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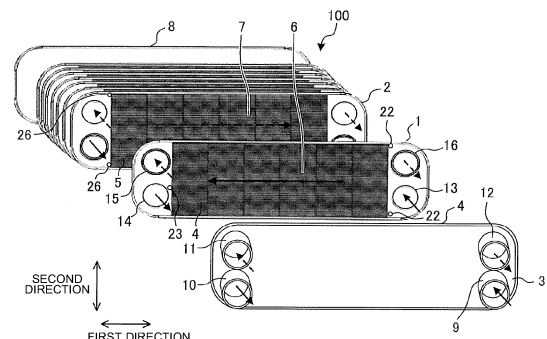
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(54) **PLATE-TYPE HEAT EXCHANGER, HEAT PUMP DEVICE, AND HEAT-PUMP-TYPE COOLING/HEATING HOT-WATER SUPPLY SYSTEM**

(57) A plate-type heat exchanger includes a plurality of heat transfer plates stacked on top of each other, a flow passage, formed by each space between the plurality of heat transfer plates, through which a fluid flows in a first direction; an inner fin disposed in the flow passage, a first projecting portion provided on an inflow side of each of the heat transfer plates and configured to prevent the fluid from flowing into gaps between both ends of the inner fin in a second direction and both ends of the heat transfer plate in the second direction, and a second projecting portion formed on an outflow side of each of the heat transfer plates and configured to perform positioning in placing the inner fin into the heat transfer plate. The first direction is a direction of flow of the fluid through the flow passage. The second direction is a direction orthogonal to the first direction. The inner fin is disposed between the first projecting portion and the second projecting portion.

FIG. 1



Description

TECHNICAL FIELD

[0001] The present invention relates to a plate-type heat exchanger including an inner fin, to a heat pump device, and to a heat-pump-type cooling and heating hot-water supply system.

BACKGROUND ART

[0002] Hitherto, there has been known a stacked plate-type heat exchanger including a plurality of heat transfer plates stacked with an inner fin interposed therebetween, and is configured to allow different fluids to alternately flow through each flow passage formed between a heat transfer plate and a heat transfer plate, and also is configured to exchange heat via the heat transfer plates (see, for example, Patent Literature 1).

[0003] In Patent Literature 1, the plate-type heat exchanger has a cuboidal shape as a whole and, at both ends of the inner fin in a transverse direction, has gaps between the inner fin and wall surfaces erected from both ends of each of the heat transfer plates. The presence of such gaps undesirably causes a fluid to preferentially flow into the gaps without flowing through the inner fin. Taking these circumstances into consideration, in Patent Literature 1, the wall surfaces in the gaps to inhibit the fluid from undesirably flowing into the gaps.

CITATION LIST

PATENT LITERATURE

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication JP 2015-203508 A

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] By providing the wall surfaces, Patent Literature 1 can inhibit the fluid from preferentially flowing into the gaps. This makes it possible to bring about improvement in heat exchangeability in the flow passage.

[0006] Incidentally, a plate-type heat exchanger is required to be configured such that positioning of the inner fin with relative to the heat transfer plates is performed during assembling at the time of manufacture. However, Patent Literature 1 is unclear about a configuration in which positioning of the inner fin is performed.

[0007] The present invention has been made in view of the above circumstances and is aimed at providing a plate-type heat exchanger configured to allow positioning of an inner fin to be performed with improvement in in-plane distributive performance of a fluid, a heat pump device, and a heat-pump-type cooling and heating hot-water supply system.

SOLUTION TO THE PROBLEM

[0008] A plate-type heat exchanger according to an embodiment of the present invention includes a plurality of heat transfer plates stacked on top of each other, a flow passage, formed by each space between the plurality of heat transfer plates, through which a fluid flows in a first direction, an inner fin disposed in the flow passage, a first projecting portion provided on an inflow side of each of the heat transfer plates and configured to prevent the fluid from flowing into gaps between both ends of the inner fin in a second direction and both ends of the heat transfer plate in the second direction, and a second projecting portion formed on an outflow side of each of the heat transfer plates and configured to perform positioning in placing the inner fin into the heat transfer plate. The first direction is a direction of flow of the fluid through the flow passage. The second direction is a direction orthogonal to the first direction. The inner fin is disposed between the first projecting portion and the second projecting portion.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] According to an embodiment of the present invention, the first projection portion provided on an inflow side of each of the heat transfer plates and configured to prevent the fluid from flowing into gaps between both ends of the inner fin in the second direction and both ends of the heat transfer plate in the second direction makes it possible to improve the in-plane distributive performance of the fluid in the flow passage.

[0010] Further, the second projecting portion formed on an outflow side of each of the heat transfer plates and configured to perform positioning in placing the inner fin into the heat transfer plate and the disposition of the inner fin between the first projecting portion and the second projecting portion make it possible to perform positioning of the inner fin.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

- FIG. 1 is an exploded side perspective view of a plate-type heat exchanger according to Embodiment 1 of the present invention.
- FIG. 2 is a front view of a first heat transfer plate of the plate-type heat exchanger according to Embodiment 1 of the present invention.
- FIG. 3 is a front view of a second heat transfer plate of the plate-type heat exchanger according to Embodiment 1 of the present invention.
- FIG. 4 is a front perspective view of a heat transfer set of the plate-type heat exchanger according to Embodiment 1 of the present invention.
- FIG. 5 is a cross-sectional view taken along line A-A in FIG. 4.

FIG. 6 is an end elevation view of a cross-section taken along line B-B in FIG. 4.

FIG. 7 is a cross-sectional view taken along line B-B in FIG. 4.

FIG. 8 is an end elevation view of a cross-section taken along line C-C in FIG. 4.

FIG. 9 is a front perspective view of a heat transfer set of a plate-type heat exchanger according to Embodiment 2 of the present invention.

FIG. 10 is an end elevation view of a cross-section taken along line B-B in FIG. 9.

FIG. 11 is an end elevation view of a cross-section taken along line C-C in FIG. 9.

FIG. 12 is a cross-sectional view taken along line A-A in a case where heat transfer plates according to a modification are used in the plate-type heat exchanger of FIG. 9.

FIG. 13 is a cross-sectional view taken along line B-B in a case where the heat transfer plates according to the modification are used in the plate-type heat exchanger of FIG. 9.

FIG. 14 is a cross-sectional view taken along line C-C in a case where the heat transfer plates according to the modification are used in the plate-type heat exchanger of FIG. 9.

FIG. 15 is a front perspective view of a heat transfer set of a plate-type heat exchanger according to Embodiment 3 of the present invention.

FIG. 16 is a front view of a first heat transfer plate of FIG. 15.

FIG. 17 is a cross-sectional view taken along line A-A in FIG. 15.

FIG. 18 is an end elevation view of a cross-section taken along line B-B in FIG. 15.

FIG. 19 is an end elevation view of a cross-section taken along line C-C in FIG. 15.

FIG. 20 is a partial front perspective view of a heat transfer set of a plate-type heat exchanger according to Embodiment 4 of the present invention.

FIG. 21 is a cross-sectional view taken along line D-D in FIG. 20.

FIG. 22 is a diagram showing a flow velocity distribution of a fluid in an inner fin according to a comparative example provided with a projecting and depressed structure in an area extending over a distance δ from a first line α .

FIG. 23 is a diagram showing a velocity distribution of inflow into the inner fin according to the comparative example provided with the projecting and depressed structure in the area extending over the distance δ from the first line α .

FIG. 24 is a diagram showing a velocity distribution of inflow into the inner fin of the plate-type heat exchanger according to Embodiment 4 of the present invention in a case where no projecting and depressed structure is provided in the area extending over the distance δ from the

first line α .

FIG. 25 is a diagram showing a velocity distribution of inflow into an inner fin in a configuration having first projecting portions in addition to a projecting and depressed structure.

FIG. 26 is a schematic view showing a configuration of a heat-pump-type cooling and heating hot-water supply system according to Embodiment 5 of the present invention.

DESCRIPTION OF EMBODIMENTS

[0012] In the following, plate-type heat exchangers according to embodiments of the present invention are described, for example, with reference to the drawings. Note that components given identical signs in the following diagrams including FIG. 1 are identical with or equivalent to each other and these signs are added to throughout the full text of the embodiments described below.

[0013] Moreover, the forms of components expressed in the entire text of the specification are merely examples, and are not limited to forms described herein. Further, a relationship in size between components in the following drawings may be different from an actual relationship in size between the components.

[0014] Further, the terms showing directions (such as "upper", "lower", "right", "left", "front", and "back") used as appropriate for ease of understanding in the following description are intended for illustrative purposes, and are not intended to limit the present invention. Further, in Embodiment 1, the terms "upper", "lower", "right", "left", "front", and "back" are used in a state where a plate-type heat exchanger 100 is viewed from the front; that is, the plate-type heat exchanger 100 is seen in a direction of stacking of heat transfer plates. Further, as for the terms "depressed" and "projecting", a portion that projects forward is deemed to be "projecting", and a portion that projects backward is deemed to be "depressed".

Embodiment 1

[0015] FIG. 1 is an exploded side perspective view of a plate-type heat exchanger according to Embodiment 1 of the present invention. FIG. 2 is a front view of a first heat transfer plate of the plate-type heat exchanger according to Embodiment 1 of the present invention. FIG. 3 is a front view of a second heat transfer plate of the plate-type heat exchanger according to Embodiment 1 of the present invention. FIG. 4 is a front perspective view of a heat transfer set of the plate-type heat exchanger according to Embodiment 1 of the present invention.

[0016] Although FIG. 4 is a perspective view, FIG. 4 is a diagram that is substantially close to a front view. FIG. 5 is a cross-sectional view taken along line A-A in FIG. 4. FIG. 6 is an end elevation view of a cross-section taken along line B-B in FIG. 4. FIG. 7 is a cross-sectional view taken along line B-B in FIG. 4. FIG. 8 is an end elevation view of a cross-section taken along line C-C in FIG. 4.

[0017] As shown in FIG. 1, a plate-type heat exchanger 100 of Embodiment 1 is configured such that a first heat transfer plate and a second heat transfer plate are alternately stacked, and has a flow passage formed by a space between adjacent heat transfer plates. An arrangement of flow passages in a direction of stacking constitutes alternation of a first flow passage 6 through which a first fluid flows and a second flow passage 7 through which a second fluid flows.

[0018] Moreover, an inner fin 4 is disposed in the flow passage 6, and an inner fin 5 is disposed in the second flow passage 7. Thus, a heat transfer set 200 includes the inner fin 4, the first heat transfer plate 1, the inner fin 5, and the second heat transfer plate 2 being stacked starting from the front. The first heat transfer plate 1, the second heat transfer plate 2, the inner fin 4, and the inner fin 5 are each formed in the shape of a long plate.

[0019] The plate-type heat exchanger 100 includes a plurality of the heat transfer sets 200 being stacked, and the first fluid flowing through the first flow passage 6 and the second fluid flowing through the second flow passage 7 exchange heat with each other. Points of contact between the heat transfer sets 200 thus stacked are joined by brazing, and the plate-type heat exchanger 100 is formed in a cuboidal shape as a whole.

[0020] The first fluid is water or brine, for example. The second fluid is, for example, refrigerant such as R410A, R32, R290, or HFO_{mix} or CO₂. In FIG. 1, the first fluid is indicated by a solid arrow, and the second fluid is indicated by a dotted arrow. Further, although, in FIG. 1, a method by which the fluids flow indicates a counter-current flow configuration in which the first fluid and the second fluid flow in directions opposite to each other, the present invention is not limited to this flow method. The method by which the fluids flow may be a co-current flow configuration in which the first fluid and the second fluid flow in an identical direction.

[0021] Operating pressure on the first fluid is the pressure of a pump that causes the first fluid to flow, and operations are always performed at low pressure. Further, operating pressure on the second fluid is the saturation pressure of the second fluid, and operations are always performed at high pressure.

[0022] Further, a first reinforcing side plate 3 and a second reinforcing side plate 8 are disposed on the outermost surfaces, respectively, of the heat transfer set 200 in the direction of stacking. In FIG. 1, the first reinforcing side plate 3 is a plate stacked on the foreground surface, and the second reinforcing side plate 8 is a plate stacked on the rearmost surface.

[0023] Further, as shown in FIG. 1, the first reinforcing side plate 3 and the second reinforcing side plate 8 are each formed in the shape of a long plate with its four corners rounded. In the four corners of the first reinforcing side plate 3, circular holes are formed. The circular holes serve as inflow ports or outflow ports through which a fluid flows in or flows out. Moreover, a cylindrically-shaped inflow pipe or outflow pipe is provided at a pe-

ripheral edge of each hole.

[0024] In particular, a first inflow pipe 9 through which the first fluid flows in is provided in the lower right corner of the first reinforcing side plate 3, and a first outflow pipe 10 through which the first fluid flows out is provided in the lower left corner of the first reinforcing side plate 3. Further, a second inflow pipe 11 through which the second fluid flows in is provided in the upper left corner of the first reinforcing side plate 3, and a second outflow pipe 12 through which the second fluid flows out is provided in the upper right corner of the first reinforcing side plate 3.

[0025] Although FIG. 1 shows a configuration in which the side plates are entirely uniform in wall thickness, the uniform configuration does not imply any limitation. For example, the wall thicknesses of portions of the side plates near the inflow pipes and the outflow pipes may be greater than the wall thicknesses of other portion, for example.

[0026] Further, although, in FIG. 1, the inflow pipes and the outflow pipes are identical in dimension, this does not imply any limitation, and the inflow pipes and the outflow pipes do not need to be identical in dimension.

[0027] The first heat transfer plate 1 and the second heat transfer plate 2 have holes that face the first inflow pipe 9, the first outflow pipe 10, the second inflow pipe 11, and the second outflow pipe 12, respectively. Specifically, as shown in FIG. 2, the first heat transfer plate 1 is provided in the lower right corner thereof a first inflow hole 13 through which the first fluid flows in, and is provided in the lower left corner thereof a first outflow hole 14 through which the first fluid flows out.

[0028] The first heat transfer plate 1 is provided in the upper left corner thereof a second inflow hole 15 through which the second fluid flows in, and is provided in the upper right corner thereof a second outflow hole 16 through which the second fluid flows out. Moreover, the first heat transfer plate 1 has a cylindrically-shaped surrounding walls W provided around the second inflow hole 15 and the second outflow hole 16, and the second inflow hole 15 and the second outflow hole 16 are configured not to communicate with the first flow passage 6. This prevents the second fluid from flowing into the first flow passage 6 through the second inflow hole 15 and the second outflow hole 16.

[0029] Further, as shown in FIG. 3, the second heat transfer plate 2 is provided in the lower right corner thereof a first inflow hole 17 through which the first fluid flows in, and is provided in the lower left corner thereof a first outflow hole 18 through which the first fluid flows out. The second heat transfer plate 2 is provided with, in the upper left corner thereof, a second inflow hole 19 through which the second fluid flows in, and is provided with, in the upper right corner thereof, a second outflow hole 20 through which the second fluid flows out.

[0030] Moreover, the second heat transfer plate 2 has cylindrically-shaped surrounding walls W provided around the first inflow hole 17 and the first outflow hole

18, and the first inflow hole 17 and the first outflow hole 18 are configured not to communicate with the second flow passage 7. This prevents the first fluid from flowing into the second flow passage 7 through the first inflow hole 17 and the first outflow hole 18.

[0031] The first heat transfer plate 1 and the second heat transfer plate 2 are hereinafter referred to collectively as "heat transfer plates" when it is not necessary to distinguish between them. Further, the first reinforcing side plate 3 and the second reinforcing side plate 8 are hereinafter referred to collectively as "side plates" when it is not necessary to distinguish between them. Further, the first flow passage 6 and the second flow passage 7 are hereinafter referred to collectively as "flow passages" when it is not necessary to distinguish between them.

[0032] Further, the term "first direction" refers to a direction of flow of a fluid, that is, a horizontal direction of FIG. 1, and the term "second direction" refers to a direction orthogonal to the first direction, that is, a vertical direction of FIG. 1.

[0033] As shown in FIG. 5, each of the heat transfer plates has a flat portion 30 and outer wall portions 31 extending outward from both ends of the flat portion 30 in the second direction, and the outer wall portions 31 of heat transfer plates that are adjacent to each other in the direction of stacking are in contact with each other. Moreover, a space is formed between each flat portion 30 and an adjacent flat portion 30, and this space serves as the first flow passage 6 or the second flow passage 7. In FIG. 5, the first flow passage 6 is located above the first heat transfer plate 1, and the second flow passage 7 is located between the first heat transfer plate 1 and the second heat transfer plate 2. Further, as shown in FIGS. 2 and 3, each of the heat transfer plates has header portions 24 provided at both ends thereof in the first direction.

[0034] While each of the heat transfer plates may be made of a material such as stainless steel, carbon steel, aluminum, copper, or an alloy thereof, the following description assumes that each of the heat transfer plates is made of stainless steel.

[0035] The inner fin 4 has a height 11 (see FIG. 5) that is equal to a flow passage height of the first flow passage 6, and is in contact with the flat portion 30 of the first heat transfer plate 1 and the flat portion 30 of the second heat transfer plate 2. The points of contact may be joined, for example, by brazing or may not be joined. Further, the inner fin 5 has a height 12 (see FIG. 5) that is equal to a flow passage height of the second flow passage 7, and is in contact with the flat portion 30 of the first heat transfer plate 1 and the flat portion 30 of the second heat transfer plate 2. Although the height 11 of the inner fin 4 is greater than the height 12 of the inner fin 5, in this example, those heights may be equal to each other, or this relationship may be inverted.

[0036] The inner fins used in this example are offset fins. The offset fins are configured such that corrugated portions each formed in a corrugated shape by alternately coupling, in the second direction, vertical walls 32 ori-

ented perpendicularly to the heat transfer plate and horizontal walls 33 oriented parallel to the heat transfer plate are formed in a staggered arrangement in the first direction with half-wave shifts. The inner fins are not limited to offset fins and may be of any one of a flat-plate fin type, a corrugated fin type, a louver type, a wavy fin, a corrugated fin type, and a pin fin type, or two or more of these types may be combined.

[0037] For convenience in manufacturing of the plate-type heat exchanger by automatic assembling, gaps 21 are formed between both ends of the inner fin 4 in the second direction and both ends of the first heat transfer plate 1 in the second direction or, specifically, the outer wall portions 31. The first fluid having flowed into the first flow passage 6 through the first inflow hole 13 of the first heat transfer plate 1 easily flows into the gaps 21, as the first fluid is subjected to a weaker resistance than in a case where it flows into the inner fin 4. For this reason, the first fluid preferentially flows into the gaps 21 without uniformly flowing through the first flow passage 6. This deteriorates heat exchange performance.

[0038] In order to solve this problem, the first heat transfer plate 1 has first projecting portions 22 provided upstream of the gaps 21. Specifically, the first projecting portions 22 are provided upstream of an edge of the inner fin 4 through which the fluid flows in and at both ends of the first heat transfer plate 1 in the second direction. The first projecting portions 22 are formed by projecting portions projecting from the flat portion 30 of the first heat transfer plate 1 toward the first flow passage 6, and are formed by press working. The first projecting portions 22 prevent the first fluid from flowing into the gaps 21.

[0039] Further, the first heat transfer plate 1 has a second projecting portion 23 provided downstream of an edge of the inner fin 4 through which the fluid flows out. In other words, the second projecting portion 23 is provided in a location at a length of the first heat transfer plate 1 in the first direction from the first projecting portions 22. The second projecting portion 23 includes a projecting portion projecting from the flat portion 30 of the first heat transfer plate 1 toward the first flow passage 6, and is formed by press working. The second projecting portion 23 may be located off the central part of the first heat transfer plate 1 in the second direction as shown in FIG. 2 or may be located in the central part, and is not limited to any particular location in the second direction.

[0040] By thus providing the first heat transfer plate 1 with the second projecting portion 23 in addition to the first projecting portions 22, the locations of both ends of the inner fin 4 in the first direction are determined, so that the inner fin 4 can be positioned in the first direction in being placed onto the first heat transfer plate 1. In this example, the first projecting portions 22 and the second projecting portion 23 are each formed in a circular shape. However, the first projecting portions 22 and the second projecting portion 23 are limited to a circular shape. The first projecting portions 22 and the second projecting portion 23 may each be formed in any one of shapes such

as a triangle, a quadrangle, and an ellipse, or two or more of these shapes may be combined.

[0041] Further, along with the automatic assembling of the plate-type heat exchanger, gaps 25 (see FIG. 5) are similarly formed between both ends of the inner fin 5 in the second direction and both ends of the second heat transfer plate 2 in the second direction or, specifically, the outer wall portions 31. The second fluid having flowed into the second flow passage 7 through the second inflow hole 19 of the second heat transfer plate 2 easily flows into the gaps 25, as the second fluid is subjected to a weaker resistance than in a case where it flows into the inner fin 5. For this reason, the second fluid preferentially flows into the gaps 25 without uniformly flowing through the second flow passage 7. This causes a decrease in heat exchange performance.

[0042] To address this problem, the second heat transfer plate 2 has first projecting portions 26 provided upstream of the gaps 25. Specifically, the first projecting portions 26 are provided upstream of an edge of the inner fin 5 through which the fluid flows in and at both ends of the second heat transfer plate 2 in the second direction. The second projecting portions 26 include projecting portions projecting from the flat portion 30 of the second heat transfer plate 2 toward the second flow passage 7, and are formed by press working. The first projecting portions 26 prevent the second fluid from flowing into the gaps 25.

[0043] Further, the second heat transfer plate 2 has a second projecting portion 27 provided downstream of an edge of the inner fin 5 through which the fluid flows out. In other words, the second projecting portion 27 is provided in a location at a length of the second heat transfer plate 2 in the first direction from the first projecting portions 26. The second projecting portion 27 is formed by a projecting portion projecting from the flat portion 30 of the second heat transfer plate 2 toward the second flow passage 7, and is formed by press working. The second projecting portion 27 may be located off the central part of the second heat transfer plate 2 in the second direction as shown in FIG. 3 or may be located in the central part, and is not limited to any particular location in the second direction.

[0044] By thus providing the second heat transfer plate 2 with the second projecting portion 27 in addition to the first projecting portions 22, the locations of both ends of the inner fin 5 in the first direction are determined, so that the inner fin 5 can be positioned in the first direction in being placed onto the second heat transfer plate 2. In this example, the first projecting portions 26 and the second projecting portion 27 are each formed in a circular shape. However, the first projecting portions 26 and the second projecting portion 27 are not limited to being circular in shape. The first projecting portions 26 and the second projecting portion 27 may each be formed in any one of shapes such as a triangle, a quadrangle, and an ellipse, or two or more of these shapes may be combined.

[0045] Note here that as shown in FIG. 5, the inner fin 4 has a shape of asperities in fine cycles. Spacings be-

tween two vertical walls 32 of the inner fin 4 that are adjacent to each other in the second direction are the same across the second direction. Moreover, in order that positioning of the inner fin 4 can be performed with an end of the inner fin 4 in the first direction surely in contact with the first projecting portions 22, it is desirable that as shown in FIG. 7, the width ψ of each of the first projecting portions 22 be twice or more as great as the distance χ between two adjacent vertical walls 32 of the inner fin 4. Making the width ψ of each of the first projecting portions 22 twice or more as great as the distance χ between the two vertical walls 32 means that the width ψ of each of the first projecting portions 22 is greater than or equal to one cycle of asperities of the inner fin 4.

[0046] The inner fin 4 is designed to get the most out of the width of the flat portion 30 of the heat transfer plate in the second direction. Therefore, the difference between the width of the inner fin 4 in the second direction and the width of the flat portion 30 in the second direction is shorter than one cycle of asperities of the inner fin 4. Therefore, by making the width ψ of each of the first projecting portions 22 twice or more as great as the distance χ between the two vertical walls 32, positioning of the inner fin 4 can be performed with the end of the inner fin 4 in the first direction surely in contact with the first projecting portions 22.

[0047] Note here that an increase in the width ψ of each of the first projecting portions 22 leads to an increase in ease of positioning of the inner fin 4 but results in the formation of a portion in the inner fin 4 into which the fluid hardly flows. For example, using as the inner fin 4 a simple corrugated plate, that is, a fin configured such that a fluid flows only in one direction may result in the formation of a corrugated portion where insufficient inflow occurs. Such a problem can be prevented by using a fin, such as an offset fin, configured such that a fluid both flows in a mainstream direction (indicated by an arrow in FIG. 2) and moderately flows in a direction of flow that intersects the mainstream direction.

[0048] Further, even in a case where an offset fin is used as the inner fin 4, too large a width ψ of each of the first projecting portions 22 may lead to an increase in area of insufficient inflow of the first fluid into the inner fin 4. Accordingly, it is desirable that the width ψ of each of the first projecting portions 22 be five times or less as great as the distance χ between two adjacent vertical walls 32 of the inner fin 4.

[0049] This makes it possible to reduce the area of insufficient inflow of the first fluid into the inner fin 4. Note here that it is for the following reason that the width ψ of each of the first projecting portions 22 is made five times or less as great as the distance χ between two adjacent vertical walls 32 of the inner fin 4. The width ψ of each of the first projecting portions 22 is made five times or less as great as the distance χ , as flow through a fin portion is affected when the width ψ is more than five times as great as the distance χ .

[0050] Although the foregoing has described the first

projecting portions 22, the same applies to the first projecting portions 26 formed on the second heat transfer plate 2. That is, the width ψ of each of the first projecting portions 26 is twice or more and five times or less as great as the distance χ between two adjacent vertical walls 32 of the inner fin 5. Further, although the foregoing has described the first projecting portions 22 and the first projecting portions 26, the same applies to the second projecting portion 23 and the second projecting portion 27. That is, it is preferable that the width ψ of each of the second projecting portions 23 and 27 be twice or more and five times or less as great as the distance χ between two adjacent vertical walls 32 of the inner fin.

[0051] Further, although, in FIG. 7, the height h of each of the first projecting portions 22 is smaller than the height 1 of the inner fin 4 ($h < 1$), the height h of each of the first projecting portions 22 may be at most equal to the height 1 of the inner fin 4 ($h = 1$). In a case where the height h of each of the first projecting portions 22 is equal to the height 1 of the inner fin 4, the flow of the first fluid in the gaps 21 can be further inhibited than in a case where the height h is smaller than the height 1. In a case where the height h of each of the first projecting portions 22 is smaller than the height 1 of the inner fin 4 ($h < 1$), the first projecting portions 22 do not make contact with the second heat transfer plate 2, but in a case where the height h of each of the first projecting portions 22 is equal to the height of the inner fin 4 ($h = 1$), the first projecting portions 22 make contact with the second heat transfer plate 2. These points of contact may be joined, for example, by brazing or may not be joined.

[0052] It is desirable to bring about improvement in structural strength of the second flow passage 7, as the high-pressure second fluid passes through the second flow passage 7. For this reason, it is desirable to set up a configuration in which the height of each of the first projecting portions 26 be equal to the height 12 of the inner fin 5 and points of contact between end faces of the first projecting portions 26 and the first heat transfer plate 1 are joined, for example, by brazing.

[0053] While the foregoing has assumed that the first projecting portions 22 are located upstream of the edge of the inner fin 4 through which the fluid flows in and at both ends of the first heat transfer plate 1 in the second direction, the following more specifically describes the locations of the first projecting portions 22. A specific scope of "both ends of the first heat transfer plate 1 in the second direction" is described with reference to FIG. 4. Each first projecting portion 22 is provided within an area surrounded by a first line α representing an inflow edge of both edges of the inner fin 4 in the first direction, two second lines β representing both edges of the flat portion 30 in the second direction, and two circular arcs 28 indicated by dotted lines in FIG. 4.

[0054] Each of the circular arcs 28 is a circular arc with a radius R centered at a point of intersection O of the first line α and a corresponding one of the second lines β , and the radius R is three times as great as the flow pas-

sage height l_1 of the first flow passage 6. The placement of the first projecting portions 22 in the aforementioned locations makes it possible to enhance the effect of inhibiting the first fluid from flowing into the gaps 21.

[0055] Note that the gaps 21 between the inner fin 4 and the outer wall portions 31 each measure approximately 1 mm. The height l_1 of the inner fin 4 is approximately 0.5 mm to 2.5 mm. A "triple" of the height l_1 of the inner fin 4 ranges from 1.5 mm to 7.5 mm. The distance between two adjacent vertical walls 32 of the inner fin 4 is approximately 0.5 mm to 1.5 mm.

[0056] The width ψ of each of the first projecting portions 22 is approximately 1.0 mm to 7.5 mm, as it is desirable that the width ψ of each of the first projecting portions 22 be twice or more and five times or less as great as the distance between two adjacent vertical walls 32 of the inner fin 4. Therefore, for minimization of the gaps 21 between the inner fin 4 and the outer wall portions 31 and enhancement of the effect of inhibiting the flow rate of the first fluid that flows into the gaps 21, the radius R is made three times as great as the flow passage height l_1 of the first flow passage 6.

[0057] Although the foregoing has described the specific scope of "both ends of the first heat transfer plate 1 in the second direction" in relation to the locations of the first projecting portions 22, the same applies to the locations of the first projecting portions 26 of the second heat transfer plate 2. That is, each first projecting portion 26 is provided within an area surrounded by a first line representing an inflow edge of both edges of the inner fin 5 in the first direction, two second lines representing both edges of the flat portion 30 in the second direction, and two circular arcs. Each of the circular arcs is a circular arc with a radius R centered at a point of intersection of the first line and a corresponding one of the second lines, and the radius R is three times as great as the flow passage height 12 of the second flow passage 7.

[0058] The following describes the flow of the fluids through the plate-type heat exchanger 100 thus configured and the action of the first projecting portions 22 and the first projecting portions 26.

[0059] The first fluid having flowed into the first inflow pipe 9 from outside flows into the first flow passage 6 via the first inflow hole 13 of the first heat transfer plate 1. The first fluid having flowed into the first flow passage 6 flows through the inner fin 4 in a direction from right to left as indicated by a solid arrow in FIG. 2 while gradually spreading toward the outer wall portions 31 of the first heat transfer plate 1 and flows out from the first outflow pipe 10 via the first outflow hole 14 of the first heat transfer plate 1.

[0060] The second fluid having flowed into the second inflow pipe 11 from outside flows into the second flow passage 7 via the second inflow hole 19 of the second heat transfer plate 2. The second fluid having flowed into the second flow passage 7 flows through the inner fin 5 in a direction from left to right as indicated by a dotted arrow in FIG. 3 while spreading toward the outer wall

portions 31 of the second heat transfer plate 2 and flows out from the second outflow pipe 12 via the second outflow hole 20 of the second heat transfer plate 2.

[0061] Thus, the flow of the first fluid through the first flow passage 6 and the flow of the second fluid through the second flow passage 7 allow the first fluid and the second fluid to exchange heat with each other via the first heat transfer plate 1 and the second heat transfer plate 2.

[0062] Note that the provision of the first projecting portions 22 in the first flow passage 6 prevents the first fluid of the first flow passage 6 from flowing into the gaps 21. This makes it possible to rectify an imbalance of the first fluid in the first flow passage 6 and bring about improvement in distributive performance to both the upper and lower sides of FIG. 2.

[0063] Further, the same applies to the second flow passage 7. That is, the provision of the first projecting portions 26 in the second flow passage 7 prevents the second fluid flowing through the second flow passage 7 from flowing into the gaps 25. This makes it possible to rectify an imbalance of the second fluid in the second flow passage 7 and bring about improvement in distributive performance to both the upper and lower sides of FIG. 3.

[0064] By thus providing the first projecting portions 22 and the first projecting portions 26 in the first flow passage 6 and the second flow passage 7, respectively, imbalances of the fluids can be better rectified than in a case where they are not provided. This can result in improvement in performance of the plate-type heat exchanger 100.

[0065] As described above, according to Embodiment 1, the first projecting portions 22 are provided on an inflow side of the first heat transfer plate 1. This makes it possible to inhibit the first fluid from preferentially flowing into the gaps 21 and improve the in-plane distributive performance of the first fluid in the first flow passage 6. Further, the second projecting portion 23, which performs positioning in placing the inner fin 4 into the first flow passage 6, is provided on an outflow side of the first heat transfer plate 1.

[0066] This makes it possible to determine the location of the inner fin 4 with the first projecting portions 22 and the second projecting portion 23. Since the first projecting portions 22 and the second projecting portion 23 are formed by press working, these effects can be achieved without addition of attachments. This makes it possible to achieve an increase in performance and a reduction in cost of the plate-type heat exchanger.

[0067] Further, the same applies to the second heat transfer plate 2. That is, the provision of the first projecting portions 26 and the second projecting portion 27 makes it possible to determine the location of the inner fin 5 while improving the in-plane distributive performance of the second fluid without addition of attachments.

[0068] Further, the joining of a portion of the second projecting portion 27 that is in contact with the first heat

transfer plate 1 and the second heat transfer plate 2 makes it possible to bring about improvement in strength.

[0069] Thus, in the first flow passage 6 or the second flow passage 7, the positioning of the inner fin 4 or the inner fin 5 can be achieved by the first projecting portions and the second projecting portion. This makes it possible to increase the distance between the inner fin and another projecting and depressed structure configured to improve strength, and makes it possible to design a projecting and depressed structure distribution that is compatible with both distributiveness and strength performance. This can result in achieving an increase in performance of the plate-type heat exchanger 100.

[0070] The inner fin includes an offset fin having a corrugated portion formed in a corrugated shape by alternately coupling, in the second direction, vertical walls 32 oriented perpendicularly to the heat transfer plate and horizontal walls 33 oriented parallel to the heat transfer plate. The width of each of the first projecting portions in the second direction is twice or more as great as the distance between two adjacent vertical walls 32 of the inner fin.

[0071] This makes it possible to position the inner fin with an end of the inner fin in the first direction surely in contact with the first projecting portions. Further, the width of each of the first projecting portions in the second direction is five times or less as great as the distance between two adjacent vertical walls 32 of the inner fin. This makes it possible to reduce an area of insufficient inflow of the fluid into the inner fin.

[0072] Further, the width of the second projecting portion may be twice or more and five times or less as great as the distance between two adjacent vertical walls 32 of the inner fin.

[0073] The first projecting portions and the second projecting portion may be provided to project toward the flow passage from one of the two heat transfer plates forming the flow passage. Moreover, improvement in strength can be brought about by configuring the first projecting portions and the second projecting portion to be joined to the other one of the two heat transfer plates forming the flow passage.

[0074] Since the first projecting portions, which are provided on the inflow sides of the heat transfer plates, and the second projecting portions, which are provided on the outflow sides of the heat transfer plates, are provided in both the first flow passage and the second flow passage, improvement in in-plane distributive performance can be brought about in both the first flow passage and the second flow passage.

[0075] The first projecting portions 22 of the first flow passage 6 and the second projecting portion 27 of the second flow passage 7 are identical in shape to each other, and are in contact with each other with an overlap in location in the second direction in a cross-section perpendicular to the direction of stacking. Further, the second projecting portion 23 of the first flow passage 6 and the first projecting portions 26 of the second flow passage

7 are identical in shape to each other, and are in contact with each other with an overlap in location in the second direction in a cross-section perpendicular to the direction of stacking. This makes it possible to improve the strength of the plate-type heat exchanger 100.

[0076] The first projecting portions are provided at both ends of the flat portion 30 of the heat transfer plate in the second direction and within an area surrounded by a first line representing an inflow edge of both edges of the inner fin in the first direction, two second lines representing both edges of the flat portion in the second direction, and two circular arcs at both ends of the flat portion in the second direction. Each of the two circular arcs is a circular arc with a radius R centered at a point of intersection of the first line and a corresponding one of the second lines, and the radius R is three times as great as the flow passage height of the flow passage. This makes it possible to enhance the effect of inhibiting the fluid from flowing into the gaps.

[0077] The second projecting portions are provided at both ends of the flat portion in the second direction and within an area surrounded by a third line representing an outflow edge of both edges of the inner fin in the first direction, two second lines, and two circular arcs at both ends of the flat portion in the second direction. Each of the two circular arcs is a circular arc with a radius R centered at a point of intersection of the third line and a corresponding one of the second lines, and the radius R is three times as great as the flow passage height of the flow passage. This makes it possible to enhance the effect of inhibiting the fluid from flowing into the gaps.

Embodiment 2

[0078] In Embodiment 1, the second projecting portion 23 and the second projecting portion 27 are each formed in one place. In Embodiment 2, second projecting portions 23 are formed in two places, and second projecting portions 27 are formed in two places. The following mainly describes points in which Embodiment 2 differs from Embodiment 1, and omits to describe constituent elements of Embodiment 2 that are similar to those of Embodiment 1.

[0079] FIG. 9 is a front perspective view of a heat transfer set of a plate-type heat exchanger according to Embodiment 2 of the present invention. FIG. 10 is an end elevation view of a cross-section taken along line B-B in FIG. 9. FIG. 11 is an end elevation view of a cross-section taken along line C-C in FIG. 9.

[0080] Embodiment 2 is identical to Embodiment 1 except for the numbers and locations of second projecting portions 23 and second projecting portions 27.

[0081] As shown in FIGS. 9 and 11, the first heat transfer plate 1 of the heat transfer set 200 of Embodiment 2 has second projecting portions 23 provided in locations at a length of the inner fin 4 in the first direction from the first projecting portions 22 and at both ends of the first heat transfer plate 1 in the second direction. Further, the

second heat transfer plate 2 has second projecting portions 27 provided in locations at a length of the inner fin 4 in the first direction from the first projecting portions 26 and, as shown in FIG. 10, at both ends of the second heat transfer plate 2 in the second direction.

[0082] Embodiment 2 brings about the same effects as Embodiment 1 and, in addition, brings about the following effects. That is, while Embodiment 1 has one second projecting portion 23 and one second projecting portion 27, Embodiment 2 has two second projecting portions 23 provided at both ends of a heat transfer plate in the second direction and two second projecting portions 27 provided at both ends of a heat transfer plate in the second direction.

[0083] The second projecting portions 23 are located on an outflow side of the first flow passage 6, and the second projecting portions 27 are located on an outflow side of the second flow passage 7. Therefore, in the first flow passage 6, outflow sides of the gaps 21, which extend in a horizontal direction, are closed by the second projecting portions 23, and in the second flow passage 7, outflow sides of the gaps 25, which extend in a horizontal direction in FIG. 9, are closed by the second projecting portions 27.

[0084] This configuration makes it possible to prevent more effectively the first fluid from flowing into the gaps 21 and the second fluid from flowing into the gaps 25 than the configuration of Embodiment 1 in which only inflow sides of the gaps 21 and the gaps 25 are closed. As a result, Embodiment 2 can bring about further improvement in in-plane distributive performance than Embodiment 1. This makes it possible to achieve an increase in performance of the plate-type heat exchanger 100.

[0085] Although the foregoing description has been made presuming that the second projecting portions 23 are located at "both ends of the first heat transfer plate 1 in the second direction" and that the second projecting portions 27 are located at "both ends of the second heat transfer plate 2 in the second direction", a specific scope of these locations are basically the same as the scope of the first projecting portions 22 and the first projecting portions 26 described in Embodiment 1.

[0086] That is, each second projecting portion 23 is provided within an area surrounded by a third line γ representing an outflow edge of both edges of the inner fin 4 in the first direction, two second lines β , and two circular arcs 28. Each of the circular arcs 28 is a circular arc with a radius R centered at a point of intersection O of the third line γ and a corresponding one of the second lines β , and the radius R is three times as large as the flow passage height I1 of the first flow passage 6.

[0087] Further, each second projecting portion 27 is provided within an area surrounded by a third line representing an outflow edge of both edges of the inner fin 5 in the first direction, two second lines β , and two circular arcs. Each of the circular arcs is a circular arc with a radius R centered at a point of intersection O of the third line and a corresponding one of the second lines β , and

the radius R is three times as large as the flow passage height 12 of the second flow passage 7.

[0088] FIG. 12 is a cross-sectional view taken along line A-A in a case where heat transfer plates according to a modification are used in the plate-type heat exchanger of FIG. 9. FIG. 13 is a cross-sectional view taken along line B-B in a case where the heat transfer plates according to the modification are used in the plate-type heat exchanger of FIG. 9. FIG. 14 is a cross-sectional view taken along line C-C in a case where the heat transfer plates according to the modification are used in the plate-type heat exchanger of FIG. 9.

[0089] The first heat transfer plate 1 and the second heat transfer plate 2 of the modification shown in FIGS. 12 and 13 each include two plates partially joined to each other. Specifically, the first heat transfer plate 1 includes plates 1a and 1b partially joined to each other. The second heat transfer plate 2 includes plates 2a and 2b partially joined to each other. In FIGS. 12 to 14, black portions 29 between plates indicate junctions.

[0090] By a heat transfer plate thus including two plates partially joined to each other, a micro-flow passage communicating with outside air is formed between the two plates. For this reason, even if a defect in a heat transfer plate dividing adjacent flow passages of two types of fluid causes leakage of a fluid into a flow passage, mixture of the two types of fluid between the flow passages (leakage into a room) can be avoided by surely draining the leaked fluid out of the flow passage. This makes it possible to use flammable refrigerant as a fluid that flows through a flow passage.

[0091] The heat transfer plates of the modification shown in FIGS. 12 to 14 are applicable not only to Embodiment 2 but also to Embodiment 1 and Embodiment 3, which is described below.

Embodiment 3

[0092] The following mainly describes points in which Embodiment 3 differs from Embodiment 2, and omits to describe components of Embodiment 3 that are similar to those of Embodiment 2.

[0093] FIG. 15 is a front perspective view of a heat transfer set of a plate-type heat exchanger according to Embodiment 3 of the present invention. Although FIG. 15 is a perspective view, FIG. 15 is a diagram that is substantially close to a front view. FIG. 16 is a front view of a first heat transfer plate of FIG. 15. FIG. 17 is a cross-sectional view taken along line A-A in FIG. 15. FIG. 18 is an end elevation view of a cross-section taken along line B-B in FIG. 15. FIG. 19 is an end elevation view of a cross-section taken along line C-C in FIG. 15. It should be noted that the opposite of Embodiment 2 is true in FIG. 15; that is, the second heat transfer plate 2 is situated at the front, and the first heat transfer plate 1 is situated at the back.

[0094] As in the case of Embodiment 2, the second heat transfer plate 2 has circular first projecting portions

26 provided on an inflow side thereof and circular second projecting portions 27 provided on an outflow side thereof. The first projecting portions 26 and the second projecting portions 27 are in contact with the first heat transfer plate 1, and these points of contact are joined, for example, by brazing.

[0095] The first projecting portions 26 and the second projecting portions 27 are equal in height to the inner fin 5. Moreover, the second heat transfer plate 2 of Embodiment 3 further has circular arc first depressed portions 40 formed to surround inflow sides of the first projecting portions 26. Further, the second heat transfer plate 2 of Embodiment 3 further has circular arc second depressed portions 41 formed to surround outflow sides of the second projecting portions 27.

[0096] As shown in FIGS. 18 and 19, the first depressed portions 40 and the second depressed portions 41 include depressed portions depressed from the second heat transfer plate 2 toward the first flow passage 6. The first depressed portions 40 and the second depressed portions 41 are half as high as the inner fin 4.

[0097] The first heat transfer plate 1 has circular arc first projecting portions 22a and circular arc second projecting portions 23a formed instead of the circular first projecting portions 22 and the circular second projecting portions 23 of Embodiment 2. As shown in FIGS. 18 and 19, the first projecting portions 22a and the second projecting portions 23a include projecting portions projecting from the first heat transfer plate 1 toward the first flow passage 6. The projecting portions 22a and the second projecting portions 23a are half as high as the inner fin 4. The first projecting portions 22a and the second projecting portions 23a are in contact with the second depressed portions 41 and the first depressed portions 40, respectively, of the second heat transfer plate 2, and these points of contact are joined, for example, by brazing.

[0098] Thus, in the plate-type heat exchanger 100 according to Embodiment 3, the circular arc projecting portions formed on the first heat transfer plate 1 and the circular projecting portions formed on the second heat transfer plate 2 are different in shape from each other.

[0099] Such a configuration of the first heat transfer plate 1 and the second heat transfer plate 2 causes circular arc flow passage blocking portions to be formed by contact between the second depressed portions 41 and the first projecting portions 22a upstream of the gaps 21 in the first flow passage 6, so that the inflow of the first fluid into the gaps 21 can be inhibited. Similarly, circular arc flow passage blocking portions are formed by contact between the first depressed portions 40 and the second projecting portions 23a downstream of the gaps 21. That is, the flow passage blocking portions are formed both upstream and downstream of the gaps 21. This configuration makes it possible to better prevent the first fluid from flowing into the gaps 21 than a configuration in which flow passage blocking portions are provided only upstream of the gaps 21.

[0100] Further, as in the case of Embodiment 2, the first projecting portions 26 and the second projecting portions 27 are provided upstream and downstream, respectively, of the gaps 25 in the second flow passage 7. This makes it possible to inhibit the second fluid from flowing into the gaps 25.

[0101] Although Embodiment 3 has illustrated a configuration in which the circular arc first projecting portions 22a and the circular arc second projecting portions 23a are formed on the first heat transfer plate 1 and the circular projecting portions 26, the circular second depressed portions, the circular arc first depressed portions 40, and the circular arc second depressed portions 41 are formed on the second heat transfer plate 2, the opposite may be true.

[0102] That is, there may be a configuration in which the circular projecting portions 26, the circular second depressed portions 27, the circular arc first depressed portions 40, and the circular arc second depressed portions 41 are formed on the first heat transfer plate 1 and the circular arc first projecting portions 22a and the circular arc second projecting portions 23a are formed on the second heat transfer plate 2.

[0103] Further, according to Embodiment 3, in the first heat transfer plate 1, improvement in in-plane distributive performance in the first flow passage 6 and positioning of the inner fin 4 are simultaneously achieved by the first projecting portions 22a and the second projecting portions 23a. Further, in the second heat transfer plate 2, improvement in in-plane distributive performance and positioning of the inner fin 5 are simultaneously achieved by the first projecting portions 26 and the second projecting portions 27.

[0104] The first projecting portions 22a and the second projecting portion 23a are not limited to being circular arc in shape. The first projecting portions 22a and the second projecting portion 23a may each be formed in any one of other shapes such as a triangle, a quadrangle, and an ellipse, or two or more of these shapes may be combined.

[0105] As described above, Embodiment 3 brings about the same effects as Embodiment 2 and brings about the following effects. That is, the structure in which the first heat transfer plate 1 and the second heat transfer plate 2 are joined at the flat portions 30 by a combination of projecting portions and depressed portions brings about improvement in strength. Further, since the first projecting portion 22a and the second projecting portions 23a of the first flow passage 6 are half as high as the first flow passage 6, the combination of projecting portions and depressed portions can be applied to a wider range due to manufacturing restrictions on percentages of elongation of the heat transfer plates.

[0106] That is, because of the percentages of elongation of the heat transfer plates, the first flow passage 6 composed of projecting portions of Embodiment 3 can be made twice as high as the first flow passage 6 composed of projecting portions of Embodiment 1. This makes it possible to easily achieve optimization of the

height of the first flow passage 6 composed of projecting portions of Embodiment 3. Alternatively, this makes it possible to more easily achieve optimization of the size of the first projecting portions 22a and the second projecting portions 23a and the height of the first flow passage 6, thus making it possible to achieve an increase in performance of the plate-type heat exchanger 100.

[0107] The first projecting portions 22a of the first heat transfer plate 1 and the second projecting portions 27 of the second heat transfer plate 2 are different in shape from each other, and are different in location in the second direction in a cross-section perpendicular to the direction of stacking.

[0108] Further, the second projecting portions 23a of the first heat transfer plate 1 and the first projecting portions 26 of the second heat transfer plate 2 are different in shape from each other, and are different in location in the second direction in a cross-section perpendicular to the direction of stacking. Thus, the combination of projecting portions and depressed portions makes it possible to inhibit the inflow of the fluids into the gaps.

Embodiment 4

[0109] Embodiment 4 is intended to bring about improvement in strength by providing the header portions 24 with projecting and depressed structures. The following mainly describes points in which Embodiment 4 differs from Embodiment 1, and omits to describe components of Embodiment 4 that are similar to those of Embodiment 1.

[0110] FIG. 20 is a partial front perspective view of a heat transfer set of a plate-type heat exchanger according to Embodiment 4 of the present invention. FIG. 21 is a cross-sectional view taken along line D-D in FIG. 20.

[0111] The header portions 24 provided on the inflow and outflow sides, respectively, of the first heat transfer plate 1 are provided with a plurality of depressed portions 50 dispersed. Further, the header portions 24 provided on the inflow and outflow sides, respectively, of the second heat transfer plate 2 are provided with a plurality of depressed portions 51 facing the depressed portions 50.

[0112] Top faces of the projecting portions 51 are in contact with bottom faces of the depressed portions 50, and these points of contact are joined. By thus providing the header portions 24 with projecting and depressed structures 52, improvement in strength of the header portions 24 is brought about. The depressed portions 50 and the projecting portions 51 are formed in circular shapes and configured to be equal in diameter and height to each other.

[0113] For the prevention of blockage of the flow of the first fluid flowing out from the inner fin 4, the depressed portions 50 are not provided in an area in the outflow-side header portion 24 extending over a distance δ from the third line γ of the inner fin 4. Similarly, the depressed portions 50 are not provided in an area in the inflow-side header portion 24 extending over the distance δ from the

first line α of the inner fin 4.

[0114] Similarly, for the prevention of blockage of the flow of the second fluid flowing out from the inner fin 5, the projecting portions 51 are not provided in an area in the outflow-side header portion 24 extending over the distance δ from the third line γ of the inner fin 5, although not illustrated. Similarly, the depressed portions 50 are not provided in an area in the inflow-side header portion 24 extending over the distance δ from the first line α of the inner fin 5.

[0115] Note here that it is desirable that the distance δ be equal to or greater than an equivalent diameter of a cross-sectional shape E obtained by cutting a junction between a depressed portion 50 and a projecting portion 51 along a surface perpendicular to the first direction through the center of the junction:

$$\delta \geq 2wl/(w + 1),$$

where w is the diameter of the depressed portion 50 and the projecting portion 51 and 1 is the height of the junction between the depressed portion 50 and the projecting portion 51.

[0116] The configuration in which no projecting and depressed structure 52 is provided in the area extending over the distance δ from the first line α makes it possible to better uniform a velocity distribution of the fluid into the inner fin than a configuration in which a projecting and depressed structure 52 is provided in the area extending over the distance δ from the first line α . This point was demonstrated by a test whose results are shown below. The following shows results of a test conducted on the second flow passage 7.

[0117] FIG. 22 is a diagram showing a flow velocity distribution of a fluid in an inner fin according to a comparative example provided with a projecting and depressed structure in the area extending over the distance δ from the first line α . FIG. 22 is equivalent to a velocity distribution in a cross-sectional taken along line F-F in FIG. 23 below. In FIG. 22, the horizontal axis represents the second direction of the inner fin, and the vertical axis represents the flow velocity. FIG. 23 is a diagram showing a velocity distribution of inflow into the inner fin according to the comparative example provided with the projecting and depressed structure in the area extending over the distance δ from the first line α .

[0118] In FIG. 23, a longer arrow indicates a higher flow velocity. FIG. 24 is a diagram showing a velocity distribution of inflow into the inner fin of the plate-type heat exchanger according to Embodiment 4 of the present invention in a case where no projecting and depressed structure is provided in the area extending over the distance δ from the first line α . In each of FIGS. 23 and 24, the horizontal axis X represents the second direction of the inner fin, the vertical axis Y represents the first direction of the inner fin, and the arrows indicate the magnitude of the flow velocity.

[0119] As is clear from a comparison between FIGS. 22 and 23 of the comparative example and FIG. 24 of Embodiment 4, Embodiment 4, which is configured such that no projecting and depressed structure 52 is provided in the area extending over the distance δ from the first line α , ensures uniformity of flow velocity across the inner fin 5 in the second direction.

[0120] FIGS. 22 to 24 are diagrams for making a comparison between a case where a projecting and depressed structure 52 is provided in the area extending over the distance δ from the first line α and a case where no projecting and depressed structure 52 is provided in the area extending over the distance δ from the first line α , and the first projecting portions 26, which serve to inhibit the inflow of the second fluid into the gaps 25 at both ends of the second flow passage 7, are not provided. For this reason, the flow velocity is high at both ends of the inner fin 5 in the second direction. Next, FIG. 25 shows a flow velocity distribution in a case where the first projecting portions 26 are provided.

[0121] FIG. 25 is a diagram showing a velocity distribution of inflow into an inner fin in a configuration having first projecting portions in addition to a projecting and depressed structure. In FIG. 25, the horizontal axis X represents the second direction of the inner fin, the vertical axis Y represents the first direction of the inner fin, and the arrows indicate the magnitude of the flow velocity. FIG. 25, which is a diagram for explaining the effect of the first projecting portions, shows a case where a projecting and depressed structure 52 is provided in the area extending over the distance δ from the first line α .

[0122] As shown in FIG. 25, the provision of the first projecting portions 26 makes the flow velocity in the gaps at both ends of the second flow passage 7 lower than it is in FIG. 24.

[0123] Although the foregoing has described a flow velocity distribution of the fluid in the second flow passage 7, the same tendency is seen in the first flow passage 6.

[0124] As described above, Embodiment 4 brings about the same effects as Embodiment 1 by providing the first projecting portions and can bring about improvement in strength of the header portions 24 by providing the header portions 24 with the projecting and depressed structures 52.

[0125] Providing the header portions 24 with the projecting and depressed structures 52 in proximity to the inner fin causes non-uniformity of flow velocity of the fluid flowing into the inner fin. However, Embodiment 4 is configured such that the projecting and depressed structures 52 are not provided at least in the areas extending over the distance δ from the first line α and the third line γ , respectively. This makes it possible to rectify a problem of a decrease in in-plane distributive performance caused by providing the header portions 24 with the projecting and depressed structures 52 and ensure uniformity of flow velocity of the fluid across the inner fin in the second direction.

[0126] Although the foregoing has described Embodiment 4,

iments 1 to 4 as separate embodiments, features of the embodiments may be combined as appropriate to constitute a plate-type heat exchanger 100. For example, Embodiment 1 and Embodiment 3 may be combined such that the width of each of the first and second projecting portions 26 and 27 in Embodiment 3 is twice or more and five times or less as great as the distance between two adjacent vertical walls of the inner fin.

[0127] Further, Embodiment 3 and Embodiment 4 may be combined to be configured such that the header portions 24 of the heat transfer set 200 of Embodiment 3 shown in FIG. 15 are provided with the projecting and depressed structures 52 of Embodiment 4. A modification that is applied to the same constituent element of each of Embodiments 1 to 4 is similarly applied to an embodiment other than the embodiment in which the modification is described.

Embodiment 5

[0128] Embodiment 5 illustrates a heat pump device mounted with the plate-type heat exchanger 100 described in Embodiments 1 to 4. The following describes a heat-pump-type cooling and heating hot-water supply system as an example of a form of utilization of the heat pump device.

[0129] FIG. 26 is a schematic view showing a configuration of a heat-pump-type cooling and heating hot-water supply system according to Embodiment 5 of the present invention.

[0130] A heat-pump-type cooling and heating hot-water supply system 300 includes a heat pump device 65 and a heat medium circuit 70, and the heat pump device 65 includes a refrigerant circuit 60. The refrigerant circuit 60 includes a compressor 61, a heat exchanger 62, a decompression device 63, and a heat exchanger being connected in sequence by pipes, and the decompression device 63 is formed of, for example, by an expansion valve or a capillary tube. The heat medium circuit 70 includes the heat exchanger 62, a cooling and heating hot-water supply device 71, and a pump 72 being connected in sequence by pipes, and the pump 72 circulates a heat medium. The compressor 61, the heat exchanger 62, the decompression device 63, and the heat exchanger 64 are housed in a housing of the heat pump device 65.

[0131] Note here that the heat exchanger 62 is the plate-type heat exchanger 100 described above in Embodiments 1 to 4, and carries out a heat exchange between refrigerant flowing through the refrigerant circuit 60 and the heat medium flowing through the heat medium circuit 70. The heat medium that is used in the heat medium circuit 70 may be a fluid, such as water, ethylene glycol, propylene glycol, or a mixture thereof, that is capable of exchanging heat with the refrigerant of the refrigerant circuit 60.

[0132] Further, the refrigerant flowing through the refrigerant circuit 60 is not limited to a particular refrigerant, and usable examples of the refrigerant include R22,

R410A, or other refrigerants. Further, since the heat-pump-type cooling and heating hot-water supply system 300 allows no refrigerant to be supplied to an indoor side, flammable refrigerant such as R32, R290, or HFO_{mix} may be used as the refrigerant.

[0133] The plate-type heat exchanger 100, which includes the heat exchanger 62, is incorporated into the heat-pump-type cooling and heating hot-water supply system 300 so that the refrigerant flows through the second flow passage 7, which is higher in heat-transfer performance than the first flow passage 6, and the heat medium flows through the first flow passage 6. Since the inner fin 4 and the inner fin 5 are equal in heat-transfer area to each other and the inner fin 5 is smaller in hydraulic diameter than the inner fin 4, the second flow passage 7 is higher in heat-transfer performance than the first flow passage 6.

[0134] The cooling and heating hot-water supply device 71 includes, for example, a hot water storage tank (not illustrated) or an indoor heat exchanger of an indoor unit (not illustrated) configured to perform indoor air conditioning. In a case where the cooling and heating hot-water supply device 71 is a hot water storage tank, the heat medium is water. The water is heated by the heat exchanger 62 exchanging heat with the refrigerant of the refrigerant circuit 60. The water thus heated is stored in the hot water storage tank (not illustrated).

[0135] Alternatively, in a case where the cooling and heating hot-water supply device 71 is an indoor heat exchanger, indoor cooling or heating is performed by guiding the heat medium of the heat medium circuit 70 to the indoor heat exchanger and exchanging heat with indoor air. The cooling and heating hot-water supply device 71 is not limited to a particular configuration such as that described above, and needs only be configured to be able to perform cooling and heating and hot-water supply through the use of heating energy of the heat medium of the heat medium circuit 70.

[0136] In a case where heating and hot-water supply is performed, the heat exchanger 62 is used as a condenser, and in the case of cooling, the heat exchanger 62 is used as an evaporator. Arrows shown in FIG. 26 indicate directions of flow of the refrigerant in the case of heating and hot-water supply, and in the case of cooling, the refrigerant flows in opposite directions (not illustrated).

[0137] In a case where the heat exchanger 62 is used as an evaporator, the refrigerant flows into the second flow passage 7 of the heat exchanger 62 in the form of a two-phase gas-liquid flow. In so doing, the two-phase gas-liquid flow is prevented by the first projecting portions 22 from flowing into the gaps 21.

[0138] Embodiment 5 makes it possible to achieve an increase in performance and a reduction in cost by including the plate-type heat exchanger 100 of Embodiments 1 to 4. Further, Embodiment 5 makes it possible to obtain a heat-pump-type cooling and heating hot-water supply system 300 with high heat exchange efficiency.

Further, Embodiment 5 makes it possible to obtain a highly-reliable heat-pump-type cooling and heating hot-water supply system 300 with improvement in strength. That is, Embodiment 5 makes it possible to achieve a heat-pump-type cooling and heating hot-water supply system 300 configured to have high heat exchange efficiency, consume less electric power, offer improved safety, and emit less CO₂.

[0139] Embodiment 5 has described, as an example of application of the plate-type heat exchanger 100 described in the foregoing embodiments, a heat-pump-type cooling and heating hot-water supply system 300 configured to cause refrigerant and water to exchange heat with each other. However, the plate-type heat exchanger 100 described in the foregoing embodiments is applicable not only to the plate-type heat exchanger 100 described in the foregoing embodiments but also to many industrial equipment and home appliances such as cooling chillers, generating equipment, and food heat sterilization equipment.

[0140] As an example of utilization of the present invention, the plate-type heat exchanger 100 described in the foregoing embodiments is easy to manufacture, has improved heat exchange performance, and is applicable to a heat pump device whose energy saving performance needs to be improved.

LIST OF REFERENCE SIGNS

[0141]

1 heat transfer plate 1a plate
1b plate
2 second heat transfer plate
2a plate
2b plate
3 first reinforcing side plate
4 inner fin
5 inner fin
6 first flow passage
7 second flow passage
8 second reinforcing side plate
9 first inflow pipe
10 first outflow pipe
11 second inflow pipe
12 second outflow pipe
13 first inflow hole
14 first outflow hole
15 second inflow hole
16 second outflow hole
17 first inflow hole
18 first outflow hole
19 second inflow hole
20 second outflow hole
21 gap
22 first projecting portion
22a first projecting portion
23 second projecting portion

23a second projecting portion
24 header portion
25 gap
26 first projecting portion
5 27 second projecting portion
28 circular arc
29 black portion
30 flat portion
31 outer wall portion
10 40 first depressed portion
41 second depressed portion
50 depressed portion
51 projecting portion
52 projecting and depressed structure
15 60 refrigerant circuit
61 compressor
62 heat exchanger
63 decompression device
64 heat exchanger
20 65 heat pump device
70 heat medium circuit
71 cooling and heating hot-water supply device
72 pump
100 plate-type heat exchanger
25 200 heat transfer set
300 heat-pump-type cooling and heating hot-water supply system

30 Claims

1. A plate-type heat exchanger comprising:

35 - a plurality of heat transfer plates stacked on top of each other;
- a flow passage, formed by each space between the plurality of heat transfer plates, through which a fluid flows in a first direction;
- an inner fin disposed in the flow passage;
40 - a first projecting portion provided on an inflow side of each of the heat transfer plates and configured to prevent the fluid from flowing into gaps between both ends of the inner fin in a second direction and both ends of the heat transfer plate in the second direction; and
45 - a second projecting portion formed on an outflow side of each of the heat transfer plates and configured to perform positioning in placing the inner fin into the heat transfer plate,
50 - the first direction being a direction of flow of the fluid through the flow passage, the second direction being a direction orthogonal to the first direction, the inner fin being disposed between the first projecting portion and the second projecting portion.
55

2. The plate-type heat exchanger of claim 1,

- wherein the inner fin includes an offset fin having a corrugated portion formed in a corrugated shape by alternately coupling, in the second direction, vertical walls oriented perpendicularly to the heat transfer plate and horizontal walls oriented parallel to the heat transfer plate, and wherein a width of the first projecting portion in the second direction is twice or more and five times or less as great as a distance between two adjacent ones of the vertical walls of the inner fin.
3. The plate-type heat exchanger of claim 2, wherein a width of the second projecting portion in the second direction is twice or more and five times or less as great as the distance between the two adjacent vertical walls of the inner fin.
 4. The plate-type heat exchanger of any one of claims 1 to 3, wherein the second projecting portion includes second projecting portions provided at both ends of the outflow side of the heat transfer plate in the second direction.
 5. The plate-type heat exchanger of claim 1 or 2, wherein the first projecting portion and the second projecting portion are provided to project toward the flow passage from one of two of the heat transfer plates forming the flow passage.
 6. The plate-type heat exchanger of claim 5, wherein the first projecting portion and the second projecting portion are joined to an other one of the two heat transfer plates forming the flow passage.
 7. The plate-type heat exchanger of any one of claims 1 to 6, wherein the flow passage includes a first flow passage and a second flow passage alternately formed in a direction of stacking of the heat transfer plates, and the first projecting portion and the second projecting portion include a first projecting portion and a second projecting portion provided in the first flow passage and a first projecting portion and a second projecting portion provided in the second flow passage.
 8. The plate-type heat exchanger of claim 7, wherein the direction of flow of the fluid through the first flow passage and the direction of flow of the fluid through the second flow passage are opposite to each other, and wherein the first projecting portion of the first flow passage and the second projecting portion of the second flow passage are identical in shape to each other and are in contact with each other with an overlap in location in the second direction in a cross-section perpendicular to the direction of stacking.
 9. The plate-type heat exchanger of claim 7, wherein the direction of flow of the fluid through the first flow passage and the direction of flow of the fluid through the second flow passage are opposite to each other, and wherein the second projecting portion of the first flow passage and the first projecting portion of the second flow passage are identical in shape to each other and are in contact with each other with an overlap in location in the second direction in a cross-section perpendicular to the direction of stacking.
 10. The plate-type heat exchanger of any one of claims 1 to 9, wherein each of the heat transfer plates has a flat portion on which the inner fin is disposed, wherein the first projecting portion includes first projecting portions provided at both ends of the flat portion in the second direction and within an area surrounded by a first line representing an inflow edge of both edges of the inner fin in the first direction, two second lines representing both edges of the flat portion in the second direction, and two circular arcs at both ends of the flat portion in the second direction, wherein each of the two circular arcs is a circular arc with a radius R centered at a point of intersection of the first line and a corresponding one of the second lines, and the radius R is three times as great as a flow passage height of the flow passage.
 11. The plate-type heat exchanger of claim 10, wherein the second projecting portion includes second projecting portions provided at both ends of the flat portion in the second direction and within an area surrounded by a third line representing an outflow edge of both edges of the inner fin in the first direction, the two second lines, and two circular arcs at both ends of the flat portion in the second direction, each of the two circular arcs is a circular arc with a radius R centered at a point of intersection of the third line and a corresponding one of the second lines, and the radius R is three times as great as a flow passage height of the flow passage.
 12. The plate-type heat exchanger of any one of claims 1 to 7,

wherein one of two of the heat transfer plates forming the flow passage is provided with the first projecting portion and the second projection portion projecting toward the flow passage, wherein another one of the two heat transfer plates has a first depressed portion and a second depressed portion located opposite the first projecting portion and the second projection portion, depressed toward the flow passage, and formed in contact with the first projecting portion and the second projecting portion.

13. The plate-type heat exchanger of claim 12, wherein points of contact between the first projecting portion and the second projection portion of one of the heat transfer plates and the first depressed portion and the second depressed portion of the other one of the heat transfer plates are joined.
14. The plate-type heat exchanger of claim 12 or 13, wherein the flow passage includes a first flow passage and a second flow passage alternately formed in a direction of stacking of the heat transfer plates, wherein the direction of flow of the fluid through the first flow passage and the direction of flow of the fluid through the second flow passage are opposite to each other, wherein the first projecting portion of one of the heat transfer plates and the second projecting portion of the other one of the heat transfer plates are different in shape from each other, and are different in location in the second direction in a cross-section perpendicular to the direction of stacking.
15. The plate-type heat exchanger of claim 12 or 13, wherein the flow passage includes a first flow passage and a second flow passage alternately formed in a direction of stacking of the heat transfer plates, the direction of flow of the fluid through the first flow passage and the direction of flow of the fluid through the second flow passage are opposite to each other, the second projecting portion of one of the heat transfer plates and the first projecting portion of the other one of the heat transfer plates are different in shape from each other, and are different in location in the second direction in a cross-section perpendicular to the direction of stacking.
16. The plate-type heat exchanger of any one of claims 1 to 15, wherein each of the heat transfer plates includes two plates partially joined to each other.
17. The plate-type heat exchanger of any one of claims 1 to 16,

wherein each of the heat transfer plates has header portions formed at both ends thereof in the first direction, and wherein each of the header portions has a projecting and depressed structure formed to bring about improvement in strength.

18. The plate-type heat exchanger of claim 17,

wherein the projecting and depressed structure has a plurality of circular depressed portions provided in one of two of the heat transfer plates forming the flow passage and a plurality of circular projecting portions provided in an other one of the two heat transfer plates to face the plurality of depressed portions, each of the depressed portions and a corresponding one of the projecting portions are joined to each other, wherein the projecting and depressed structure is not formed at least in areas extending over a distance δ from both ends of the inner fin in the first direction, and wherein the distance δ is equal to or greater than an equivalent diameter of a cross-sectional shape obtained by cutting a junction between the depressed portion and the projecting portion along a surface perpendicular to the first direction through a center of the junction.

19. A heat pump device comprising a refrigerant circuit in which a compressor, the plate-type heat exchanger of any one of claims 1 to 18, a decompression device, and a heat exchanger are connected and through which refrigerant circulates.
20. A heat-pump-type cooling and heating hot-water supply system comprising a heat medium circuit in which the heat pump device of claim 19, the plate-type heat exchanger, a cooling and heating hot-water supply device configured to perform cooling and heating and supply hot water, and a pump are connected and through which a heat medium circulates.

FIG. 1

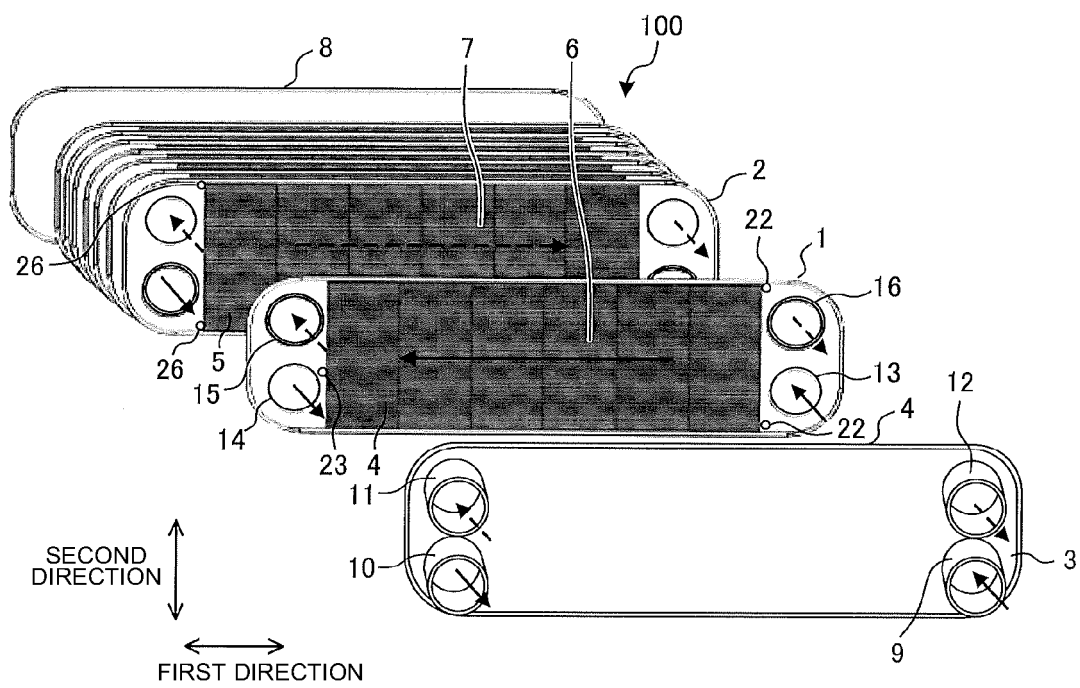


FIG. 2

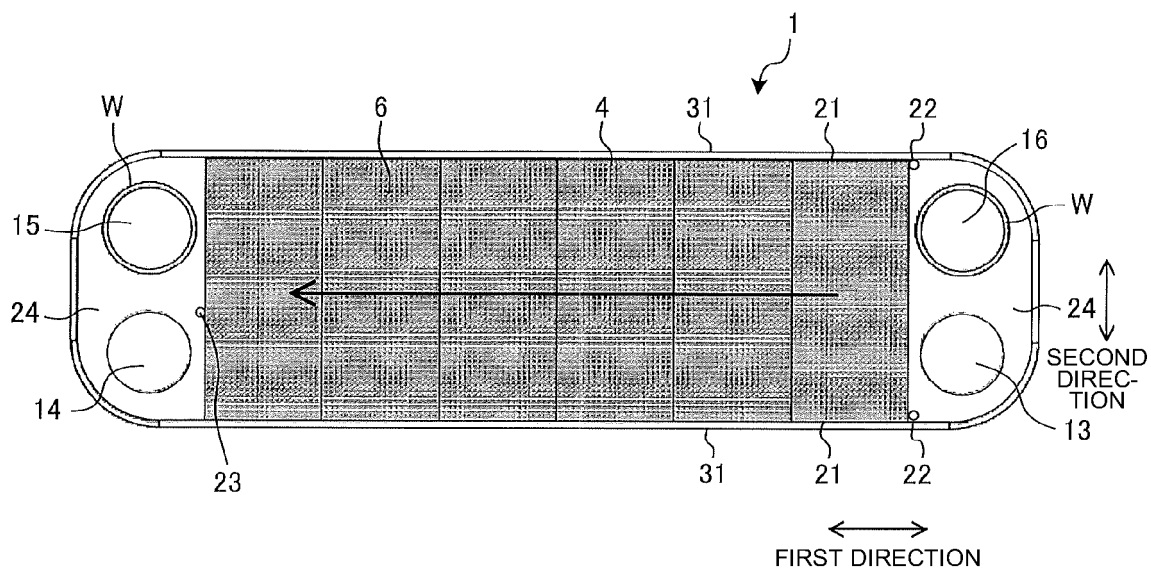


FIG. 3

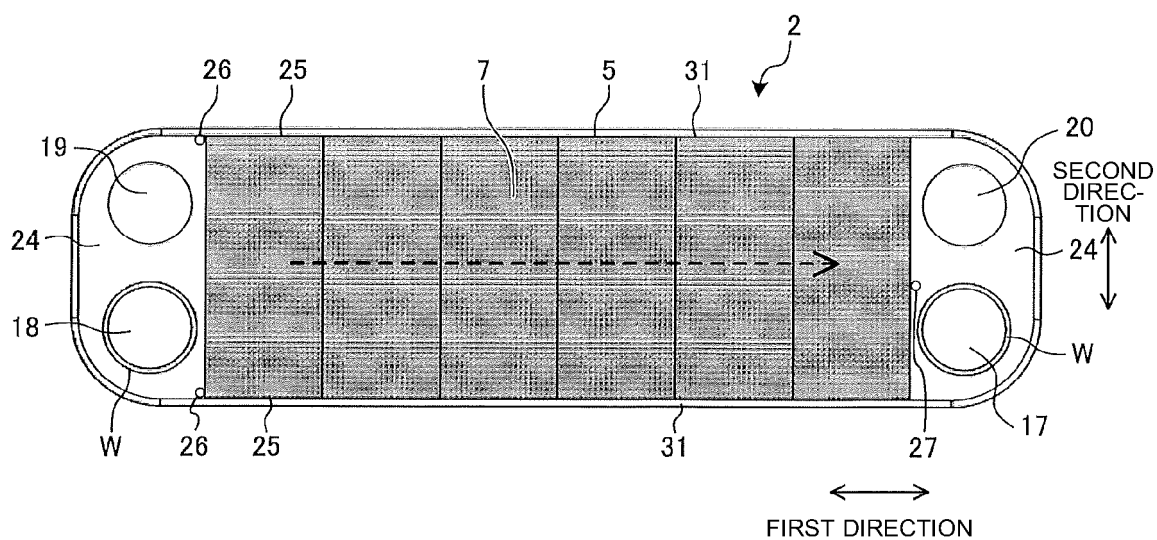


FIG. 4

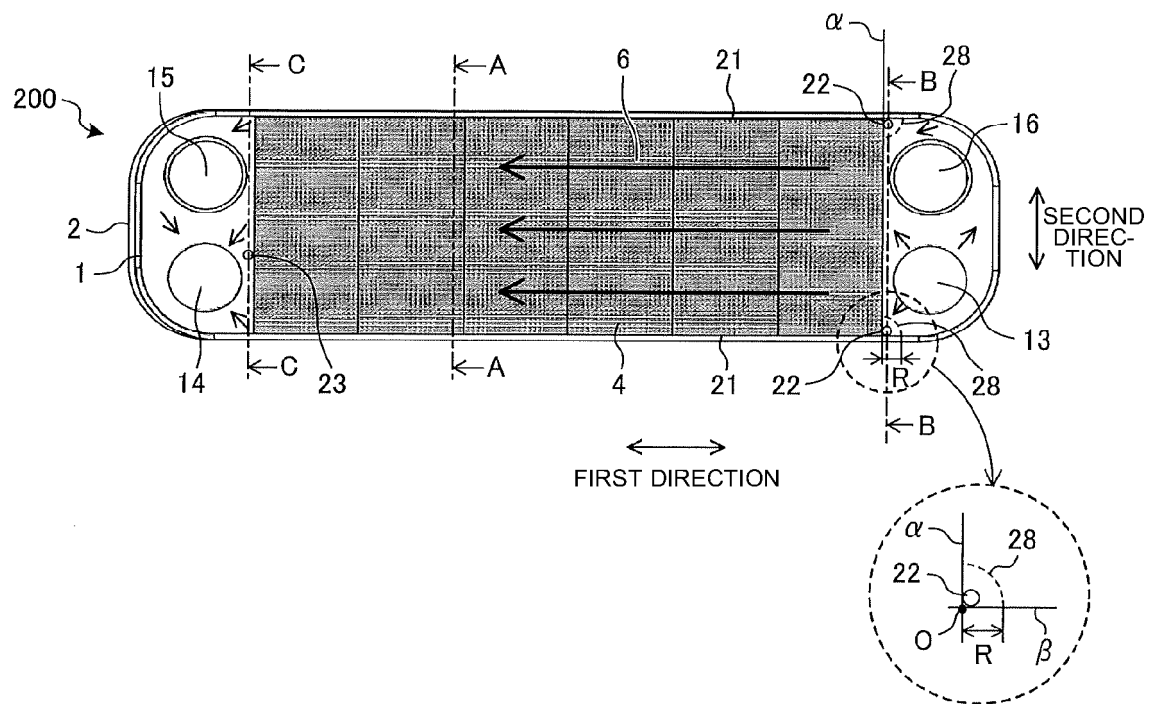


FIG. 5

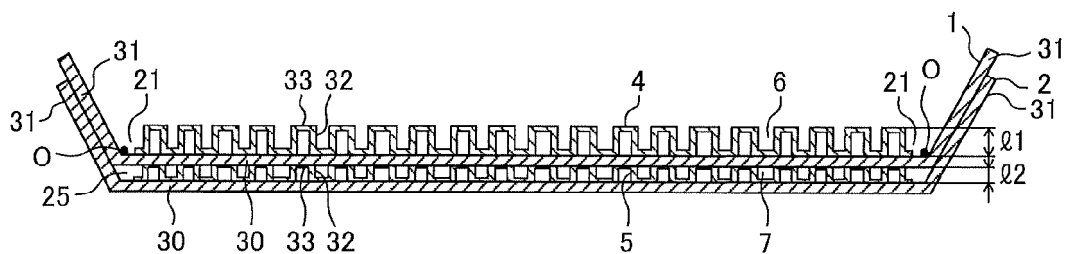


FIG. 6

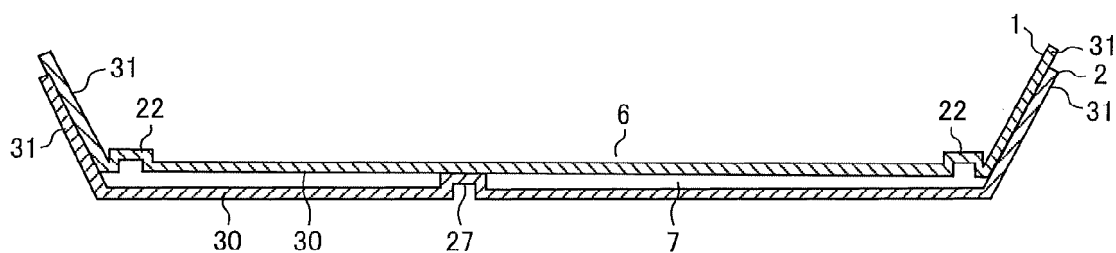


FIG. 7

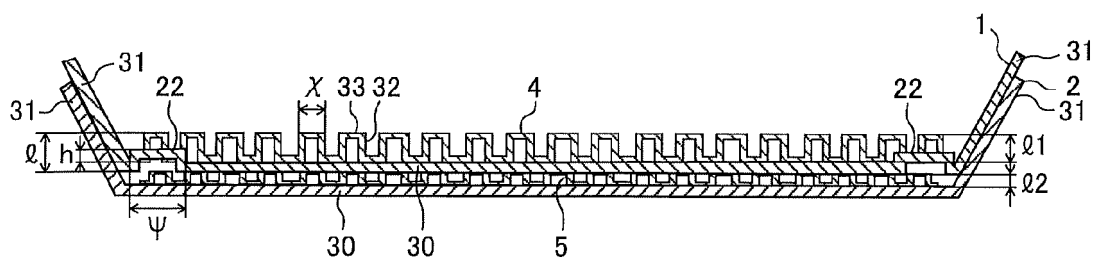


FIG. 8

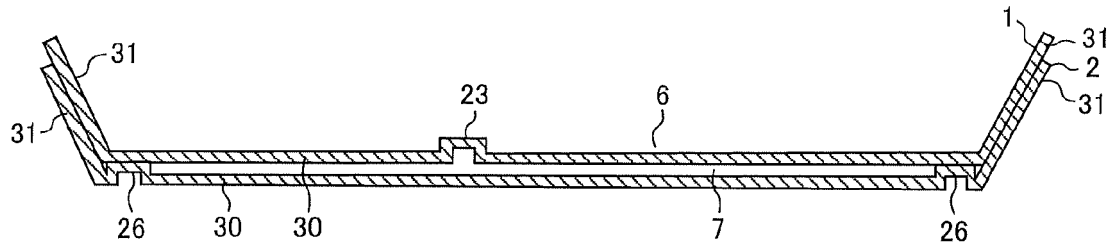


FIG. 9

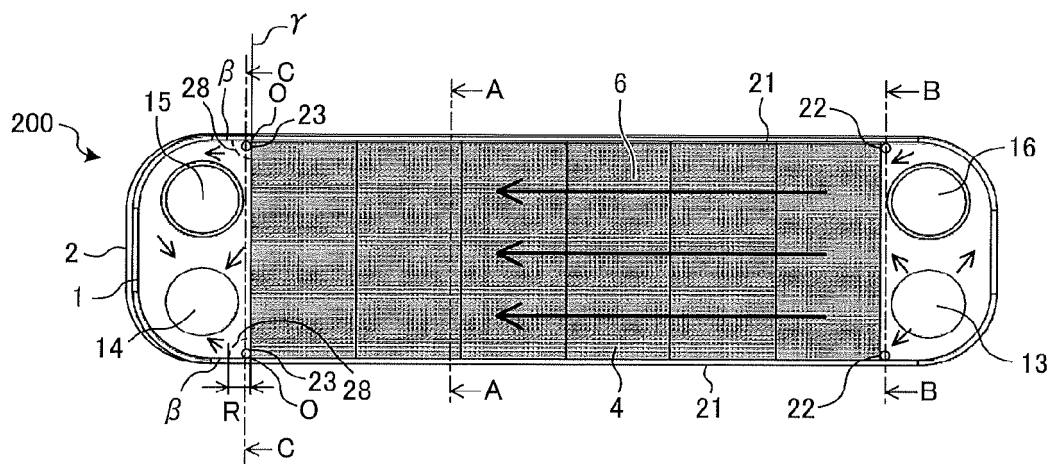


FIG. 10

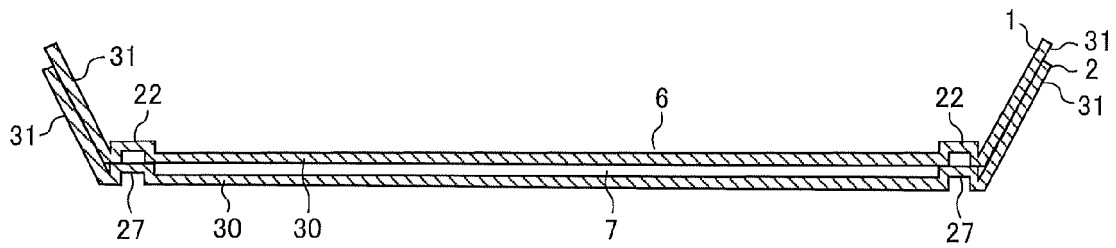


FIG. 11

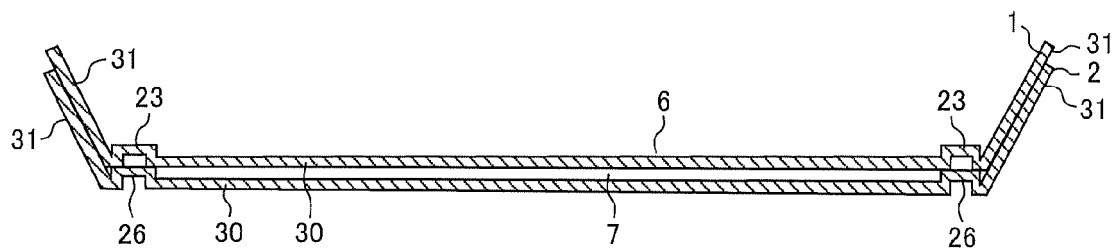


FIG. 12

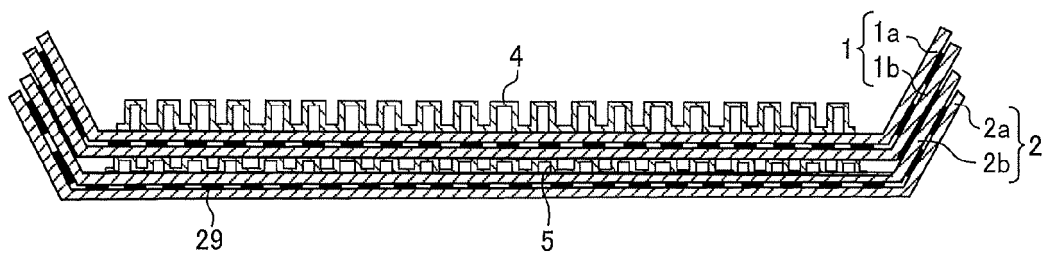


FIG. 13

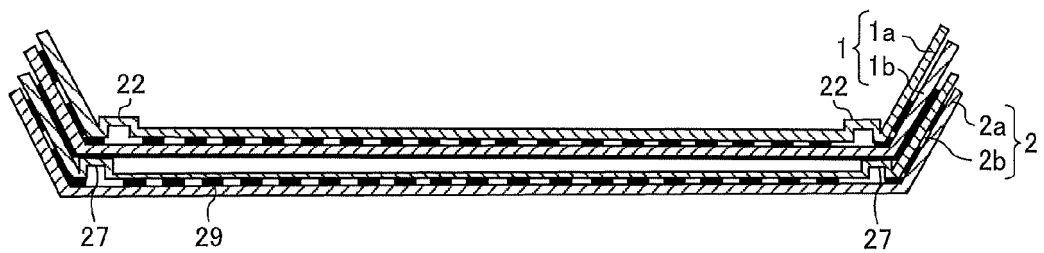


FIG. 14

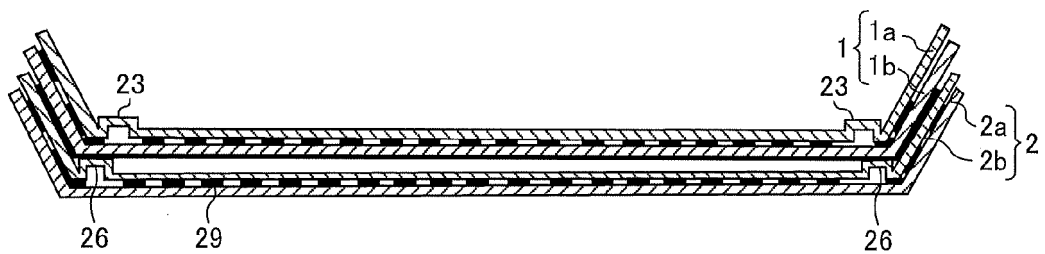


FIG. 15

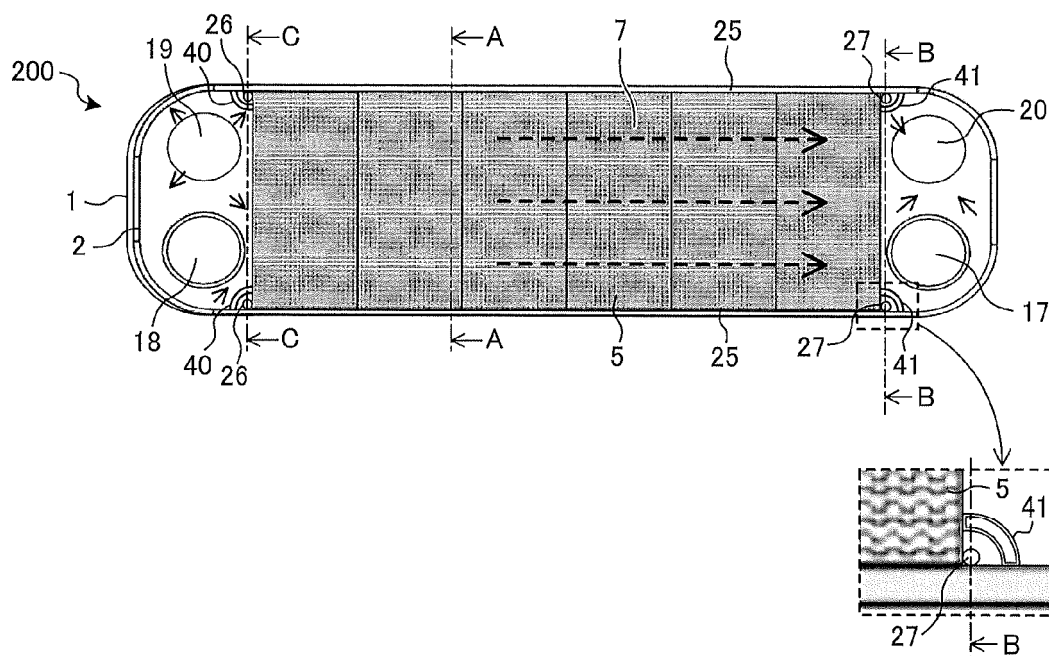


FIG. 16

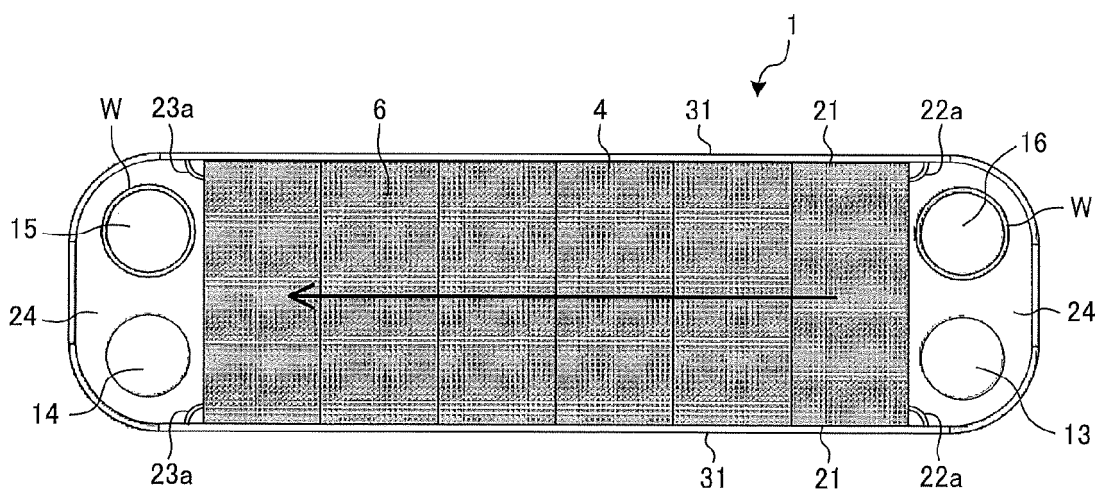


FIG. 17

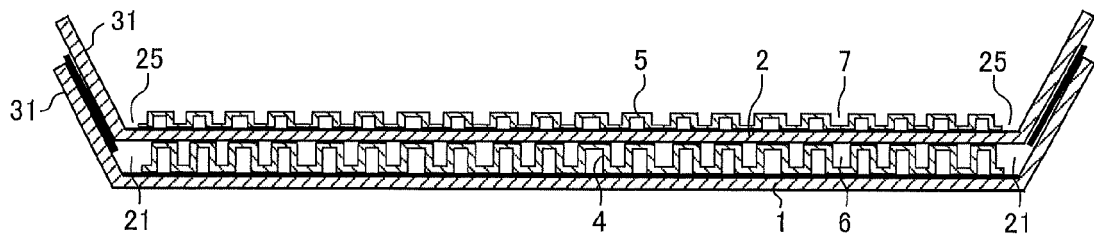


FIG. 18

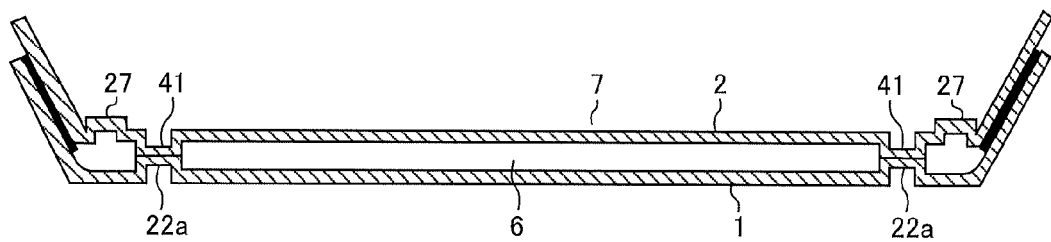


FIG. 19

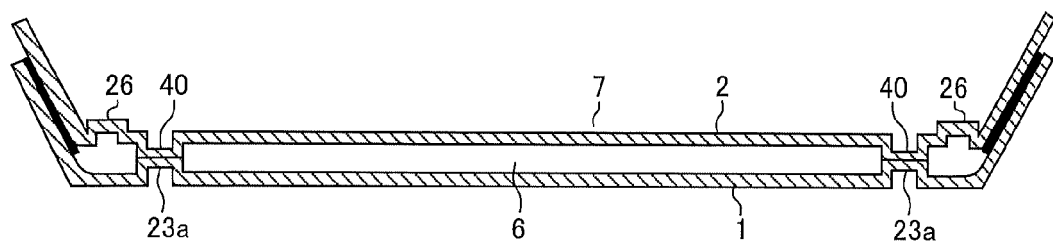


FIG. 20

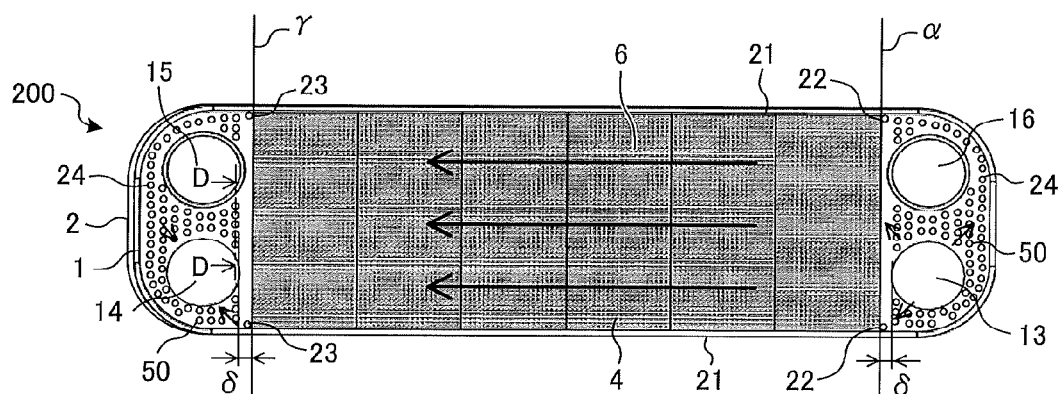


FIG. 21

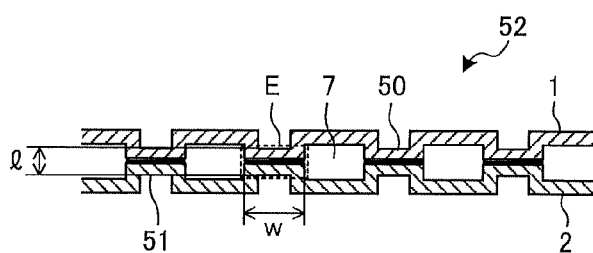


FIG. 22

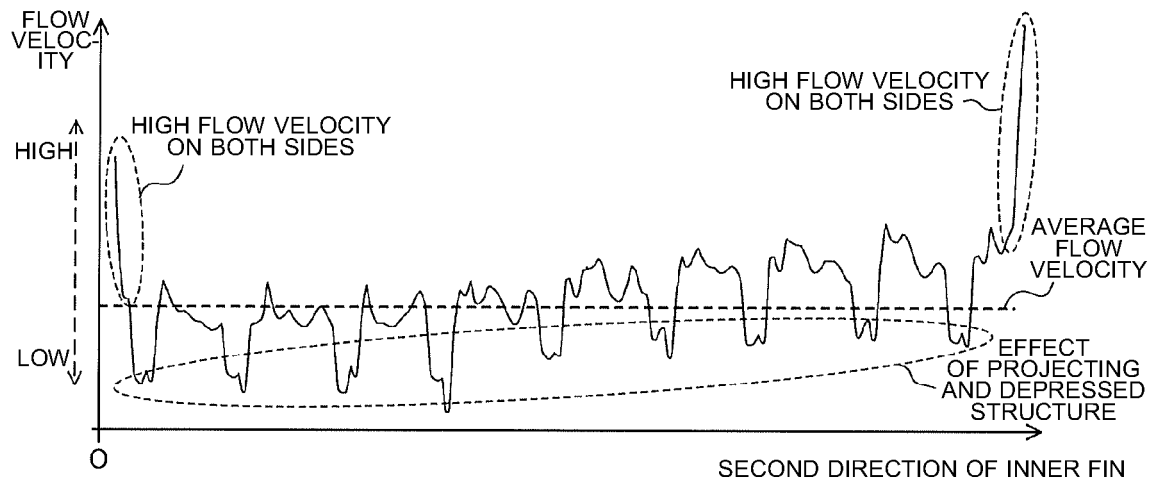


FIG. 23

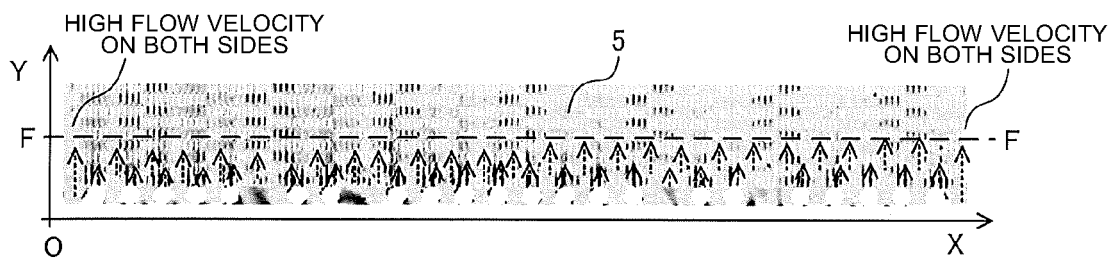


FIG. 24

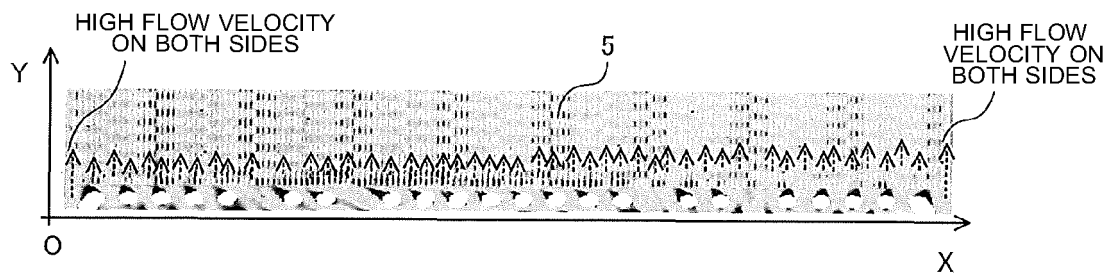


FIG. 25

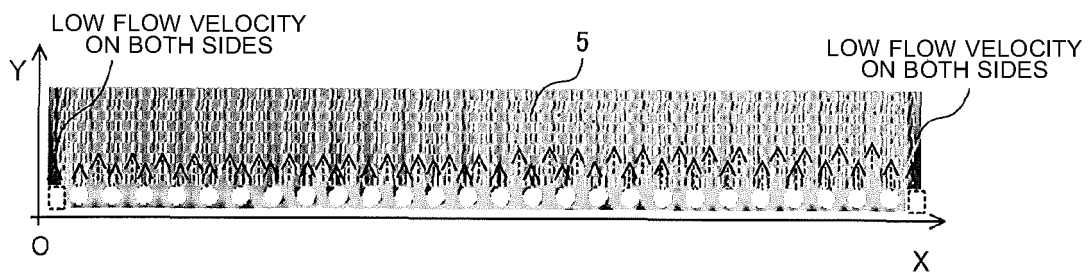
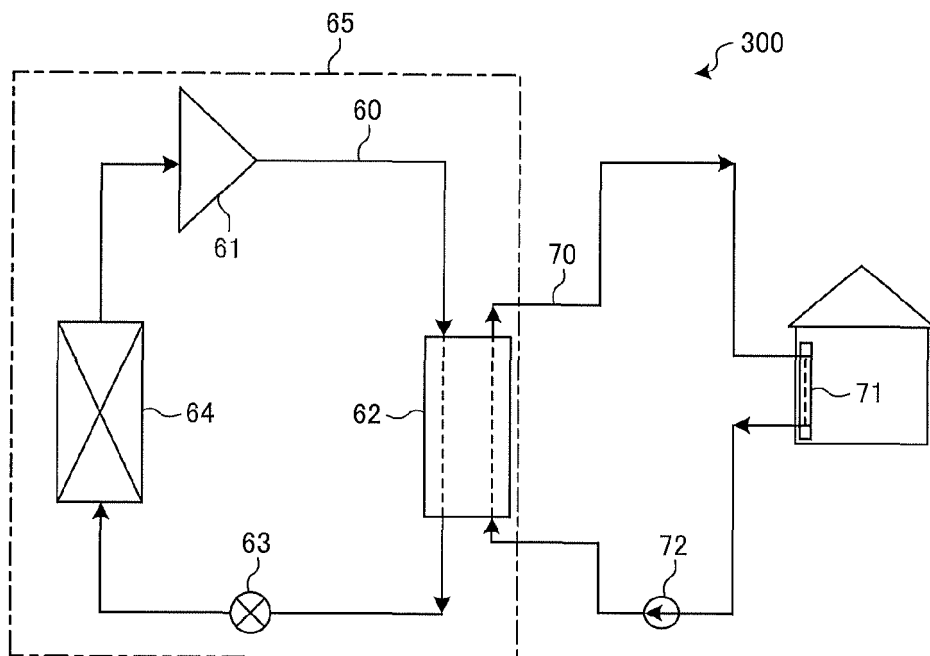


FIG. 26



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/042436

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F28F3/08 (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)

Int. Cl. F28F3/00-3/14, F28D9/00-9/04

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

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	JP 2015-50232 A (DENSO CORP.) 16 March 2015,	1, 4-5, 7-11
Y	paragraphs [0005]-[0043], fig. 1-10 & US	16-20
A	2016/0211192 A1, paragraphs [0010]-[0057], fig. 1-10 & WO 2015/029411 A1 & CN 105493276 A	2-3, 6, 12-15
Y	JP 2908020 B2 (ALFA-LAVAL THERMAL AB) 21 June 1999, column 3, line 13 to column 8, line 16, fig. 1-4 & US 5178207 A, column 1, line 5 to column 5, line 16, fig. 1-4 & WO 91/18253 A1 & EP 483336 A1 & DE 69101297 C & SE 466027 B	16-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

27.12.2018

Date of mailing of the international search report

15.01.2019

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Japan Patent Office
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Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/042436

C (Continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 4-155191 A (HITACHI, LTD.) 28 May 1992, fig. 6 (Family: none)	2

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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