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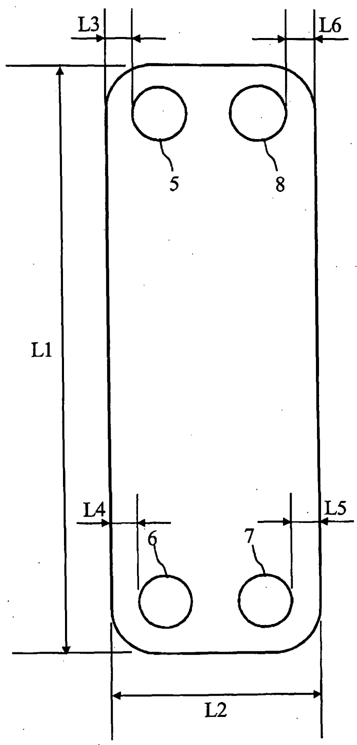
(54) PLATE-TYPE HEAT EXCHANGER AND REFRIGERATING AIR-CONDITIONING DEVICE

(57) It is aimed to enhance the strength of a plate heat exchanger while maintaining the heat exchange capability of the plate heat exchanger. A plate heat exchanger 20 is configured with a plurality of stacked plates 2 and 3. Each of the plates 2 and 3 includes at four corners thereof a first inlet hole 5 which acts as an inlet for a first fluid, a first outlet hole 6 which acts as an outlet for the first fluid, a second inlet hole 7 which acts as an inlet for a second fluid, and a second outlet hole 8 which acts as an outlet for the second fluid. Each of the plates 2 and 3 and an adjacent plate define therebetween a first flow path for passing the first fluid and a second flow path for passing the second fluid, so as to exchange heat between the first fluid and the second fluid. In each of the plates 2 and 3, a longitudinal length L1 is 4 or more times a lateral length L2.

Fig. 7



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Description

Technical Field

[0001] This invention relates to a plate heat exchanger configured with a plurality of stacked plates and a refrigeration air conditioner including the plate heat exchanger, for example.

Background Art

[0002] Patent Document 1 discusses a plate heat exchanger in which a fluid inlet hole and a fluid outlet hole are elliptically shaped. Patent Document 1 also discusses a plate heat exchanger in which the diameter of a fluid inlet hole and the diameter of a fluid outlet hole are identical in size.
Patent Document 2 discusses a plate heat exchanger in which the diameter of a fluid inlet hole and the diameter of a fluid outlet hole are different in size. Patent Document 2 also discusses a plate heat exchanger which includes reinforcement members for a fluid inlet hole and a fluid outlet hole, thereby providing enhanced strength.

Citation List

Patent Documents

[0003]

Patent Document 1: JP 9-72685 A
Patent Document 2: JP 7-508581 W

Disclosure of Invention

Technical Problem

[0004] Conventional plate heat exchangers have the following problems (1) to (3):

(1) Plate heat exchangers in general have thin plates, so that the strength is low.
(2) In a plate exchanger which includes reinforcement members for an inlet hole and an outlet hole, dirt tends to accumulate in the inlet hole and the outlet hole.
(3) When large volumes of fluid flow through a plate heat exchanger, there will be a point where the flow rate reaches a limit at a fluid inlet hole and a fluid outlet hole. Accordingly, to process large volumes of fluid, the inlet hole and the outlet hole need to have larger opening areas. However, to enlarge the opening areas of the inlet hole and the outlet hole, the widths of the inlet hole and the outlet hole must be increased. Increasing the widths of the inlet hole and the outlet hole reduces strength, as well as reduces a heat transfer area. That is, the plate heat exchanger in which the inlet hole and the outlet hole have large opening areas has drawbacks in terms of strength and heat exchange capability

[0005] This invention aims to enhance the strength of a plate heat exchanger while maintaining the heat exchange capability of the plate heat exchanger, for example.

Solution to Problem

[0006] A plate heat exchanger according to this invention is, for example,
a plate heat exchanger configured with a plurality of stacked plates, wherein each plate of the plurality of stacked plates includes:
a first inlet hole which acts as an inlet for a first fluid, the first inlet hole being located near one edge in a longitudinal direction;
a first outlet hole which acts as an outlet for the first fluid, the first outlet hole being located near another edge opposite from the first inlet hole in the longitudinal direction;
a second inlet hole which acts as an inlet for a second fluid, the second inlet hole being located near one edge in the longitudinal direction; and
a second outlet hole which acts as an outlet for the second fluid, the second outlet hole being located near another edge opposite from the second inlet hole in the longitudinal direction,
wherein the each plate and an adjacent plate define therebetween either one of a first flow path and a second flow path, the first flow path passing the first fluid entered from the first inlet hole to the first outlet hole such that the first fluid spreads in a lateral direction, and the second flow path passing the second fluid entered from the second inlet hole to the second outlet hole such that the second fluid spreads in the lateral direction, and the each plate exchanges heat between the first fluid flowing through the first flow path and the second fluid flowing through the second flow path, and
wherein the each plate is configured such that a length in the longitudinal direction is 4 or more times a length in the lateral direction.

Advantageous Effects of Invention

[0007] A plate heat exchanger according to this invention is configured such that a length in a longitudinal direction is 4 or more times a length in a lateral direction. Accordingly, stress applied to edges of each plate can be reduced. Thus, the plate heat exchanger according to this invention provides enhanced strength.

Brief Description of Drawings

[0008]

Fig. 1 is a side view of a plate heat exchanger 20;
Fig. 2 is a front view of a reinforcement side plate 1;

Fig. 3 is a front view of a second plate 2;
Fig. 4 is a front view of a first plate 3;
Fig. 5 is a front view of a reinforcement side plate 4;
Fig. 6 is an exploded perspective view of the plate heat exchanger 20;
Fig. 7 is a diagram showing dimensions of the plates 2 and 3 of the plate heat exchanger 20;
Fig. 8 is a diagram depicting the relationship between stress and the ratio of a longitudinal length and a lateral length of the plates 2 and 3.
Fig. 9 is a diagram depicting the relationship between the weight of the plate heat exchanger 20 and the ratio of the longitudinal length and the lateral length of the plates 2 and 3.
Fig. 10 is a diagram showing the plates 2 and 3 in which the diameters of first inlet and outlet holes are smaller than the diameters of second inlet and outlet holes.
Fig. 11 is a diagram showing the plate heat exchanger 20 in which the nearer each of the plates 2 and 3 is to the reinforcement side plate 1, the smaller the diameter of a first inlet hole 5.
Fig. 12 is a diagram showing dimensions of the plates 2 and 3 in which the inlet and outlet holes are positioned nearer to four corners of each plate.
Fig. 13 is a diagram describing a flow of a first fluid on the first plate 3 in which the inlet and outlet holes are positioned nearer to the four corners of the plate.
Fig. 14 is a diagram describing corrugations 9 of the first plate 3 in which the inlet and outlet holes are positioned nearer to the four corners of the plate.
Fig. 15 is a diagram showing the corrugations 9 of the second plate 2 in which the inlet and outlet holes are positioned nearer to the four corners of the plate.
Fig. 16 is a diagram showing the corrugations 9 of the first plate 3 in which the inlet and outlet holes are positioned nearer to the four corners of the plate.
Fig. 17 is a diagram showing the plates 2 and 3 in which the first inlet and outlet holes are differently shaped from the second inlet and outlet holes.
Fig. 18 is a diagram showing the plates 2 and 3 in which the first inlet and outlet holes are differently shaped from the second inlet and outlet holes.
Fig. 19 is a diagram showing the plates 2 and 3 in which the first inlet and outlet holes are differently shaped from the second inlet and outlet holes.
Fig. 20 is a diagram comparing a case in which the first inlet and outlet holes and the second inlet and outlet holes are identical in shape, and a case in which the first inlet and outlet holes and the second inlet and outlet holes are different in shape.
Fig. 21 is a diagram showing the plates 2 and 3 in which the first inlet and outlet holes and the second inlet and outlet holes are formed in an identical non-circular shape.
Fig. 22 is a diagram showing the plates 2 and 3 in which the first inlet and outlet holes and the second inlet and outlet holes are formed in an identical non-circular shape.
Fig. 23 is a diagram showing the plates 2 and 3 in which the first inlet and outlet holes and the second inlet and outlet holes are formed in an identical non-circular shape.
Fig. 24 is a diagram showing the plates 2 and 3 in which the first inlet and outlet holes and the second inlet and outlet holes are formed in an identical non-circular shape; and
Fig. 25 is a diagram showing a heating and hot water system 29.

Description of Embodiments

First embodiment

[0009] Figs. 1 to 6 are diagrams describing a plate heat exchanger 20 according to a first embodiment. Fig. 1 is a side view of the plate heat exchanger 20. Fig. 2 is a front view of a reinforcement side plate 1. Fig. 3 is a front view of a second plate 2. Fig. 4 is a front view of a first plate 3. Fig. 5 is a front view of a reinforcement side plate 4. Fig. 6 is an exploded perspective view of the plate heat exchanger 20.

[0010] As shown in Fig. 1, the plate heat exchanger 20 includes a plurality of stacked plates 2 and 3. The plate heat exchanger 20 also includes the reinforcement side plates 1 and 4 stacked at the forefront (an A side in Fig. 1) and the rear end (a B side in Fig. 1), respectively. As shown in Figs. 3 and 4, each of the plates 2 and 3 is formed as a plate of an approximately rectangular shape. Each of the plates 2 and 3 includes a first inlet hole 5 near one edge (an upper side) in a long-side (longitudinal) direction of the approximately rectangular shape. Each of the plates 2 and 3 includes a first outlet hole 6 near another edge (a lower side) in the longitudinal direction opposite from the first inlet hole 5. Each of the plates 2 and 3 includes a second inlet hole 7 near the same edge (the lower side) in the longitudinal direction as the first outlet hole 6. Each of the plates 2 and 3 includes a second outlet hole 8 near the same edge (the upper side) in the longitudinal direction as the first inlet hole 5. Each of the plates 2 and 3 includes the first inlet hole 5 and the first outlet hole 6 near the same edge (a left side) in a short-side (lateral) direction of the approximately rectangular shape. Each of the plates 2 and 3 includes the second inlet hole 7 and the second outlet hole 8 near another edge (a right side) in the lateral direction opposite from the first inlet hole 5 and the first outlet hole 6.
That is, the first inlet hole 5, the first outlet hole 6, the second inlet hole 7, and the second outlet hole 8 are provided at four corners of each of the plates 2 and 3. The first inlet hole 5 and the first outlet hole 6 will be referred to as first inlet and outlet holes. Likewise, the second inlet hole 7 and the second outlet hole 8 will be referred to as second inlet and outlet holes.

[0011] Like the plates 2 and 3, the reinforcement side plates 1 and 4 are also formed as plates in an approximately rectangular shape, as shown in Figs. 2 and 5. As shown in Fig. 2, the reinforcement side plate 1 stacked at the forefront includes the first inlet hole 5 (a first inlet duct), the first outlet hole 6 (a first outlet duct), the second inlet hole 7 (a second inlet duct), and the second outlet hole 8 (a second outlet duct) at the same positions as in the plates 2 and 3.

On the other hand, as shown in Fig. 5, the reinforcement side plate 4 stacked at the rear end does not include the first inlet hole 5, the first outlet hole 6, the second inlet hole 7, and the second outlet hole 8. In Fig. 5, the positions of the first inlet hole 5, the first outlet hole 6, the second inlet hole 7, and the second outlet hole 8 are indicated by dashed lines, but these holes are not actually present in the reinforcement side plate 4.

[0012] Each of the plates 2 and 3 and the reinforcement side plate 1 are stacked such that the respective first inlet holes 5, first outlet holes 6, second inlet holes 7, and second outlet holes 8 are aligned with one another. The second plate 2 and the first plate 3 are stacked alternately.

The plates 2 and 3 and the reinforcement side plates 1 and 4 are formed approximately identically in an approximately rectangular shape.

[0013] As shown in Figs. 3 and 4, each of the plates 2 and 3 has a plurality of V-shaped concave portions and convex portions (corrugations 9) arranged in longitudinal arrays. The corrugations 9 have ends 13 at both sides in the lateral direction. The corrugations 9 are formed in the shape of a V having turning points 12, each turning point 12 being longitudinally misaligned with respect to the corresponding ends 13 at both sides. The pitch (width) of the corrugations 9 is indicated as W in Fig. 4. The corrugations 9 are provided such that the direction thereof is reversed between the second plate 2 and the first plate 3. That is, in the second plate 2, the corrugations 9 are formed in the shape of a V with each turning point 12 positioned lower than the corresponding ends 13 at both sides. On the other hand, in the first plate 3, the corrugations 9 are formed in the shape of a V (a reversed V) with each turning point 12 positioned higher than the corresponding ends 13 at both sides.

In this way, the V-shaped corrugations 9 are formed in the plates 2 and 3 by reversing the direction of the V shape between the plates 2 and 3. By stacking the plates 2 and 3 alternately, flow paths with high heat transfer efficiency are defmed between the plates 2 and 3. That is, as shown in Fig. 6, a first flow path is defined between the back surface of the second plate 2 and the front surface of the first plate 3 such that a first fluid entered from the first inlet hole 5 flows to the first outlet hole 6. Likewise, a second flow path is defmed between the back surface of the first plate 3 and the front surface of the second plate 2 such that a second fluid entered from the second inlet hole 7 flows to the second outlet hole 8.

The first fluid flowing through the first flow path is heat-exchanged with the second fluid flowing through the second flow path via the plates 2 and 3.

[0014] Fig. 7 is a diagram showing dimensions of the plates 2 and 3 of the plate heat exchanger 20. In Fig. 7, a length L1 indicates a length of the plates 2 and 3 in the longitudinal direction. A length L2 indicates a length of the plates 2 and 3 in the lateral direction. A length L3 indicates a length from the first inlet hole 5 to a plate edge proximate to the first inlet hole 5 in the lateral direction. A length 4 indicates a length from the first outlet hole 6 to a plate edge proximate to the first outlet hole 6 in the lateral direction. A length L5 indicates a length from the second inlet hole 7 to a plate edge proximate to the second inlet hole 7 in the lateral direction. A length L6 indicates a length from the second outlet hole 8 to a plate edge proximate to the second outlet hole 8 in the lateral direction.

[0015] Fig. 8 is a diagram depicting the relationship between stress and the ratio (length ratio) of the longitudinal length and the lateral length of the plates 2 and 3. The horizontal axis in Fig. 8 depicts the ratio (length ratio) between the longitudinal length and the lateral length of the plates 2 and 3. That is, the horizontal axis in Fig. 8 depicts the ratio of the longitudinal length L1 of the plates 2 and 3 to the lateral length L2 of the plates 2 and 3. The vertical axis in Fig. 8 depicts the stress applied to the edges (periphery) of the plates 2 and 3. In Fig. 8, stress is expressed as a stress ratio. The reference value of the stress ratio is a value indicated by the second point from the right, namely, a point P, in Fig. 8. Each point in Fig. 8 represents a calculated value of a stress ratio relative to a length ratio. The line in Fig. 8 represents values calculated from each point by using a least-square method. As shown in Fig. 8. the shorter the lateral length L2 of the plates 2 and 3 is relative to the longitudinal length L1 of the plates 2 and 3, the smaller the stress applied to the periphery of the plates 2 and 3. Thus, the length L2 should preferably be as short as possible relative to the length L1. Specifically, the length L2 should preferably be shortened such that the length L1 is 4 or more times the length L2. However, due to limitations on the manufacture of the plate heat exchanger 20, the length L2 cannot be shortened significantly Accordingly, the length L2 should preferably be shortened such that the length L1 is approximately from 4 to 6.5 times the length L2.

By making the lengths L3, L4, L5, and L6 shorter, the stress applied to the edges of the plates 2 and 3 is reduced. Specifically, the lengths L3, L4, L5, and L6 should preferably be set to not more than 6 percent of the lateral length L2 of the plates 2 and 3. The lengths L3, L4, L5, and L6 may be set to not more than 5.6 mm, irrespective of the lateral length L2 of the plates 2 and 3. However, due to limitations on the manufacture of the plate heat exchanger 20, the lengths L3, L4, L5, and L6 cannot be shortened significantly. Accordingly, the lengths L3, L4, L5, and L6 should preferably be set to between not less than 3 percent and not more than 6 percent of the lateral length L2 of the plates 2 and 3. Likewise, the lengths L3, L4, L5, and L6 should preferably be set to not less than

3 mm and not more than 5.6 mm.

[0016] Fig. 9 is a diagram depicting the relationship between the ratio of the longitudinal length and the lateral length of the plates 2 and 3 and the weight of the plate heat exchanger 20. Specifically, Fig. 9 depicts the extent to which the weight of the plate heat exchanger 20 can be reduced by shortening the lateral length of the plates 2 and 3 without changing the longitudinal length of the plates 2 and 3.

As in Fig. 8, the horizontal axis in Fig. 9 depicts the ratio (length ratio) of the longitudinal length and the lateral length of the plates 2 and 3. The vertical axis in Fig. 9 depicts the reduction ratio of the weight of the plate heat exchanger 20. The reduction ratio of the weight of the plate heat exchanger 20 is a value calculated based on the weight of the plate heat exchanger 20 manufactured with the length ratio selected as the reference value of the stress ratio in Fig. 8 (the value indicated by the second point from the right, namely, the point P).

By making the length L2 shorter, the size of the plate heat exchanger 20 is reduced, so that the weight of the plate heat exchanger 20 can be reduced. However, by making the length L2 shorter, not only the weight can be reduced due to the reduced overall size, but also the thickness of the plates 2 and 3 and the thickness of the reinforcement side plates 1 and 4 can be reduced, so that the weight can be reduced further. That is, by making the length L2 shorter, the strength of the plate heat exchanger 20 is enhanced. Accordingly, the thickness of the plates 2 and 3 and the thickness of the reinforcement side plates 1 and 4 can be reduced, so that the weight of the plate heat exchanger 20 can be reduced.

As a result, by shortening the length L2 relative to the length L1, the weight of the plate heat exchanger 20 can be reduced more than by the weight reduction due to reduction in overall size.

[0017] As described above, in the plate heat exchanger 20 according to the first embodiment, the lateral length L2 of the plates 2 and 3 is shortened relative to the longitudinal length L1 of the plates 2 and 3, so that the strength of the plate heat exchanger 20 is enhanced.

In the plate heat exchanger 20 according to the first embodiment, the lengths between the inlet or outlet holes 5, 6, 7, and 8 and the plate edge (the lengths L3, L4, L5, and L6) are also shortened, so that the strength of the plate heat exchanger 20 is enhanced.

Furthermore, due to the enhanced strength of the plate heat exchanger 20, the weight of the plate heat exchanger 20 can be reduced.

[0018] By making the lateral length L2 shorter, a fluid entered from the first inlet hole 5 or the second inlet hole 7 is also facilitated to spread in the lateral direction. This eliminates the need to provide distribution facilitating members around the first inlet hole 5 and the second inlet hole 7 so as to facilitate spreading of the fluid. The enhanced strength of the plate heat exchanger 20 also eliminates the need to provide reinforcement members around the inlet holes (the first inlet hole 5, the second inlet hole 7). Thus, because there is no need to provide distribution facilitating members or reinforcement members, press working of the plates 2 and 3 is simplified.

Accordingly, the cost of manufacturing the plate heat exchanger 20 can be reduced. Variation in height of the corrugations 9 can also be reduced. That is, the plate heat exchanger 20 of stable quality can be manufactured.

[0019] When stagnation occurs in a fluid in a plate heat exchanger, dirt and scales tend to accumulate in a location where the stagnation occurred. The plates 2 and 3 are prone to corrosion in the location where dirt and scales are accumulated. If a heat exchanger in which stagnation may occur in a fluid is used in an evaporator, a drift may occur causing an uneven distribution of temperature. This may cause the fluid to freeze in some locations. When the fluid freezes, the strength of the heat exchanger is reduced. However, in the plate heat exchanger 20 according to the first embodiment, the lateral length of the plates 2 and 3 is short, so that the possibility of stagnation in a fluid is lessened. Thus, the possibility of accumulation of dirt and scales is lessened, and the strength is not reduced. The plate heat exchanger 20 according to the first embodiment is effective not only when the fluid is water but also for other types of fluid which have a tendency to drift due to a small density and a high pressure loss (e.g., a hydrocarbon refrigerant or a low-GWP refrigerant). With a chlorofluorocarbon refrigerant, effectiveness is also provided for preventing accumulation of refrigerant oil in the heat exchanger. This permits power consumption to be reduced in an apparatus using the plate heat exchanger 20 according to the first embodiment.

Second embodiment

[0020] In a second embodiment, there will be described the plate heat exchanger 20 in which the diameters of the first inlet and outlet holes are smaller than the diameters of the second inlet and outlet holes. That is, in the second embodiment, there will be described the plate heat exchanger 20 in which the opening areas of the first inlet and outlet holes are smaller than the opening areas of the second inlet and outlet holes.

[0021] Fig. 10 is a diagram showing the plates 2 and 3 in which the diameters of the first inlet and outlet holes are smaller than the diameters of the second inlet and outlet holes.

For example, when the plate heat exchanger 20 is used to exchange heat between a liquid such as water and a refrigerant such as chlorofluorocarbon, there is a risk that the plates may wear out (become thinner) due to erosion at an inlet hole for the liquid (the second inlet hole 7 here). For this reason, the diameters of the inlet and outlet holes for the liquid (the second inlet hole 7, the second outlet hole 8) need to be sufficiently large. However, there is no need to make the diameters of the inlet and outlet holes for the refrigerant (the first inlet hole 5, the first outlet hole 6) as large as the diameters of the inlet and outlet holes for the liquid (the second inlet hole 7, the second outlet hole 8). That is, the diameters of the first inlet hole 5 and the first outlet hole 6 may be smaller than the diameters of the second inlet hole 7 and the second outlet hole 8. When the diameters of the first inlet hole 5 and the first outlet hole 6 are reduced as described above, the lateral length of the plates 2 and 3 can be correspondingly shortened. Thus, the strength of the plate heat exchanger 20 is enhanced, and the weight of the plate heat exchanger 20 can be reduced, as described in the first embodiment.

The refrigerant is not limited to chlorofluorocarbon, and may also be a hydrocarbon refrigerant or a low-GWP refrigerant. A CO2 refrigerant requires the plate heat exchanger 20 to be strong due to a high working pressure. When the CO2 refrigerant is used, it is especially effective to configure the inlet and outlet holes for the refrigerant to be smaller than the inlet and outlet holes for the liquid. Since the CO2 refrigerant has a higher density and a smaller pressure loss compared to the chlorofluorocarbon refrigerant, the diameters of the first inlet hole 5 and the first outlet hole 6 can be further reduced.

[0022] Fig. 11 is a diagram showing the plate heat exchanger 20 configured such that the nearer each of the plates 2 and 3 is to the reinforcement side plate 1, the smaller the diameter of the first inlet hole 5.

The plate heat exchanger 20 shown in Fig. 11 is configured such that not only the diameters of the first inlet and outlet holes are smaller than the diameters of the second inlet and outlet holes, but also the nearer each of the stacked plates 2 and 3 is to the reinforcement side plate 1, the smaller the diameter of the first inlet hole 5. That is, the nearer each of the stacked plates 2 and 3 is to the reinforcement side plate 1 than to the reinforcement side plate 4 , the smaller the diameter of the first inlet hole 5. In other words, the nearer each of the stacked plates 2 and 3 is to the entrance side of the first fluid, the smaller the diameter of the first inlet hole 5. Specifically, the first inlet hole 5 is extremely small like a fine nozzle in the plates 2 and 3 stacked near the reinforcement side plate 1.

Because the first inlet hole 5 is extremely small in the plates 2 and 3 stacked near the reinforcement side plate 1, the first fluid can flow at high speed even when a large number of the plates 2 and 3 are stacked. This also facilitates distribution of the first fluid toward the plates 2 and 3 stacked near the reinforcement side plate 4.

Furthermore, the nearer each of the stacked plates 2 and 3 is to the reinforcement side plate 4, the larger the diameter of the first inlet hole 5 is. This facilitates an even distribution of the first fluid through the first flow path defined by each pair of the plates 2 and 3.

Third embodiment

[0023] In a third embodiment, there will be described the plate heat exchanger 20 in which the inlet and outlet holes are positioned not only nearer to the edges of each plate in the lateral direction, but also nearer to the edges of each plate in the longitudinal direction. That is, in the third embodiment, there will be described the plate heat exchanger 20 in which the inlet and outlet holes are positioned nearer to the four corners of the plates 2 and 3.

[0024] Fig. 12 is a diagram showing dimensions of the plates 2 and 3 in which the inlet and outlet holes are positioned nearer to the four corners of each plate. In Fig. 12, a length L7 indicates a length from the first inlet hole 5 to a plate edge proximate to the first inlet hole 5 in the longitudinal direction. A length L8 indicates a length from the first outlet hole 6 to a plate edge proximate to the first outlet hole 6 in the longitudinal direction. A length L9 indicates a length from the second inlet hole 7 to a plate edge proximate to the second inlet hole 7 in the longitudinal direction. A length L10 indicates a length from the second outlet hole 8 to a plate edge proximate to the second outlet hole 8 in the longitudinal direction. The lengths L7, L8, L9, and L10 are approximately equivalent to the lengths L3, L4, L5, and L6 shown in Fig. 7, respectively. In this way, by making the lengths L7, L8, L9, and L10 shorter, the stress applied to the periphery of each plate can be further reduced.

[0025] Specifically, in the plates 2 and 3 shown in Fig. 12, the diameters of the first inlet and outlet holes are smaller than the diameters of the second inlet and outlet holes. Accordingly, the centers of the first inlet and outlet holes are positioned nearer to the corners of the plates 2 and 3 relative to the centers of the second inlet and outlet holes.

In this way, by positioning the first inlet and outlet holes having smaller diameters (the first inlet hole 5, the first outlet hole 6) nearer to the four corners of the plates 2 and 3, the distance from the first inlet hole 5 to the first outlet hole 6 is increased. That is, the length of the first flow path is increased. Accordingly, the heat transfer area is increased, and the heat exchange capability of the plate heat exchanger 20 is enhanced.

[0026] Fig. 13 is a diagram describing a flow of the first fluid on the first plate 3 in which the inlet and outlet holes are positioned nearer to the four corners of the plate. Fig. 13 only applies to the first plate 3 instead of the plates 2 and 3. This is because a sealing portion 11 is shown in Fig. 13. That is, the sealing portion 11 is provided at different locations between the second plate 2 and the first plate 3.

By positioning the first inlet hole 5 having a smaller diameter nearer to the corner of the plates 2 and 3, an entrance region 10 for the first flow path can be provided near the first inlet hole 5. The entrance region 10 is a narrow region between the plate edge and the sealing portion 11. This means that the width of the entrance region 10 (a length L11 from the plate edge to the sealing portion 11) is narrower than the lateral width (the length L2) of the first plate 3. The first fluid entered from the first inlet hole 5 passes through the narrow entrance region 10, then spreads in the lateral direction of the plate heat exchanger 20, and flows to the first outlet hole 6.

The sealing portion 11 is a wall which prevents the first fluid entered from the first inlet hole 5 from flowing to the second outlet hole 8. The sealing portion 11 is formed as a protrusion raised in the stacking direction of the plates 2 and 3. The sealing portion 11 is normally provided around the second outlet hole 8 in a circular shape. However, the sealing portion 11 is provided here, starting from near the edge (the upper side) in the longitudinal direction where the first inlet hole 5 and the second outlet hole 8 are located and extending toward the edge (the lower side) in the longitudinal direction where the second inlet hole 7 and the second outlet hole 8 are located in such a manner as to gradually curve toward the edge (the right side) in the lateral direction near the second outlet hole 8. Specifically, in Fig. 13, the sealing portion 11 is formed to gradually curve to the right in a downward direction.

The sealing portion 11 facilitates the first fluid which has flowed through the entrance region 10 to spread toward the edge (the right side) in the lateral direction near the second outlet hole 8. That is, the entrance region 10 and the sealing portion 11 provide a guiding effect for guiding the first fluid toward the edge (the right side) in the lateral direction near the second outlet hole 8. This guiding effect can prevent the first fluid from stagnating around the sealing portion 11 or near the periphery of the plates 2 and 3, thereby enhancing the heat exchange capability This guiding effect can also reduce the pressure loss of the first fluid. That is, the plate heat exchanger 20 with enhanced performance can be provided.

When the sealing portion 11 is provided around the second outlet hole 8 in a circular shape, as is normally done, it is necessary to provide a distribution facilitating member around the first inlet hole 5 so as to prevent the first fluid from drifting. The distribution facilitating member is formed, for example, in a complex shape such as a radial shape. Thus, it is difficult to manufacture the plate heat exchanger 20 including the distribution facilitating member. However, the plate heat exchanger 20 according to the third embodiment simply includes the sealing portion 11 which is curved, and thus is simple to manufacture. For this reason, the plate heat exchanger 20 according to the third embodiment is highly suitable for mass production.

[0027] Fig. 14 is a diagram describing the corrugations 9 in the first plate 3 in which the inlet and outlet holes are positioned nearer to the four corners. Fig. 15 is a diagram showing the corrugations 9 in the second plate 2 in which the inlet and outlet holes are positioned nearer to the four corners. Fig. 16 is a diagram showing the corrugations 9 in the first plate 3 in which the inlet and outlet holes are positioned nearer to the four corners.

As has been described in the first embodiment, each of the plates 2 and 3 includes the corrugations 9 arranged in a plurality of longitudinal arrays, the corrugations 9 having the ends 13 at both sides in the lateral direction and also having the turning points 12 longitudinally misaligned with respect to the corresponding ends 13 at both sides, so that the corrugations 9 are V-shaped. The turning points 12 of the corrugations 9 in the plates 2 and 3 shown in Figs. 3 and 4 are positioned at the lateral center. That is, the corrugations 9 are formed in a bilaterally symmetrical manner.

In the plates 2 and 3 shown in Fig. 14, the diameters of the first inlet and outlet holes are smaller than the diameters of the second inlet and outlet holes. That is, in Fig. 14, the diameters of the first inlet hole 5 and the first outlet hole 6 are smaller than the diameters of the second inlet hole 7 and the second outlet hole 8. For this reason, if the turning points 12 are positioned at the lateral center as in the plates 2 and 3 shown in Figs. 3 and 4, this will create regions where the corrugations 9 are not formed near the first inlet hole 5 and the first outlet hole 6. Thus, in the regions near the first inlet hole 5 and the first outlet hole 6, the corrugations 9 are formed by shifting the positions of the turning points 12 of the corrugations 9 nearer to the first inlet hole 5 and the first outlet hole 6, respectively. That is, as shown in Fig. 14, a line 15 linking the turning points 12 of the corrugations 9 is defmed in a gradual curve, curving toward the first inlet hole 5 and the first outlet hole 6, respectively, from a center line 14 at the lateral center.

In this way, the corrugations 9 can also be formed in the regions near the first inlet hole 5 and the first outlet hole 6, so that the heat transfer area is increased. Accordingly, the heat exchange capability of the plate heat exchanger 20 is enhanced. The plates 2 are joined with the respective adjacent plates 3 at portions where the corrugations 9 are formed. Generally speaking, the plates 2 and 3 are prone to separation from one another in regions near the inlet and outlet holes. However, by forming the corrugations 9 also in the regions near the inlet and outlet holes, the joining points between the plates 2 and 3 are increased in number, so that the plates 2 and 3 can be prevented from separating from one another. Further, the position of each turning point 12 of the corrugations 9 gradually moves from the first inlet hole 5 toward the lateral center and from the lateral center toward the first outlet hole 6. This makes it possible to smoothly transfer the first fluid entered from the first inlet hole 5 to the lateral center and from the lateral center to the first outlet hole 6. Accordingly, the pressure loss of the first fluid can be reduced.

As in the first plate 3, the corrugations 9 are also formed in the second plate 2 by shifting the positions of the turning points 12 nearer to the first inlet hole 5 and the first outlet hole 6 in the regions near the first inlet hole 5 and the first outlet hole 6 having smaller diameters, respectively, as shown in Fig. 16.

Fourth embodiment

[0028] In a fourth embodiment, there will be described the plate heat exchanger 20 in which the shapes of the first inlet and outlet holes and the second inlet and outlet holes are modified.

[0029] Figs. 17 to 19 are diagrams showing the plates 2 and 3 in which the first inlet and outlet holes are shaped differently from the second inlet and outlet holes while maintaining required opening areas.

In Fig. 17, the first inlet and outlet holes and the second inlet and outlet holes are formed in approximately elliptical shapes different from each other. In Fig. 18, a circle is divided into two such that one of the two portions is the first inlet or outlet hole and the other portion is the second outlet or inlet hole. In Fig. 19, an approximately rectangular shape is divided into two such that one of the two portions is the first inlet or outlet hole and the other portion is the second outlet or inlet hole.

In Figs. 17 to 19, the diameters of the first inlet and outlet holes are smaller than the diameters of the second inlet and outlet holes.

[0030] Fig. 20 is a diagram comparing a case in which the first inlet and outlet holes and the second inlet and outlet holes are identical in shape , and a case in which the first inlet and outlet holes and the second inlet and outlet holes are different in shape. Fig. 20 shows the longitudinal side of the plates 2 and 3 where the first outlet hole 6 and the second inlet hole 7 are located. Fig. 20(a) shows the plates 2 and 3 in which the first outlet hole 6 and the second inlet hole 7 are both circularly shaped. On the other hand, Fig. 20(b) shows the plates 2 and 3 in which a circle is divided into two such that one of the two portions is the first inlet or outlet hole and the other portion is the second outlet or inlet hole, as shown in Fig. 18. In Fig. 20(a) and Fig. 20(b), the diameters of the first inlet and outlet holes are smaller than the diameters of the second inlet and outlet holes.

The first outlet hole 6 shown in Fig. 20(a) is a circle having a diameter of "12 mm", and the second inlet hole 7 is a circle having a diameter of "28 mm". The distance between the first outlet hole 6 and the second inlet hole 7 is "3 mm". Accordingly, the opening area of the first outlet hole 6 is "36 πm^2", and the opening area of the second inlet hole 7 is "196 πm^2". The length from the edge of the first outlet hole 6 to the edge of the second inlet hole 7 is "43 mm".

On the other hand, the first outlet hole 6 shown in Fig. 20(b) is a quarter of a circle having a diameter of "24 mm", and the second inlet hole 7 is three-quarters of a circle of "31 mm". The distance between the first outlet hole 6 and the second inlet hole 7 is "3 mm". Accordingly, the opening area of the first outlet hole 6 is "36 πm^2", and the opening area of the second inlet hole 7 is "192 πm^2". The length from the edge of the first outlet hole 6 to the edge of the second inlet hole 7 is "31 mm".

That is, the opening area of the first outlet hole 6 shown in Fig. 20(a) and the opening area of the second inlet hole 7 shown in Fig. 20(b) are both "36 πm^2" and thus are the same. The opening area of the first outlet hole 6 shown in Fig. 20(a) and the opening area of the second inlet hole 7 shown in Fig. 20(b) are "196 πm^2" and "192 πm^2", respectively, and thus are approximately the same. However, the length from the edge of the first outlet hole 6 to the edge of the second inlet hole 7 is "43 mm" in the plates 2 and 3 shown in Fig. 20(a), whereas this length is "31 mm" in the plates 2 and 3 shown in Fig. 20(b). That is, the length from the edge of the first outlet hole 6 to the edge of the second inlet hole 7 is significantly shorter in the plates 2 and 3 shown in Fig. 20 (b) than in the plates 2 and 3 shown in Fig. 20 (a). This means that by forming the first outlet hole 6 and the second inlet hole 7 as shown in Fig. 20 (b), the lateral length of the plates 2 and 3 can be significantly shortened while maintaining the required opening areas of the first outlet hole 6 and the second inlet hole 7.

[0031] Figs. 21 to 24 are diagrams showing the plates 2 and 3 in which the first inlet and outlet holes and the second inlet and outlet holes are formed in identical non-circular shapes while maintaining the required opening areas.

In Fig. 21, the first inlet and outlet holes and the second inlet and outlet holes are formed identically in an approximately elliptical shape. In Figs. 22 and 23, the first inlet and outlet holes and the second inlet and outlet holes are formed identically in a fan-like shape. In Fig. 24, the first inlet and outlet holes and the second inlet and outlet holes are formed identically in a star-like shape.

[0032] By forming the first inlet and outlet holes and the second inlet and outlet holes in various combinations of shapes as described above, the lateral length of the plates 2 and 3 can be shortened. Thus, the effects described in the first embodiment can be obtained. When the first inlet and outlet holes and the second inlet and outlet holes are shaped identically, the plate heat exchanger 20 can be configured with the plates 2 and 3 of a single type.

Fifth embodiment

[0033] In a fifth embodiment, there will be described a heating and hot water system 29, which is a usage example of the plate heat exchanger 20 described in the above embodiments.

[0034] Fig. 25 is a diagram showing the heating and hot water system 29.

The heating and hot water system 29 includes a compressor 21, the plate heat exchanger 20, an expansion valve 22, a heat exchanger 23, a water heater 24, a heater 25, a refrigerant path 26, and a water path 27. The plate heat exchanger 20 here is the plate heat exchanger 20 described in the above embodiments. The compressor 21, the plate heat exchanger 20, the expansion valve 22, the heat exchanger 23, and the refrigerant path 26 constitute a heat exchange system 28.

A refrigerant flows through the refrigerant path 26 by circulating sequentially through the compressor 21, the plate heat exchanger 20, the expansion valve 22, and the heat exchanger 23. As described above, the compressor 21 compresses the refrigerant. The plate heat exchanger 20 exchanges heat between the refrigerant compressed by the compressor 21 and a fluid (water in this case) flowing through the water path 27. Here, the refrigerant is cooled and the water is warmed by heat exchange in the plate heat exchanger 20. The expansion valve 22 controls expansion of the refrigerant heat-exchanged by the plate heat exchanger 20. The heat exchanger 23 exchanges heat between air and the refrigerant expanded based on control by the expansion valve 22. Here, the refrigerant is warmed and the air is cooled by heat exchange in the heat exchanger 23. Then, the warmed refrigerant enters the compressor 21.

On the other hand, the water flows through the water path 27 among the plate heat exchanger 20, the water heater 24, and the heater 25. As described above, the water is warmed by heat exchange in the plate heat exchanger 20. Then, the warmed water flows to the water heater 24 or the heater 25. The water for hot-water supply may be different from the water heat-exchanged by the plate heat exchanger 20. That is, the water heater 24 or the like may further exchange heat between the water flowing through the water path 27 and the water for hot-water supply.

[0035] The plate heat exchanger 20 described in the above embodiments provides enhanced strength, a compact and lightweight structure, and enhanced efficiency. Thus, the heat exchange system 28 using the plate heat exchanger 20 described in the above embodiments also provides enhanced efficiency. The heating and hot water system 29 using the heat exchange system 28 also provides enhanced efficiency.

Here, a heat exchange system (an air-to-water (ATW) system) has been described, wherein the plate heat exchanger 20 described in the above embodiments heats water by using a compressed refrigerant. However, the implementation is not limited to this, and a refrigeration cycle (a refrigeration air conditioner) may be configured for exchanging heat by using the plate heat exchanger 20 described in the above embodiments so as to heat or cool a fluid such as air.

[0036] The above embodiments are summarized as follows:

The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** the ratio of the height (H) to the width (W) of the plates is in a range of 4 to 6.5.

[0037] The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** the widthwise distance between each of the first and second fluid inlets and outlets and the periphery of the plate is 3 to 6 % of the width (W) of the plate.

[0038] The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** the widthwise distance between each of the first and second fluid inlets and outlets and the periphery of the plate is 3 to 5.6 mm.

[0039] The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** the diameters of the first inlet and outlet are differently sized from the diameters of the second fluid inlet and outlet.

[0040] The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** the centers of the first fluid inlet and outlet are misaligned with the centers of the second fluid inlet and outlet such that the fluid inlets and outlets are shifted nearer to the periphery of the plate.

[0041] The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** crest portions formed at turning points of waves are arranged to gradually curve from the center of the plate such that the turning points of the waves are formed in regions near the inlet and outlet.

[0042] The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** the centers of the diameters of the first fluid inlet and outlet are misaligned with the centers of the diameters of the second inlet and outlet, and the first inlet and outlet and the second inlet and outlet are formed in a combination of different shapes such as circular shapes or polygonal shapes while maintaining required opening areas according to a processing flow amount of the second fluid.

[0043] The plate heat exchanger 20 is configured with a plurality of stacked plates such that flow holes which act as inlets or outlets for a fluid are formed at four corners of each plate, and inlet ducts and outlet ducts are provided in the plurality of stacked plates. The plate heat exchanger 20 is **characterized in that** the first inlet and outlet and the second inlet and outlet are formed in a combination of an identical shape such as a circular shape or a polygonal shape while maintaining required opening areas according to a processing flow amount of the second fluid.

Reference Signs List

[0044] 1, 4: reinforcement side plates, 2: second plate, 3: first plate, 5: first inlet hole, 6: first outlet hole, 7: second inlet hole, 8: second outlet hole, 9: corrugations, 10: entrance region, 11: sealing portion, 12: turning point, 13: ends, 14: center line in the lateral direction, 15: line linking the turning points 12, 20: plate heat exchanger, 21: compressor, 22: expansion valve, 23: heat exchanger, 24: water heater, 25: heater, 26: refrigerant path, 27: water path, 28: heat exchange system

Claims

1. A plate heat exchanger configured with a plurality of stacked plates,
wherein each plate of the plurality of stacked plates includes:

    a first inlet hole which acts as an inlet for a first fluid, the first inlet hole being located near one edge in a longitudinal direction;
    a first outlet hole which acts as an outlet for the first fluid, the first outlet hole being located near another edge opposite from the first inlet hole in the longitudinal direction;
    a second inlet hole which acts as an inlet for a second fluid, the second inlet hole being located near one edge in the longitudinal direction; and
    a second outlet hole which acts as an outlet for the second fluid, the second outlet hole being located near another edge opposite from the second inlet hole in the longitudinal direction,
    wherein the each plate and an adjacent plate define therebetween either one of a first flow path and a second flow path, the first flow path passing the first fluid entered from the first inlet hole to the first outlet hole such that the first fluid spreads in a lateral direction, and the second flow path passing the second fluid entered from the second inlet hole to the second outlet hole such that the second fluid spreads in the lateral direction, and the each plate exchanges heat between the first fluid flowing through the first flow path and the second fluid flowing through the second flow path, and
    wherein the each plate is configured such that a length in the longitudinal direction is 4 or more times a length in the lateral direction.

2. The plate heat exchanger according to claim 1, wherein each of a length from the first inlet hole to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 6 percent of the length in the lateral direction.

3. The plate heat exchanger according to claim 1, wherein each of a length from the first inlet hole to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 5.6 mm.

4. The plate heat exchanger according to claim 1, wherein each of an opening area of the first inlet hole and an opening area of the first outlet hole is smaller than either of an opening area of the second inlet hole and an opening area of the second outlet hole.

5. The plate heat exchanger according to claim 4, wherein a center of the first inlet hole and a center of the first outlet hole are positioned nearer to a plate edge relative to a center of the second inlet hole and a center of the second outlet hole.

6. The plate heat exchanger according to claim 4, wherein a first plate and a second plate are stacked alternately,
wherein the first inlet hole and the second outlet hole are positioned near a same edge in the longitudinal direction, and
wherein the first plate includes a sealing portion for preventing a fluid entered from the first inlet hole from flowing to the second outlet hole, the sealing portion being formed as a protrusion raised in a stacking direction of the plurality of stacked plates such that the sealing portion extends from near the edge where the first inlet hole and the second outlet hole are located toward an opposite edge in the longitudinal direction, so as to gradually approach an edge in the lateral direction near the second outlet hole.

7. The plate heat exchanger according to claim 4, wherein the each plate includes V-shaped convex portions and concave portions arranged in a plurality of arrays in the longitudinal direction, each of the convex portions and concave portions having ends at both ends in the lateral direction and also having a turning point longitudinally misaligned with the ends, so that the convex portions and concave portions are formed in a V shape, and
wherein, in a vicinity of at least either hole of the first inlet hole and the first outlet hole, the V-shaped convex portions and concave portions are formed such

that a position of the turning point is gradually shifted toward the either hole away from a center in the lateral direction as a position of each of the V-shaped convex portions and concave portions becomes nearer to the each hole.

8. The plate heat exchanger according to claim 4, wherein the plurality of stacked plates are stacked such that the first inlet hole of the each plate is aligned with first inlet holes of other plates, so that the first fluid sequentially flows from the first inlet hole of the each plate stacked at one side of the stacking direction into the first inlet hole of the each plate stacked at another side of the stacking direction, and
wherein the nearer the each plate of the plurality of stacked plates is to the one side from which the first fluid enters, the smaller a diameter of the first inlet hole.

9. The plate heat exchanger according to claim 1, wherein the first inlet hole and the second outlet hole are formed near a same edge in the longitudinal direction, and the second inlet hole and the first outlet hole are formed near a same edge in the longitudinal direction, and
wherein a shape of the first inlet hole is different from a shape of the second outlet hole, and a shape of the second inlet hole is different from a shape of the first outlet hole.

10. The plate heat exchanger according to claim 9, wherein the first inlet hole and the second outlet hole are formed by dividing one hole of a circular, elliptical, or polygonal shape into two holes, and
wherein the second inlet hole and the first outlet hole are formed by dividing one hole of a circular, elliptical, or polygonal shape into two holes.

11. A refrigeration air conditioner comprising the plate heat exchanger according to claim 1.

12. A plate heat exchanger configured with a plurality of stacked plates,
wherein each plate of the plurality of stacked plates includes:

a first inlet hole which acts as an inlet for a first fluid, the first inlet hole being located near one edge in the longitudinal direction;
a first outlet hole which acts as an outlet for the first fluid, the first outlet hole being located near another edge opposite from the first inlet hole in the longitudinal direction;
a second inlet hole which acts as an inlet for a second fluid, the second inlet hole being located near one edge in the longitudinal direction; and
a second outlet hole which acts as an outlet for the second fluid, the second outlet hole being located near another edge opposite from the second inlet hole in the longitudinal direction,
wherein the each plate and an adjacent plate define therebetween either one of a first flow path and a second flow path, the first flow path passing the first fluid entered from the first inlet hole to the first outlet hole such that the first fluid spreads in a lateral direction, and the second flow path passing the second fluid entered from the second inlet hole to the second outlet hole such that the second fluid spreads in the lateral direction, and the each plate exchanges heat between the first fluid flowing through the first flow path and the second fluid flowing through the second flow path, and
wherein each of a length from the first inlet hole to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 6 percent of a length in the lateral direction.

13. A plate heat exchanger configured with a plurality of stacked plates,
wherein each plate of the plurality of stacked plates includes:

a first inlet hole which acts as an inlet for a first fluid, the first inlet hole being located near one edge in the longitudinal direction;
a first outlet hole which acts as an outlet for the first fluid, the first outlet hole being located near another edge opposite from the first inlet hole in the longitudinal direction;
a second inlet hole which acts as an inlet for a second fluid, the second inlet hole being located near one edge in the longitudinal direction; and
a second outlet hole which acts as an outlet for the second fluid, the second outlet hole being located near another edge opposite from the second inlet hole in the longitudinal direction,
wherein the each plate and an adjacent plate define therebetween either one of a first flow path and a second flow path, the first flow path passing the first fluid entered from the first inlet hole to the first outlet hole such that the first fluid spreads in a lateral direction, and the second flow path passing the second fluid entered from the second inlet hole to the second outlet hole such that the second fluid spreads in the lateral direction, and the each plate exchanges heat between the first fluid flowing through the first flow path and the second fluid flowing through

the second flow path, and
wherein each of a length from the first inlet hole to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 5.6 mm.

Amended claims under Art. 19.1 PCT

1. A plate heat exchanger configured with a plurality of stacked plates,
wherein each plate of the plurality of stacked plates includes:

a first inlet hole which acts as an inlet for a first fluid, the first inlet hole being located near one edge in a longitudinal direction;
a first outlet hole which acts as an outlet for the first fluid, the first outlet hole being located near another edge opposite from the first inlet hole in the longitudinal direction;
a second inlet hole which acts as an inlet for a second fluid, the second inlet hole being located near one edge in the longitudinal direction; and
a second outlet hole which acts as an outlet for the second fluid, the second outlet hole being located near another edge opposite from the second inlet hole in the longitudinal direction,
wherein the each plate and an adjacent plate define therebetween either one of a first flow path and a second flow path, the first flow path passing the first fluid entered from the first inlet hole to the first outlet hole such that the first fluid spreads in a lateral direction, and the second flow path passing the second fluid entered from the second inlet hole to the second outlet hole such that the second fluid spreads in the lateral direction, and the each plate exchanges heat between the first fluid flowing through the first flow path and the second fluid flowing through the second flow path,
wherein the each plate is configured such that a length in the longitudinal direction is 4 or more times a length in the lateral direction, and
wherein each of a length from the first inlet hole to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 5.6 mm.

2. The plate heat exchanger according to claim 1,
wherein each of a length from the first inlet hole to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 6 percent of the length in the lateral direction.

3. The plate heat exchanger according to claim 1,
wherein each of an opening area of the first inlet hole and an opening area of the first outlet hole is smaller than either of an opening area of the second inlet hole and an opening area of the second outlet hole.

4. The plate heat exchanger according to claim 3,
wherein a center of the first inlet hole and a center of the first outlet hole are positioned nearer to a plate edge relative to a center of the second inlet hole and a center of the second outlet hole.

5. The plate heat exchanger according to claim 3,
wherein a first plate and a second plate are stacked alternately,
wherein the first inlet hole and the second outlet hole are positioned near a same edge in the longitudinal direction, and
wherein the first plate includes a sealing portion for preventing a fluid entered from the first inlet hole from flowing to the second outlet hole, the sealing portion being formed as a protrusion raised in a stacking direction of the plurality of stacked plates such that the sealing portion extends from near the edge where the first inlet hole and the second outlet hole are located toward an opposite edge in the longitudinal direction, so as to gradually approach an edge in the lateral direction near the second outlet hole.

6. The plate heat exchanger according to claim 3,
wherein the each plate includes V-shaped convex portions and concave portions arranged in a plurality of arrays in the longitudinal direction, each of the convex portions and concave portions having ends at both ends in the lateral direction and also having a turning point longitudinally misaligned with the ends, so that the convex portions and concave portions are formed in a V shape, and
wherein, in a vicinity of at least either hole of the first inlet hole and the first outlet hole, the V-shaped convex portions and concave portions are formed such that a position of the turning point is gradually shifted toward the either hole away from a center in the lat-

eral direction as a position of each of the V-shaped convex portions and concave portions becomes nearer to the each hole.

7. The plate heat exchanger according to claim 3, wherein the plurality of stacked plates are stacked such that the first inlet hole of the each plate is aligned with first inlet holes of other plates, so that the first fluid sequentially flows from the first inlet hole of the each plate stacked at one side of the stacking direction into the first inlet hole of the each plate stacked at another side of the stacking direction, and
wherein the nearer the each plate of the plurality of stacked plates is to the one side from which the first fluid enters, the smaller a diameter of the first inlet hole.

8. The plate heat exchanger according to claim 1, wherein the first inlet hole and the second outlet hole are formed near a same edge in the longitudinal direction, and the second inlet hole and the first outlet hole are formed near a same edge in the longitudinal direction, and
wherein a shape of the first inlet hole is different from a shape of the second outlet hole, and a shape of the second inlet hole is different from a shape of the first outlet hole.

9. The plate heat exchanger according to claim 8, wherein the first inlet hole and the second outlet hole are formed by dividing one hole of a circular, elliptical, or polygonal shape into two holes, and
wherein the second inlet hole and the first outlet hole are formed by dividing one hole of a circular, elliptical, or polygonal shape into two holes.

10. A refrigeration air conditioner comprising the plate heat exchanger according to claim 1.

11. A plate heat exchanger configured with a plurality of stacked plates,
wherein each plate of the plurality of stacked plates includes:

a first inlet hole which acts as an inlet for a first fluid, the first inlet hole being located near one edge in the longitudinal direction;
a first outlet hole which acts as an outlet for the first fluid, the first outlet hole being located near another edge opposite from the first inlet hole in the longitudinal direction;
a second inlet hole which acts as an inlet for a second fluid, the second inlet hole being located near one edge in the longitudinal direction; and
a second outlet hole which acts as an outlet for the second fluid, the second outlet hole being located near another edge opposite from the second inlet hole in the longitudinal direction,
wherein the each plate and an adjacent plate define therebetween either one of a first flow path and a second flow path, the first flow path passing the first fluid entered from the first inlet hole to the first outlet hole such that the first fluid spreads in a lateral direction, and the second flow path passing the second fluid entered from the second inlet hole to the second outlet hole such that the second fluid spreads in the lateral direction, and the each plate exchanges heat between the first fluid flowing through the first flow path and the second fluid flowing through the second flow path, and
wherein each of a length from the first inlet hole to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 6 percent of a length in the lateral direction.

12. A plate heat exchanger configured with a plurality of stacked plates,
wherein each plate of the plurality of stacked plates includes:

a first inlet hole which acts as an inlet for a first fluid, the first inlet hole being located near one edge in the longitudinal direction;
a first outlet hole which acts as an outlet for the first fluid, the first outlet hole being located near another edge opposite from the first inlet hole in the longitudinal direction;
a second inlet hole which acts as an inlet for a second fluid, the second inlet hole being located near one edge in the longitudinal direction; and
a second outlet hole which acts as an outlet for the second fluid, the second outlet hole being located near another edge opposite from the second inlet hole in the longitudinal direction,
wherein the each plate and an adjacent plate define therebetween either one of a first flow path and a second flow path, the first flow path passing the first fluid entered from the first inlet hole to the first outlet hole such that the first fluid spreads in a lateral direction, and the second flow path passing the second fluid entered from the second inlet hole to the second outlet hole such that the second fluid spreads in the lateral direction, and the each plate exchanges heat between the first fluid flowing through the first flow path and the second fluid flowing through the second flow path, and
wherein each of a length from the first inlet hole

to a plate edge proximate to the first inlet hole in the lateral direction, a length from the first outlet hole to a plate edge proximate to the first outlet hole in the lateral direction, a length from the second inlet hole to a plate edge proximate to the second inlet hole in the lateral direction, and a length from the second outlet hole to a plate edge proximate to the second outlet hole in the lateral direction is not more than 5.6 mm.

Fig. 1

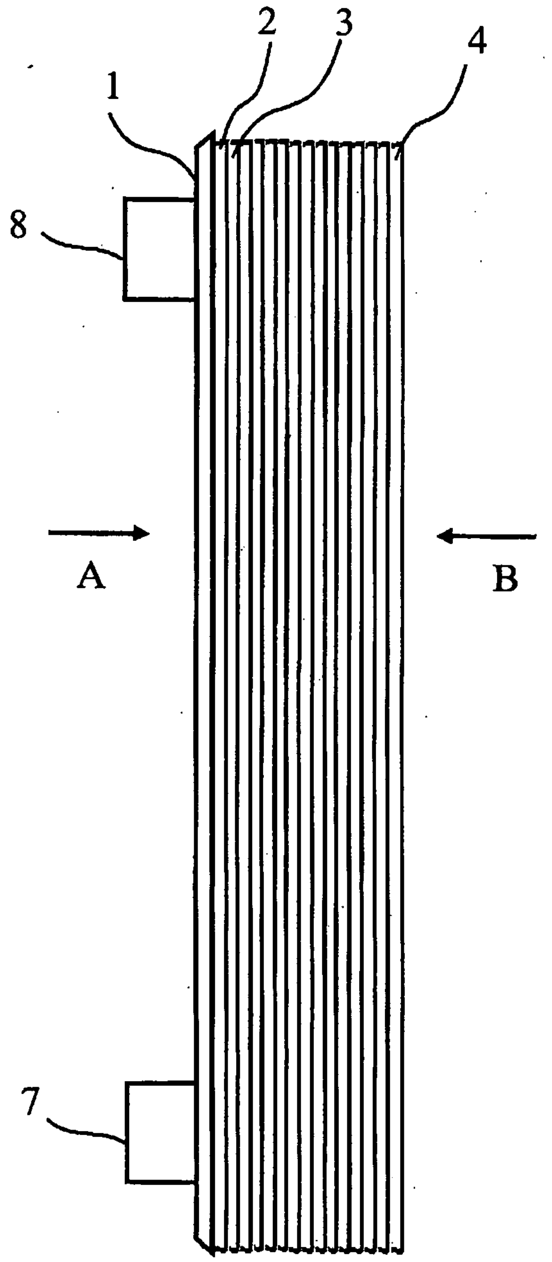


Fig. 2

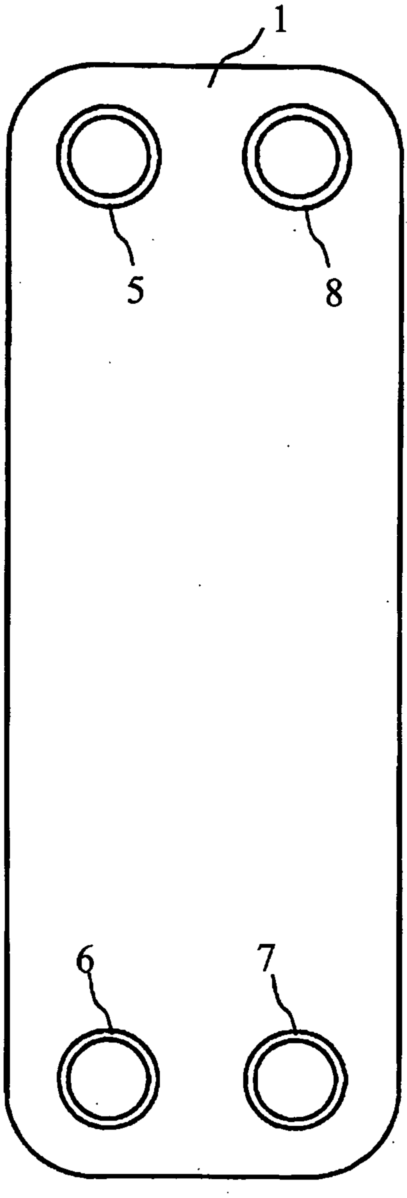


Fig. 3

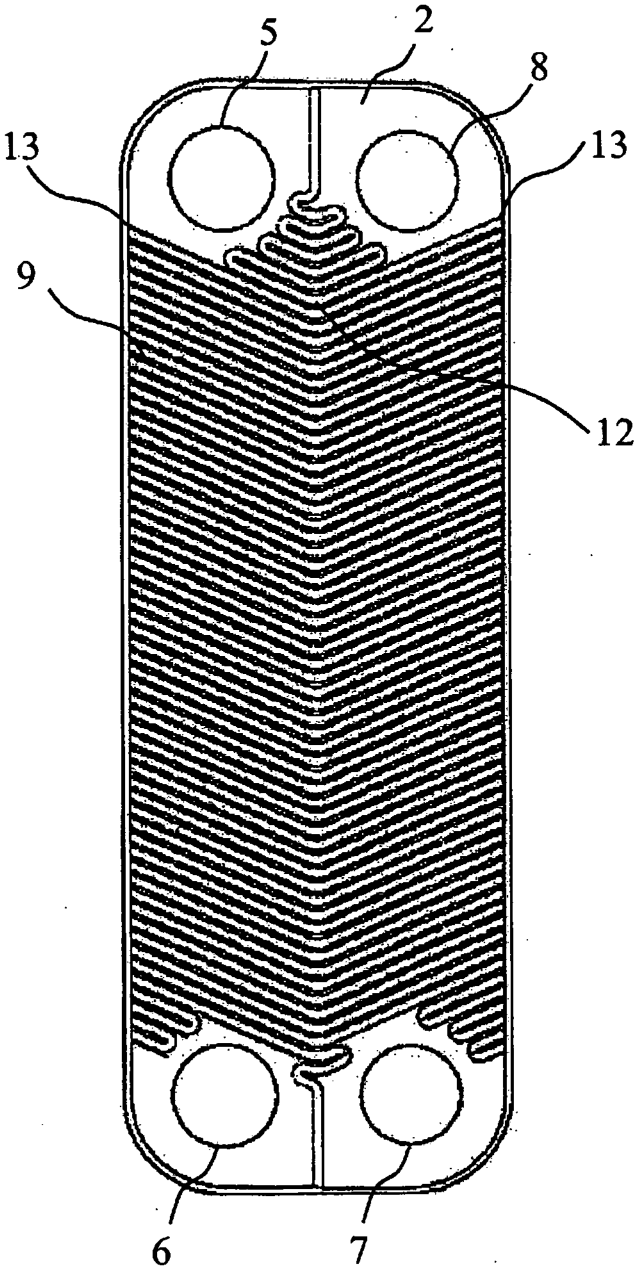


Fig. 4

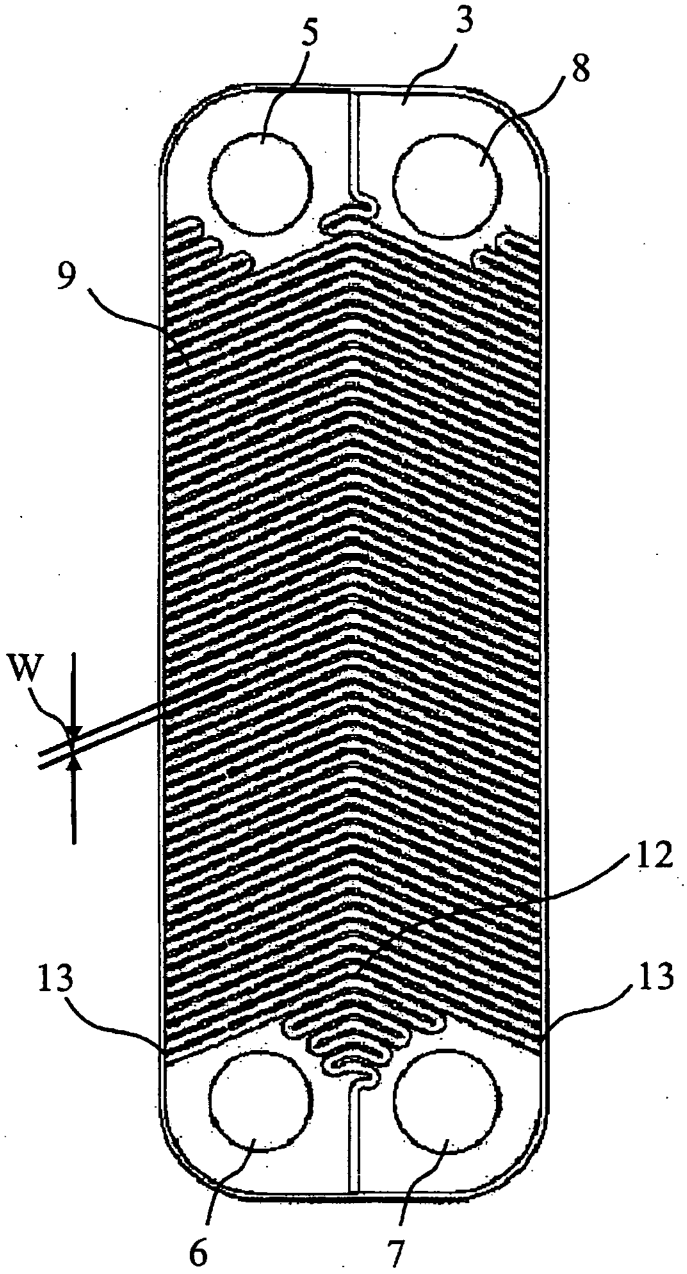
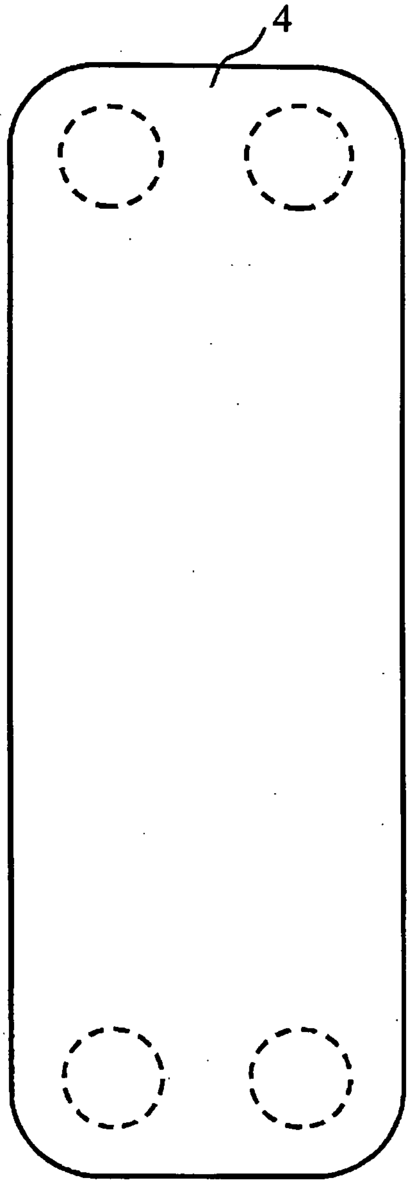


Fig. 5



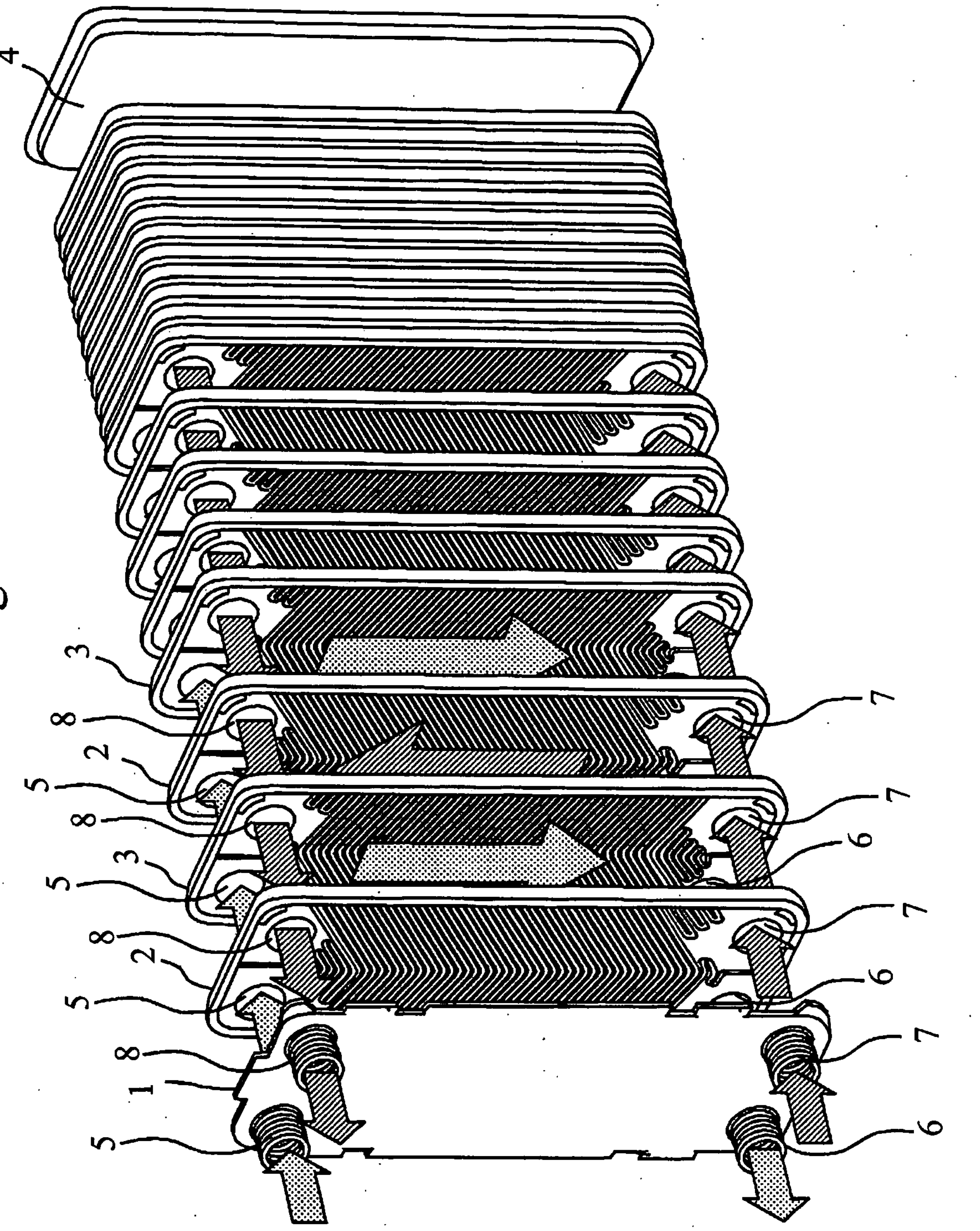


Fig.6

Fig. 7

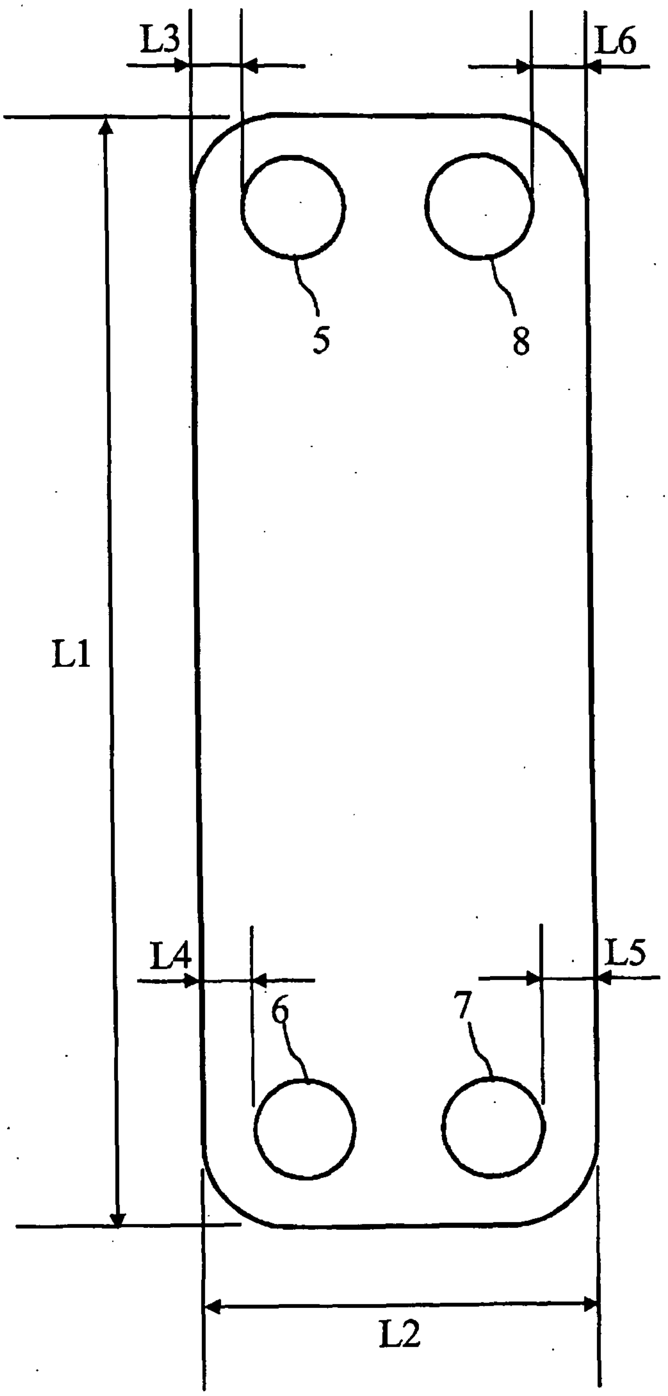


Fig. 8

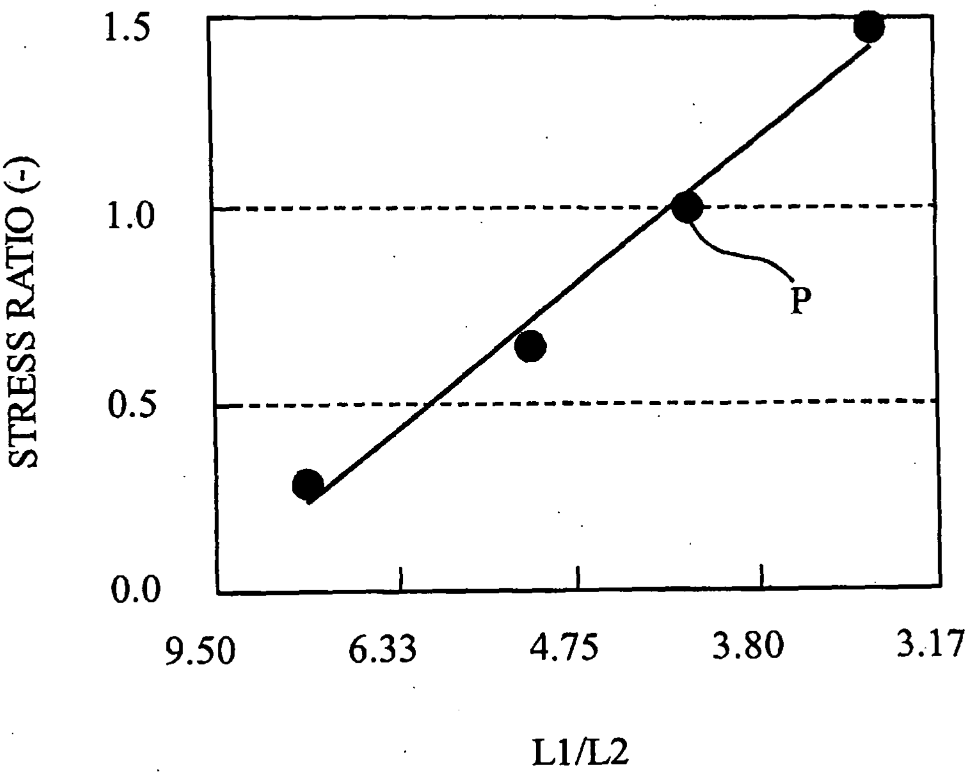


Fig. 9

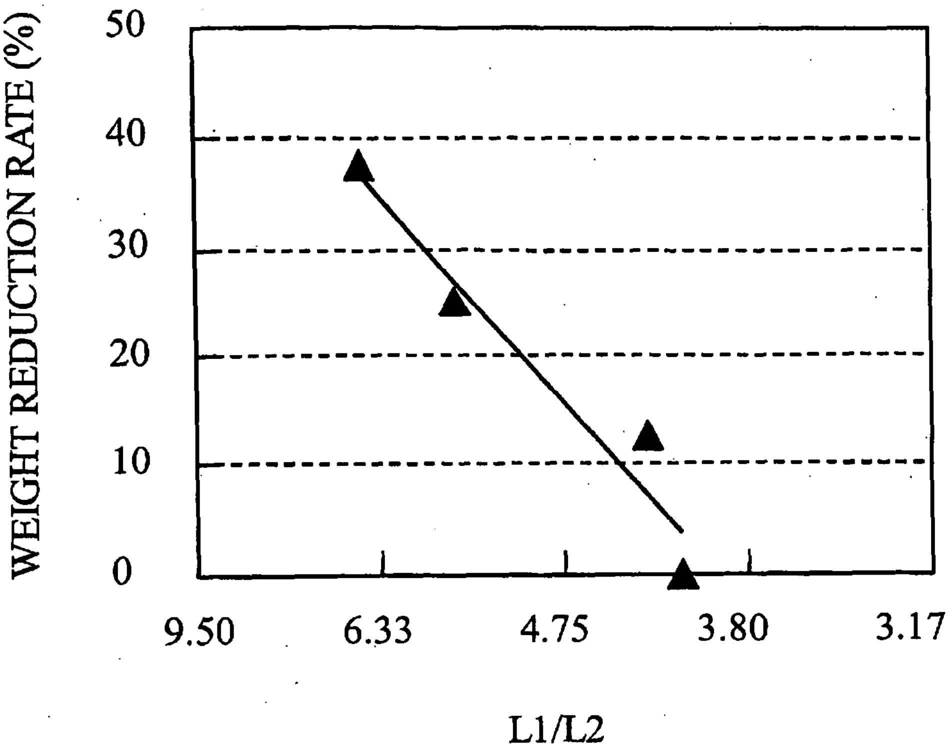


Fig. 10

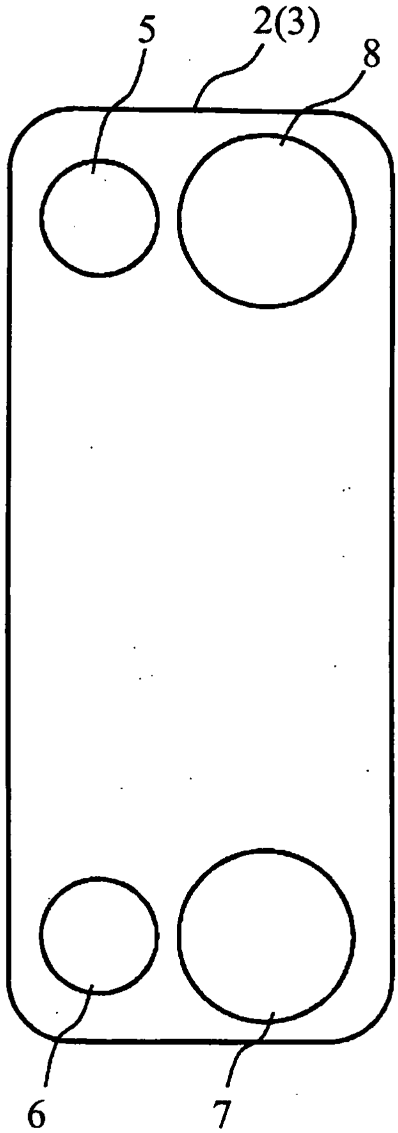


Fig.11

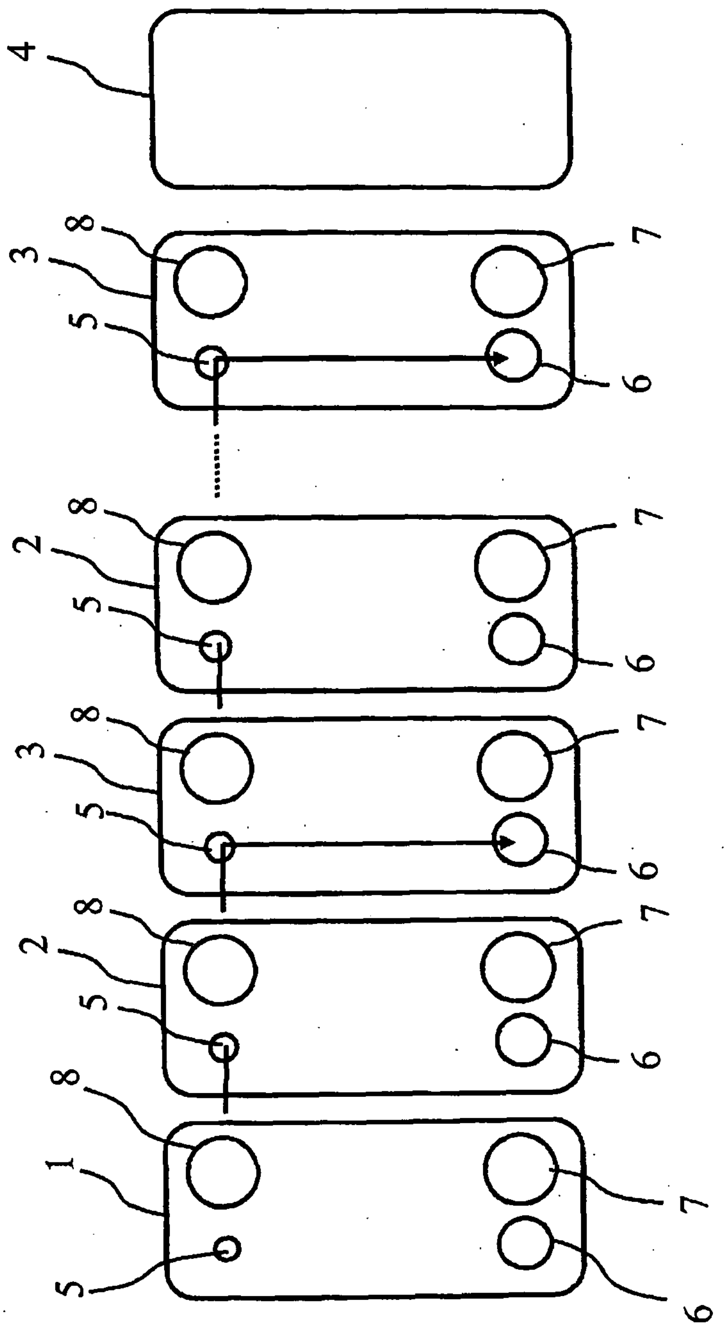
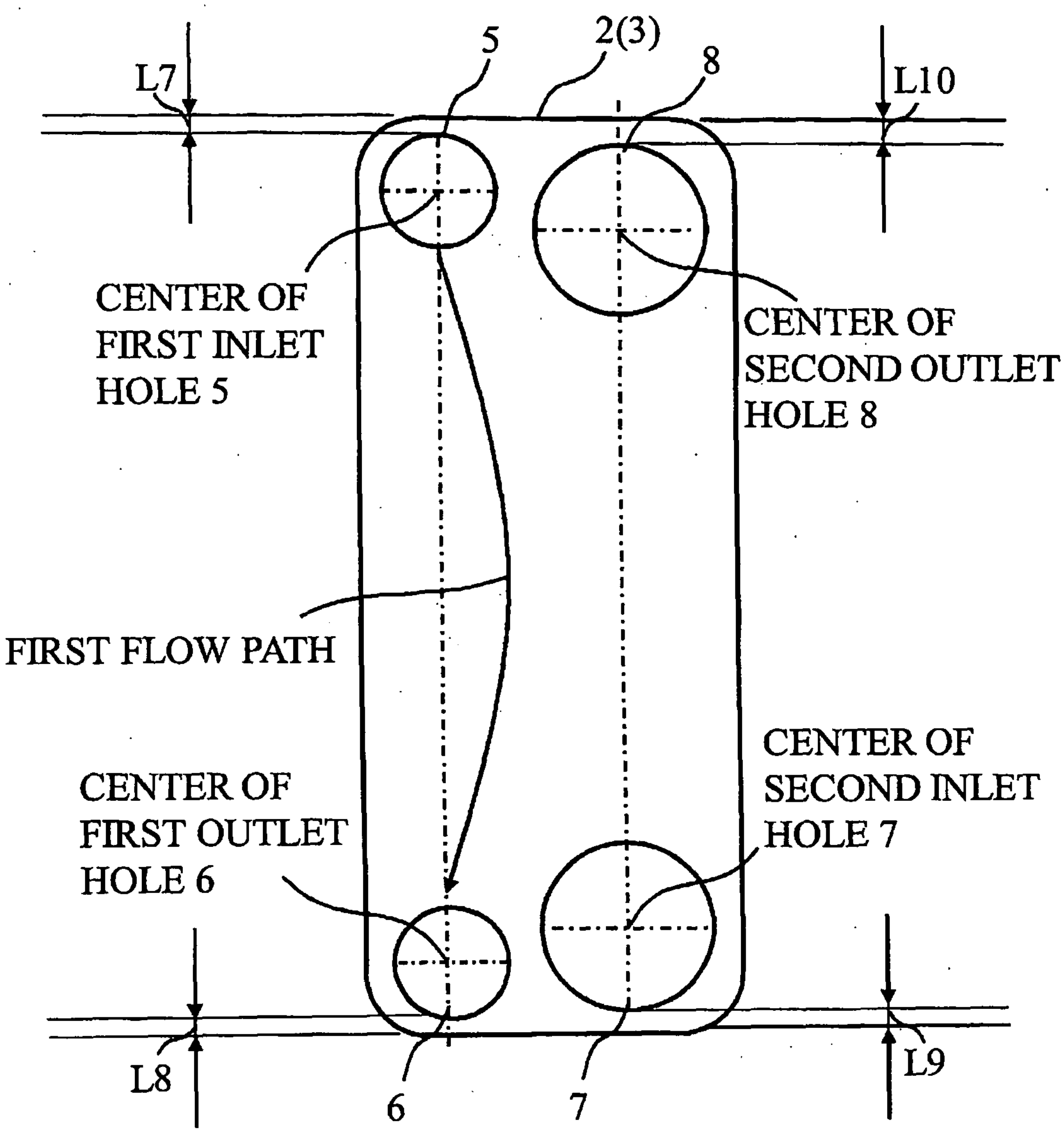


Fig. 12



5
2(3)
8
L7
L10
CENTER OF
FIRST INLET
HOLE 5
CENTER OF
SECOND OUTLET
HOLE 8
FIRST FLOW PATH
CENTER OF
SECOND INLET
HOLE 7
CENTER OF
FIRST OUTLET
HOLE 6
L8
L9
6
7

Fig. 13

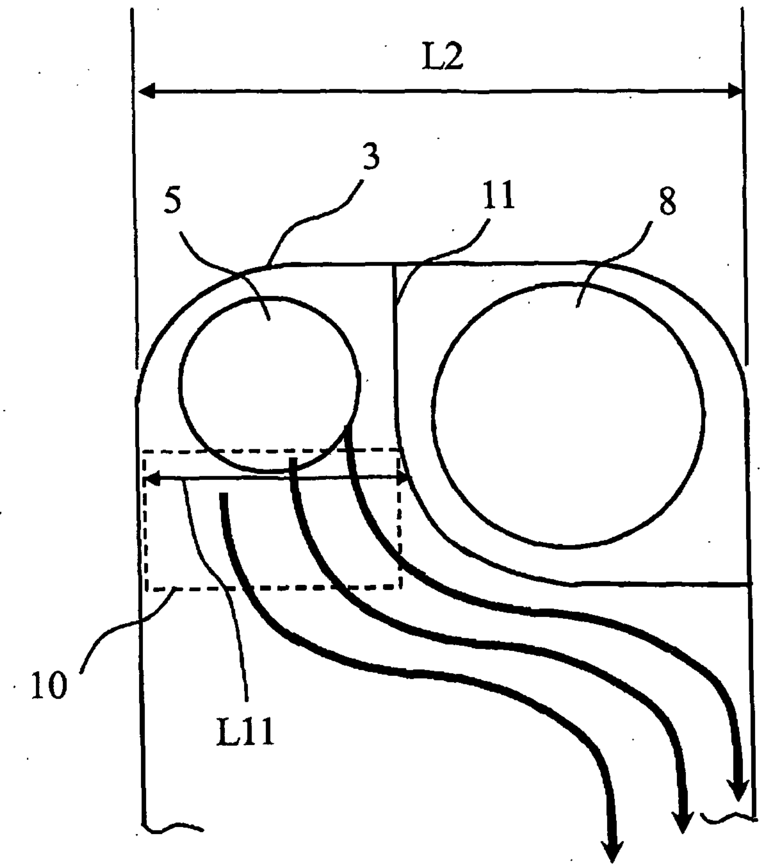


Fig. 14

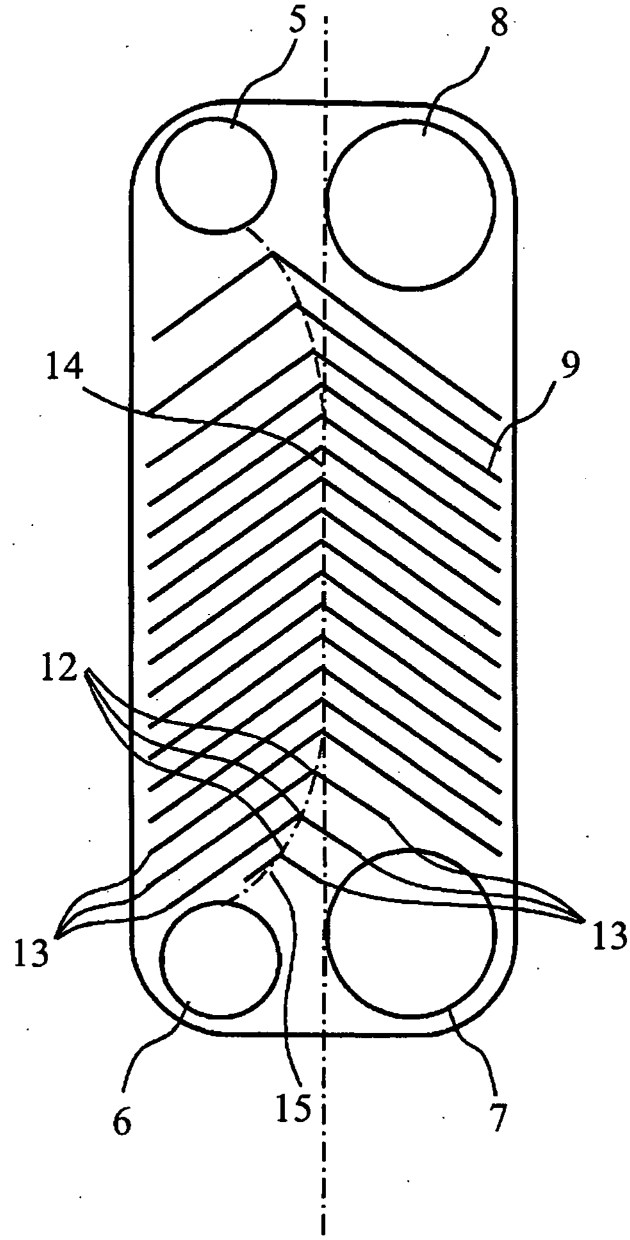


Fig. 15

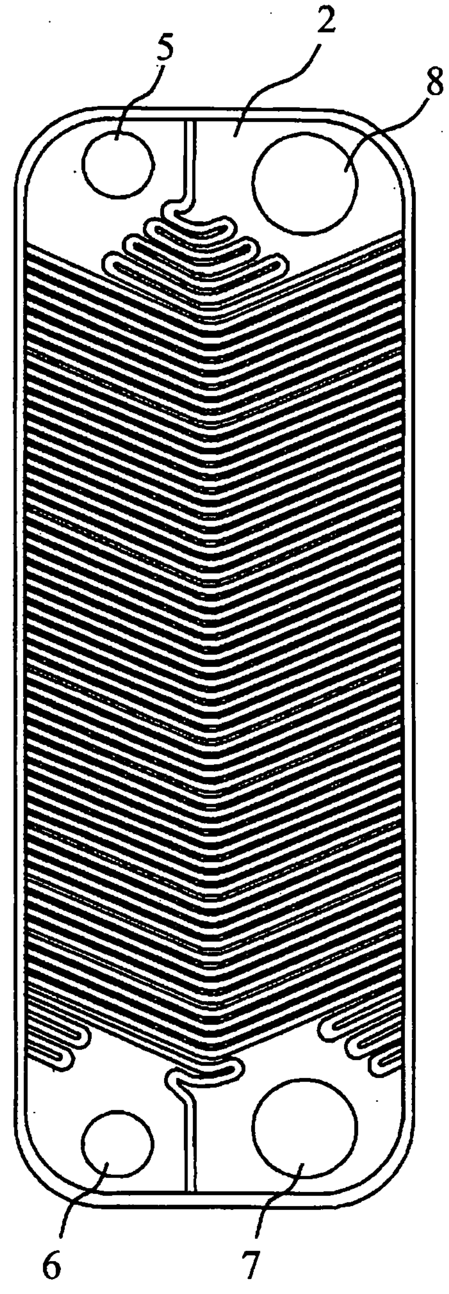


Fig. 16

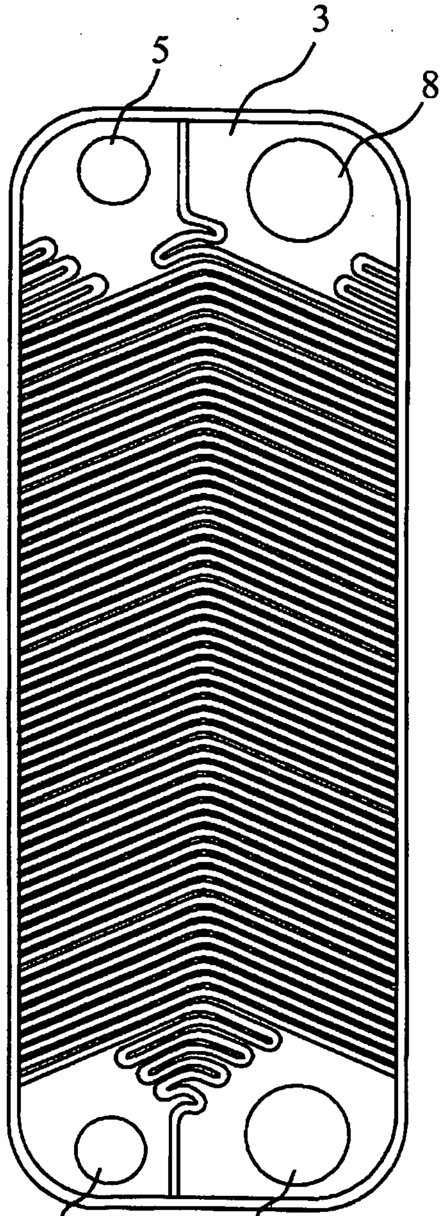


Fig. 17

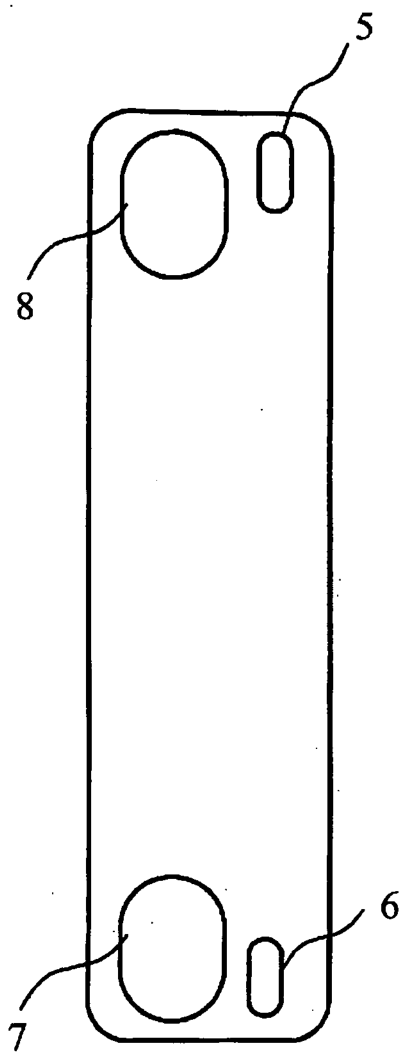


Fig. 18

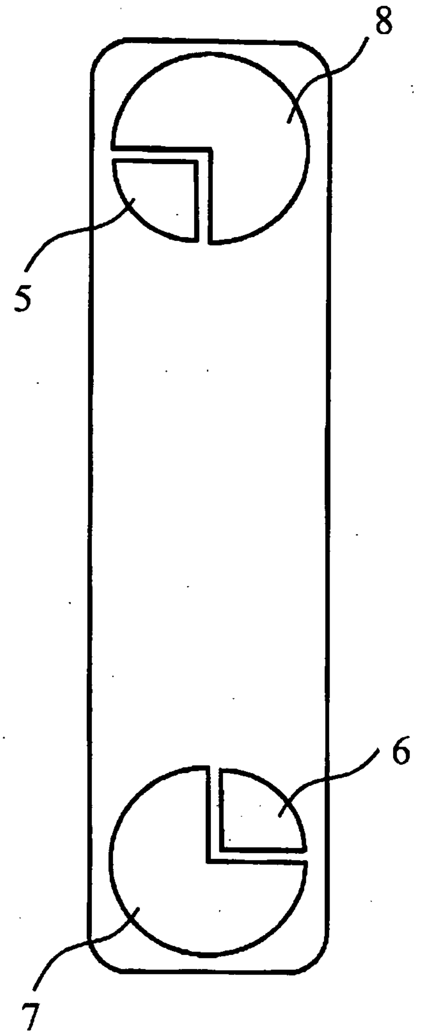


Fig. 19

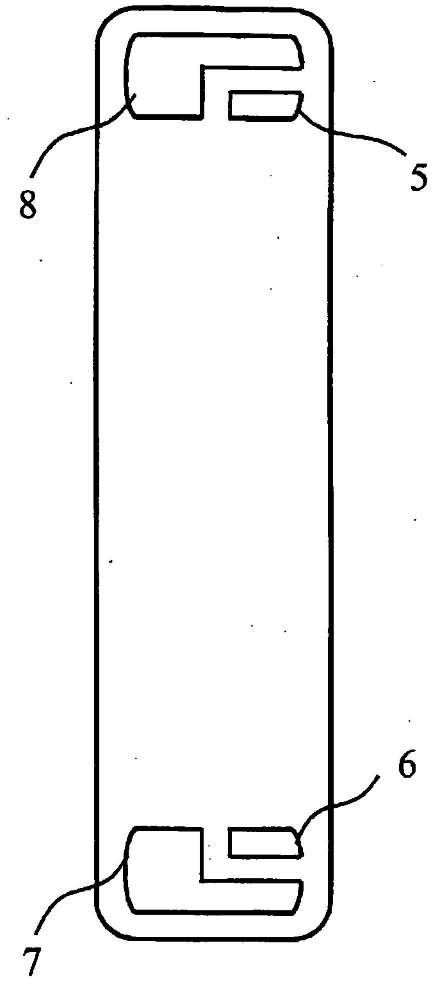
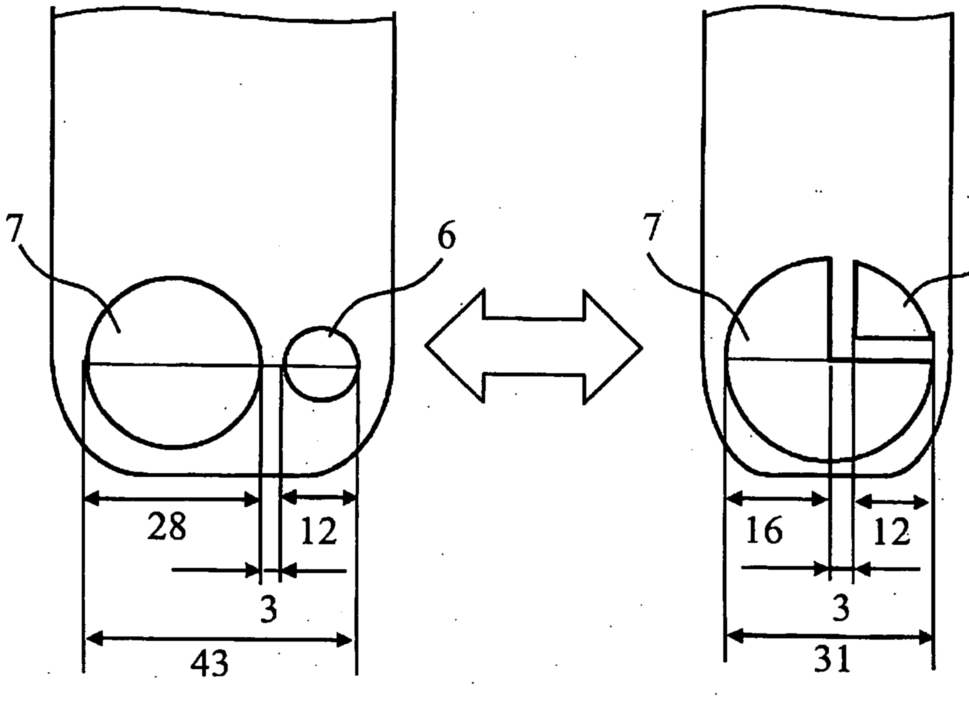


Fig. 20



(a) (b)

Fig. 21

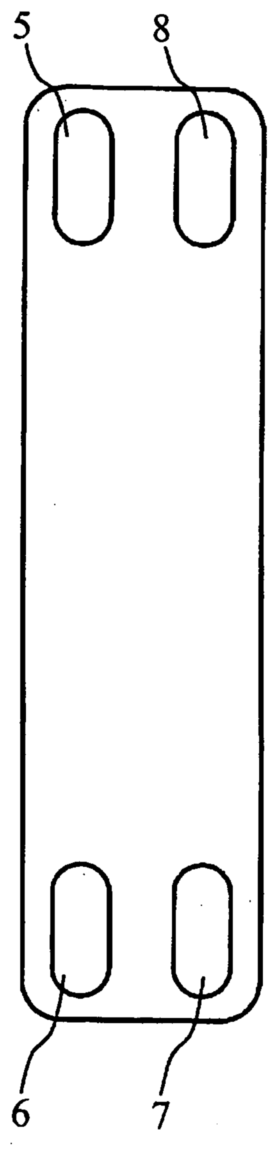


Fig. 22

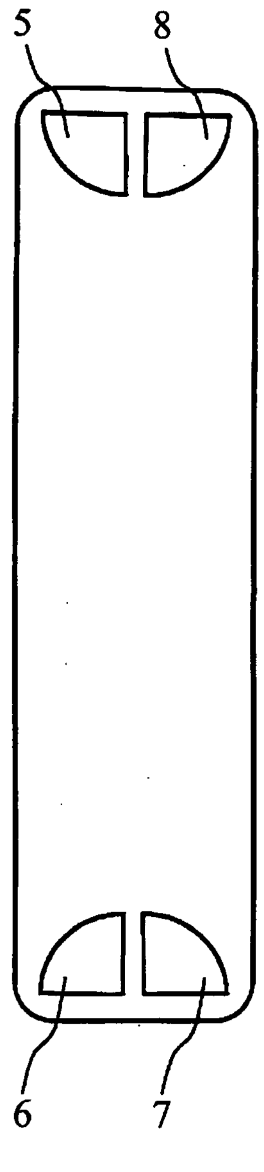


Fig. 23

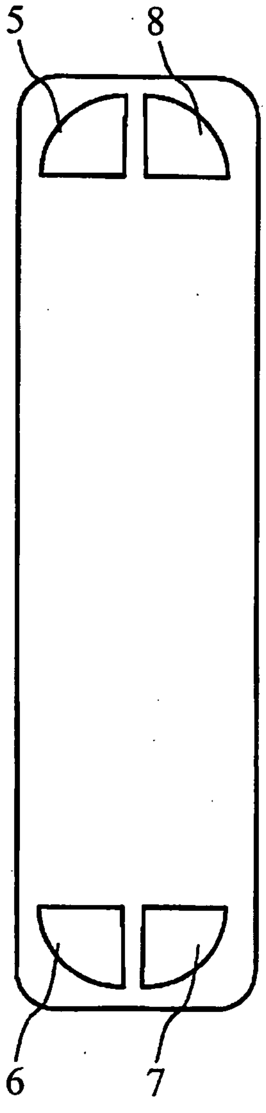


Fig. 24

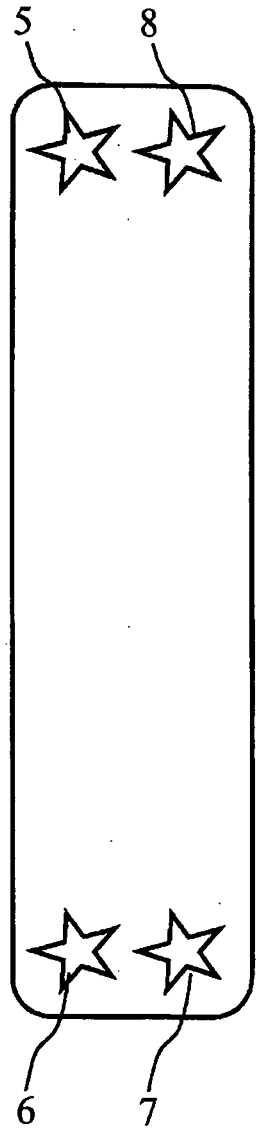
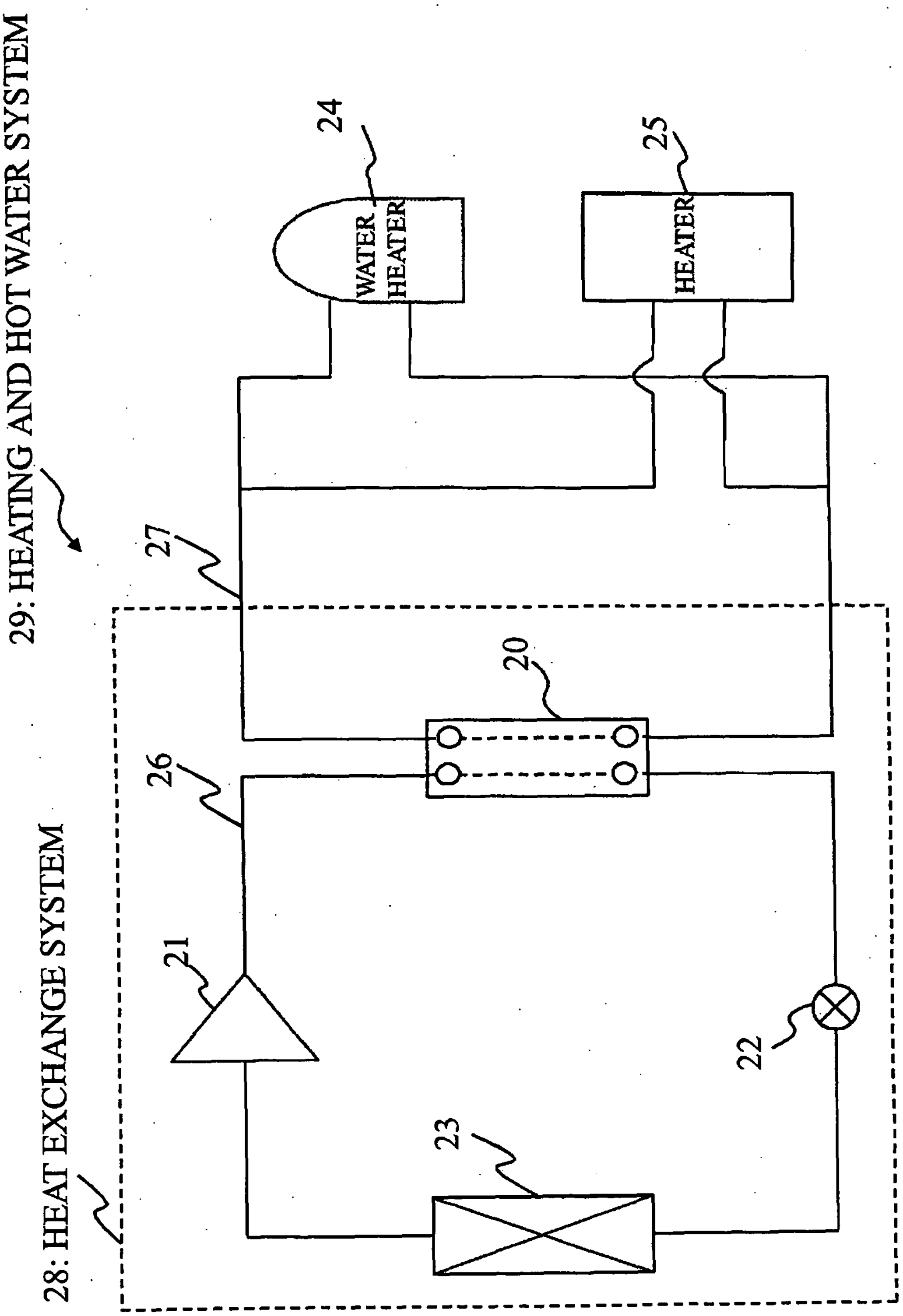


Fig.25


29: HEATING AND HOT WATER SYSTEM
28: HEAT EXCHANGE SYSTEM
WATER HEATER
HEATER
24
25
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26
20
21
22
23

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/071230

A. CLASSIFICATION OF SUBJECT MATTER
F28F3/00(2006.01)i, *F28D9/02*(2006.01)i, *F28F3/04*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F28F3/00, F28D9/02, F28F3/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 11-248392 A (Daikin Industries, Ltd.), 14 September 1999 (14.09.1999), paragraphs [0002], [0036] to [0044]; fig. 1 to 4 & JP 11-248392 A & US 6394178 B1 & EP 1070928 A1 & WO 1999/044003 A1 & DE 69907662 T & CN 1287610 A	1,11 2-10,12,13
X Y	JP 2008-516181 A (Brooks Automation Inc.), 15 May 2008 (15.05.2008), paragraphs [0001], [0057] to [0059]; fig. 5 & EP 1805471 A & WO 2006/042015 A1 & KR 10-2007-0073827 A & CN 101084409 A	1,11 2-10,12,13

☒ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 March, 2010 (15.03.10)	30 March, 2010 (30.03.10)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/071230

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 7-508581 A (Alfa Laval Thermal AB.), 21 September 1995 (21.09.1995), entire text; fig. 1 to 4 & US 5531269 A & EP 643820 A & WO 1993/025860 A1 & DE 69314788 D & SE 9202057 A	2-8,12,13
Y	JP 9-89482 A (Hisaka Works, Ltd.), 04 April 1997 (04.04.1997), paragraphs [0011] to [0018]; fig. 1 to 7 (Family: none)	7
Y	JP 2005-326135 A (Showa Denko Kabushiki Kaisha), 24 November 2005 (24.11.2005), paragraphs [0027], [0046], [0047]; fig. 4 to 6 & WO 2005/100900 A & DE 112005000797 T & CN 1938554 A	8
Y	JP 2000-241087 A (Sanyo Electric Co., Ltd.), 08 September 2000 (08.09.2000), paragraph [0018]; fig. 1 to 3 (Family: none)	9,10
Y	WO 2009/13801 A1 (Tokyo Roki Co., Ltd.), 29 January 2009 (29.01.2009), paragraphs [0002] to [0004]; fig. 11 (Family: none)	9,10

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 9072685 A **[0003]**
- JP 7508581 W **[0003]**