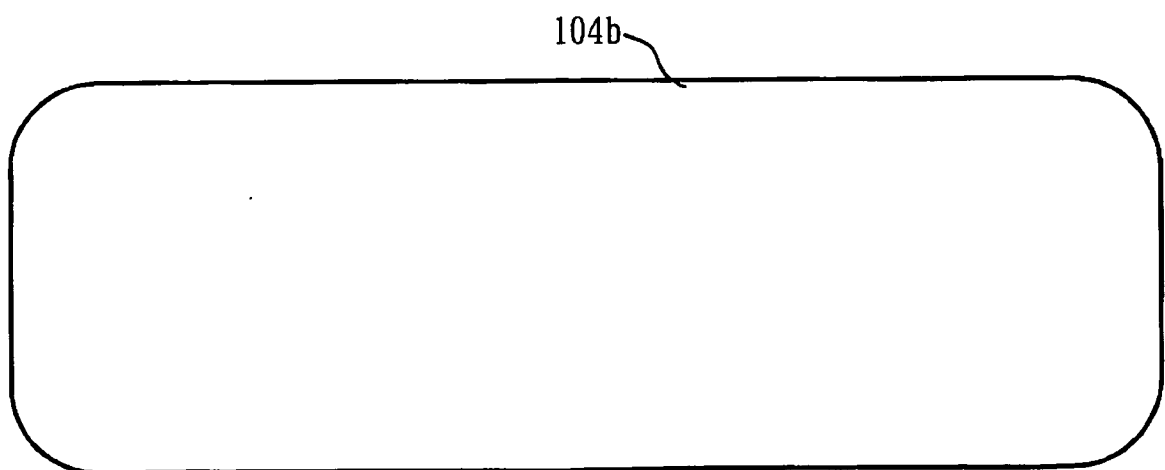


Fig. 6

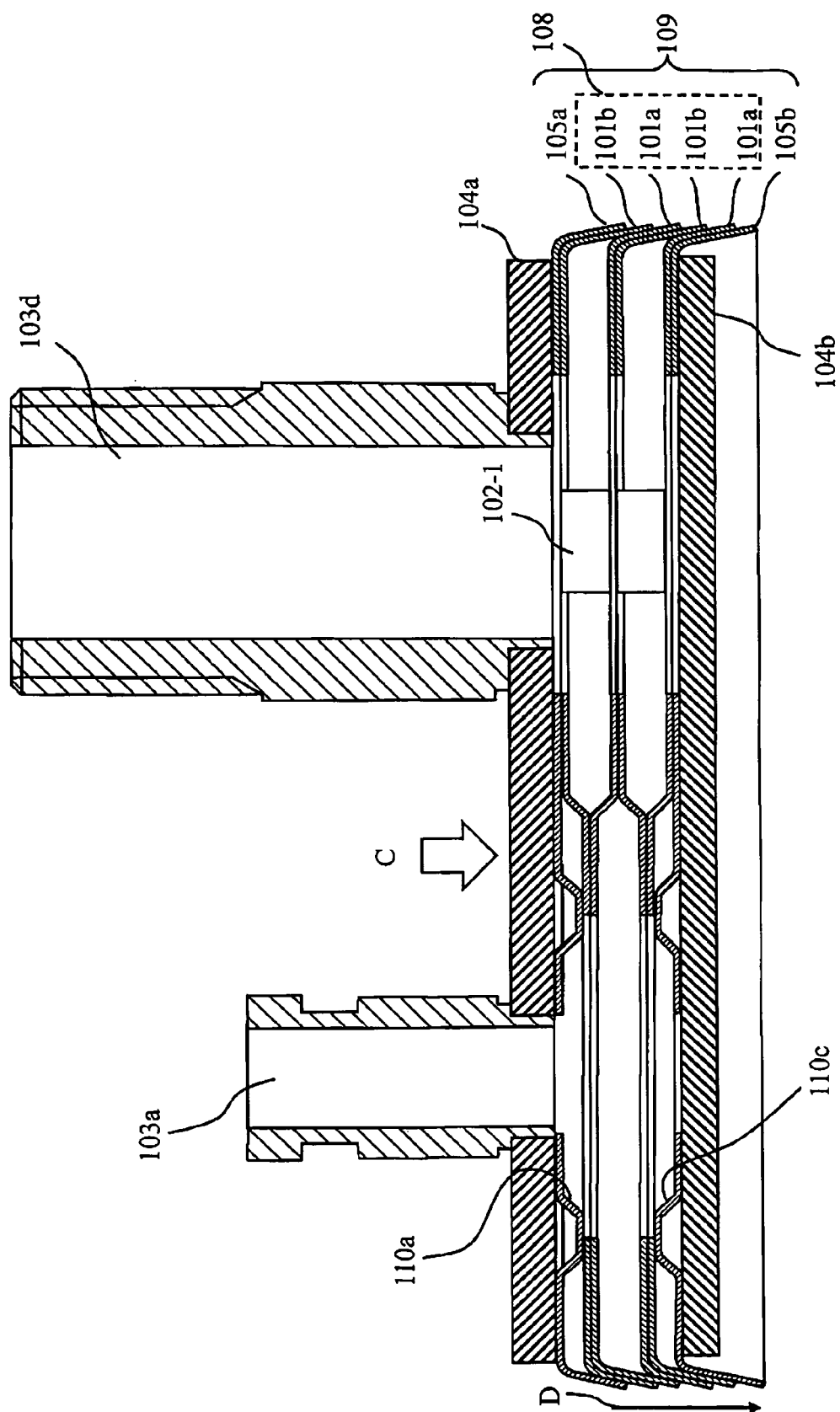


Fig. 7

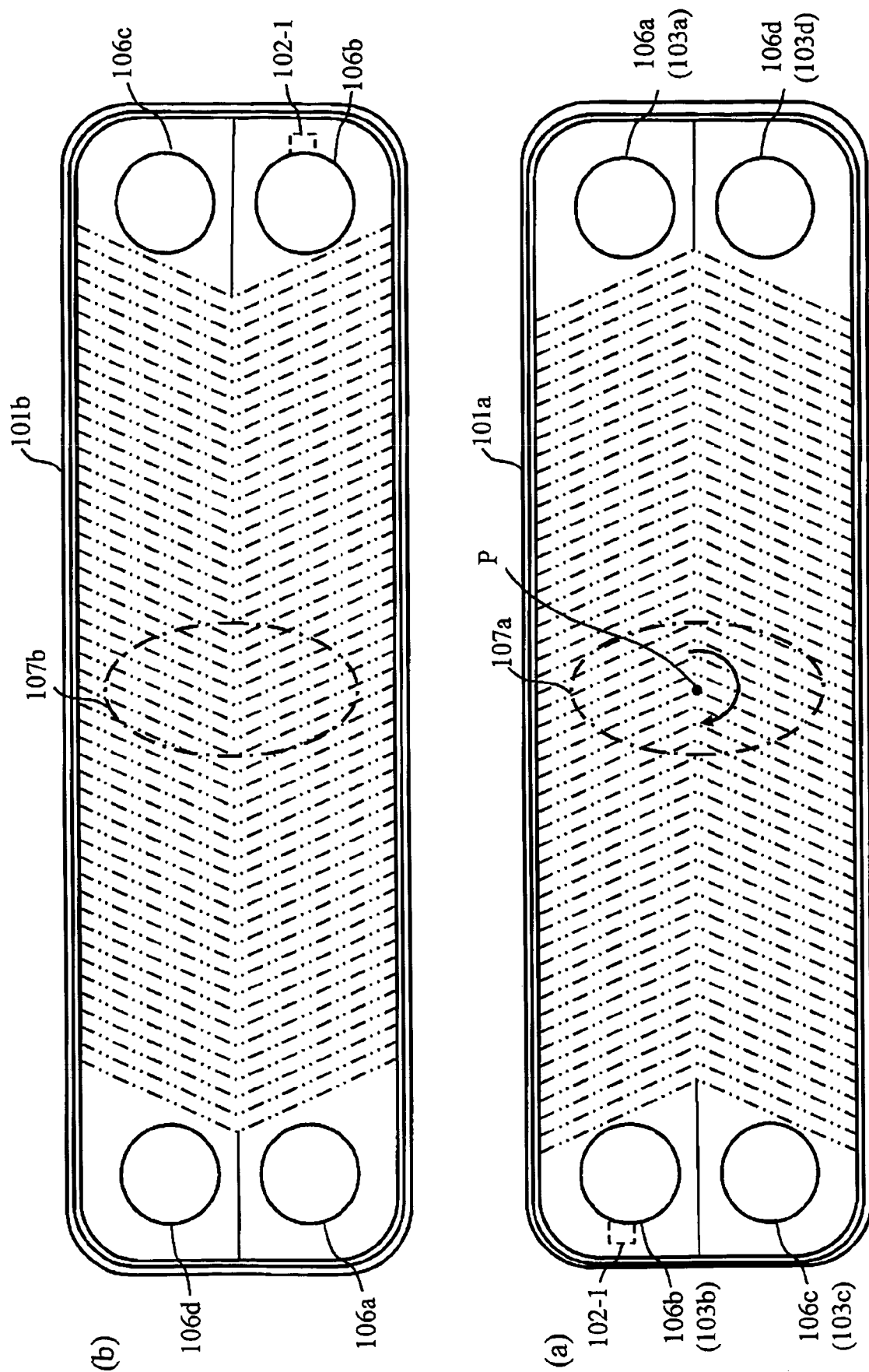


Fig. 8

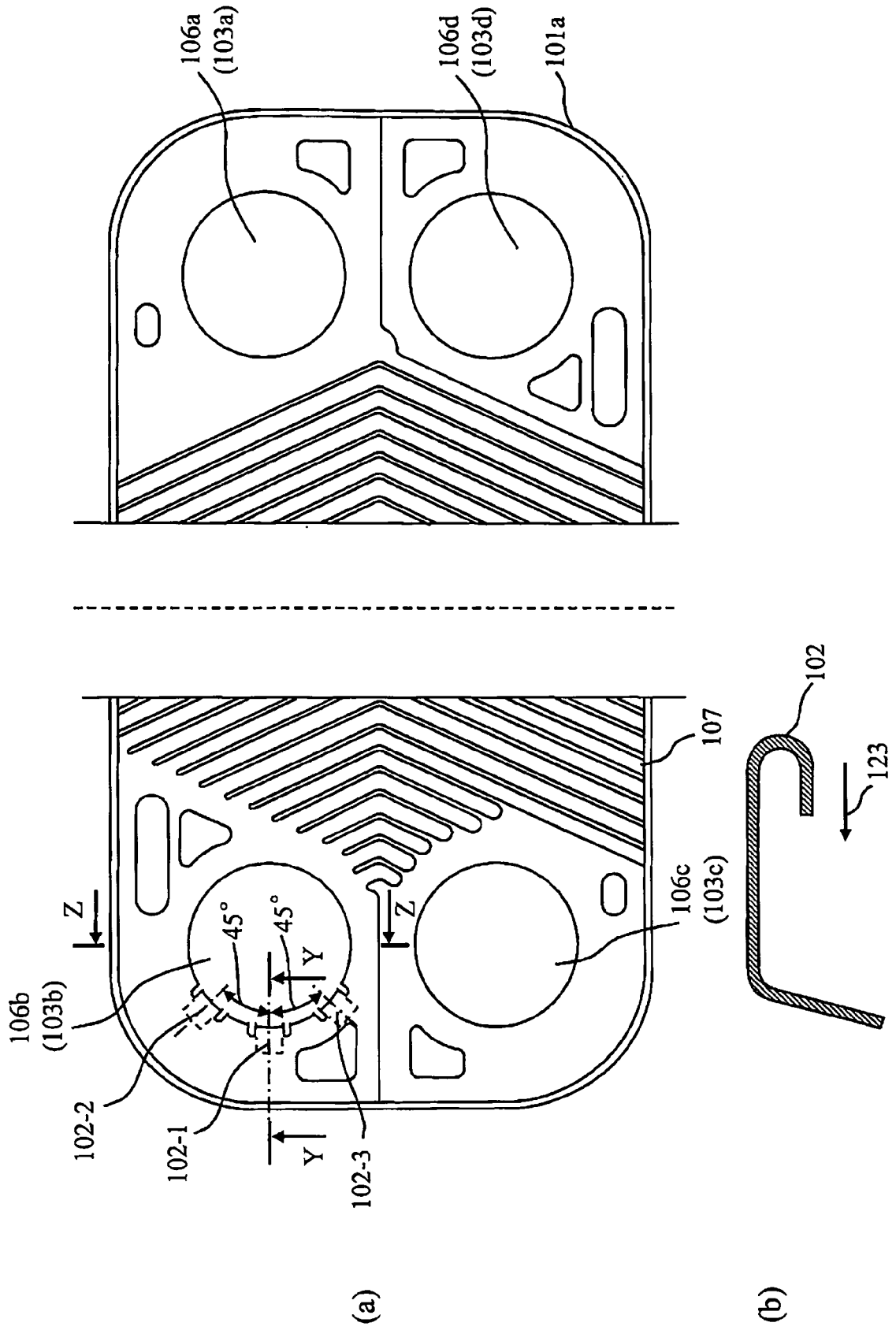


Fig. 9

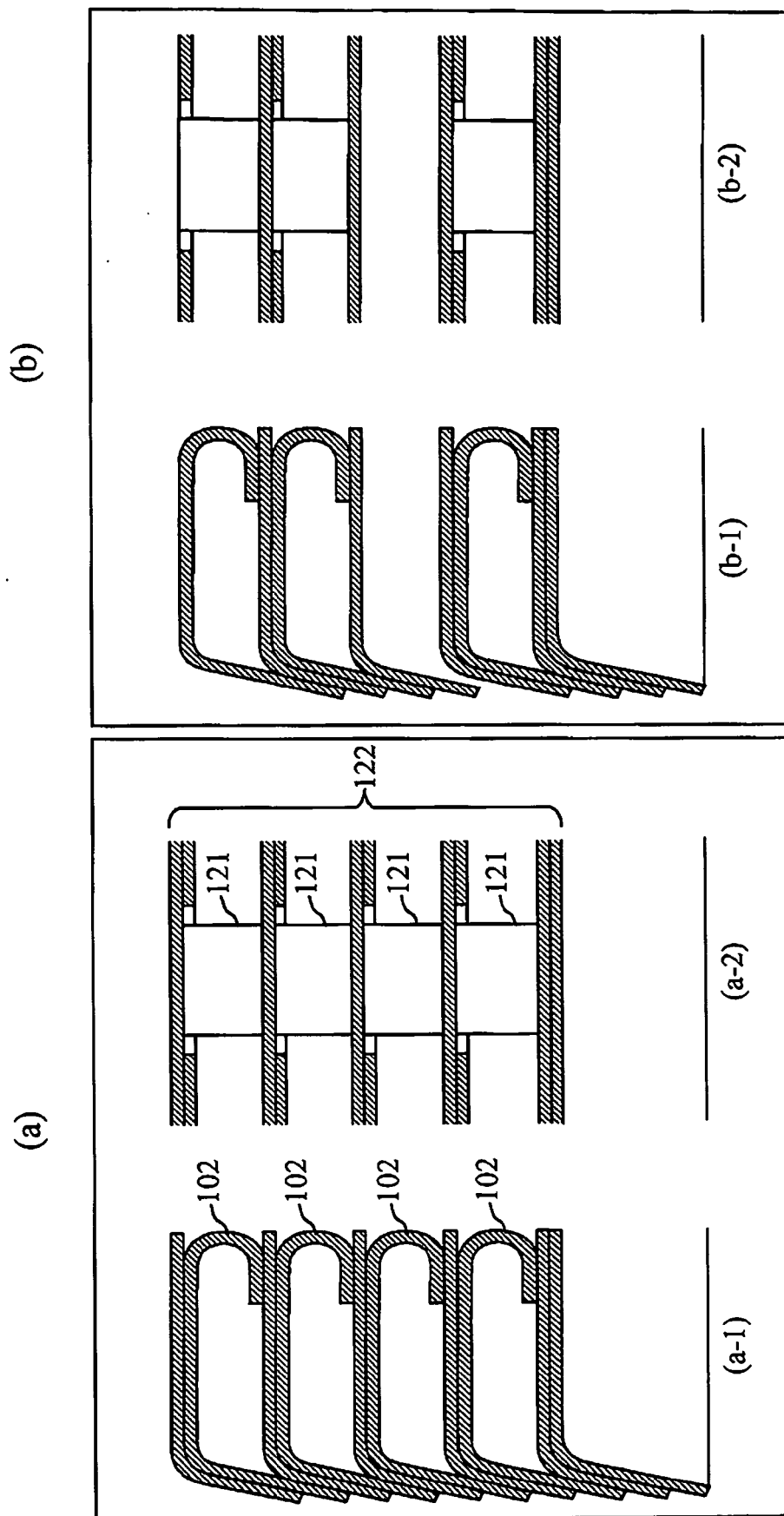


Fig.10

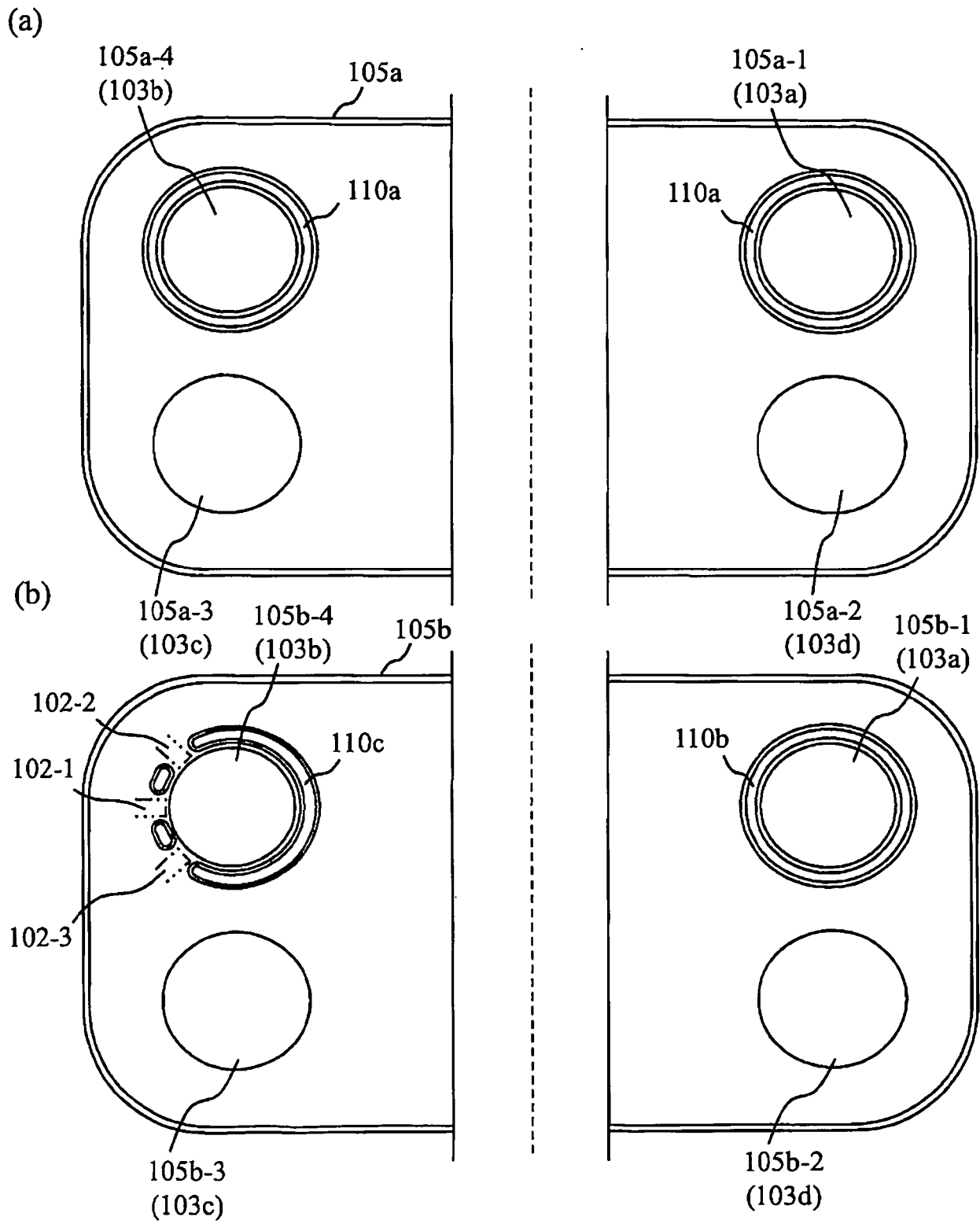
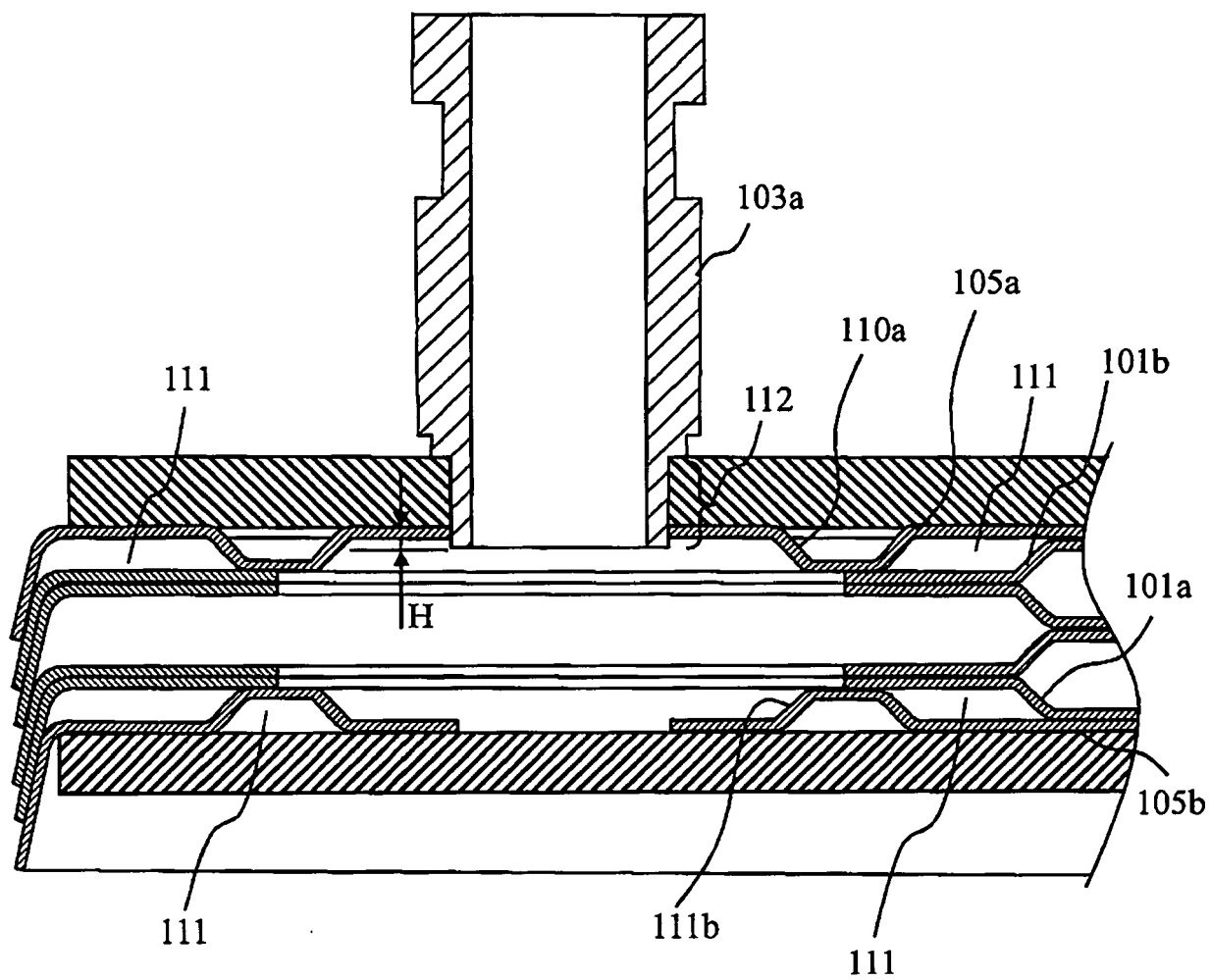


Fig.11



REFERENCES CITED IN THE DESCRIPTION

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