



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
27.01.2016 Bulletin 2016/04

(51) Int Cl.:
F28F 3/06 (2006.01)

(21) Application number: **13878608.2**

(86) International application number:
PCT/JP2013/058210

(22) Date of filing: **22.03.2013**

(87) International publication number:
WO 2014/147804 (25.09.2014 Gazette 2014/39)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventor: **ITO, Daisuke**
Tokyo 100-8310, (JP)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

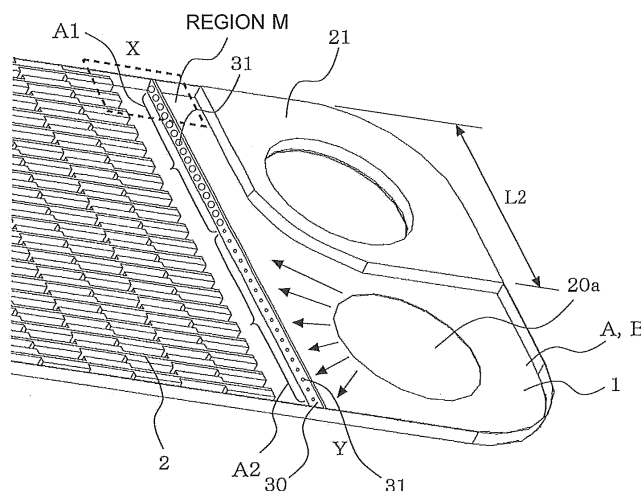
(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

(54) **PLATE-TYPE HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE WITH SAME**

(57) The present invention provides a plate-type heat exchanger in which first flow passages A and second flow passages B are alternately formed between a plurality of heat transfer plates 1 provided at predetermined intervals, and the first flow passages A and the second flow passages B are each provided with an inner fin 2, wherein: each of the plurality of heat transfer plates 1 includes an upstream-side passage hole 20a serving as an inlet of a first fluid to the first flow passage A or as an inlet of a second fluid to the second flow passage B, and a downstream-side passage hole 20b serving as an outlet of the first fluid from the first flow passage A or as an

outlet of the second fluid from the second flow passage B; a sheet-like flow straightening plate 30 is disposed in each of the first flow passages A and the second flow passages B so as to separate between the upstream-side passage hole 20a and the inner fin 2; and the flow straightening plate 30 has a plurality of opening parts 31 serving as a flow passage for the first fluid or the second fluid, and opening areas of the plurality of opening parts 31 are designed so that a flow passage resistance decreases from a side on which a distance to the upstream-side passage hole 20a is smaller toward a side on which the distance is larger in the flow straightening plate 30.

F I G. 3



Description

Technical Field

[0001] The present invention relates to a plate-type heat exchanger and a refrigeration cycle apparatus including the same.

Background Art

[0002] Conventionally, there is a stacked plate-type heat exchanger in which a plurality of heat transfer plates are stacked through an inner fin and different fluids are circulated alternately through flow passages formed between one heat transfer plate and another heat transfer plate so as to exchange heat through the heat transfer plates (e.g., see Patent Literatures 1 and 2).

[0003] This kind of plate-type heat exchanger has a passage hole serving as a fluid inlet, and a fluid flowing in from the passage hole passes through the inner fin. In the inner fin, the fluid flows at a lower velocity on the side farther away from the passage hole and flows at a higher velocity on the side closer to the passage hole. As a result, a flow velocity distribution is likely to occur inside the flow passage, and a region of a low velocity becomes a fluid stagnation part and fails to function as a heat transfer surface. Moreover, the uneven flow causes an increase in pressure loss. Therefore, in Patent Literatures 1 to 3, a flow straightening part for uniformizing the flow velocity distribution is provided.

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Patent No. 59-229193 (page 6, Fig. 4)

Patent Literature 2: Japanese Patent No. 63-140295 (page 6, Fig. 1)

Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2001-41676 (page 2, page 3, Fig. 8 to Fig. 10)

Summary of Invention

Technical Problem

[0005] Both of the flow straightening parts of Patent Literatures 1 and 2 are configured by intricately combining a plurality of sheet-like members, which makes them costly and difficult to produce.

[0006] The flow straightening member of Patent Literature 3 is formed by partially cutting and raising, and molding one sheet-like member, or folding a sheet-like member several times, and therefore further simplification of the structure is desired.

[0007] The present invention has been devised in view of these problems, and an object of the invention is to provide a low-cost plate-type heat exchanger which can uniformize flow velocity distribution with a simple structure and a refrigeration cycle apparatus including this plate-type heat exchanger.

Solution to Problem

[0008] According to the present invention, there is provided a plate-type heat exchanger in which first flow passages and second flow passages are alternately formed between a plurality of heat transfer plates provided at predetermined intervals, and the first flow passages and the second flow passages are each provided with an inner fin, wherein: each of the plurality of heat transfer plates includes an upstream-side passage hole serving as an inlet of a first fluid to the first flow passage or as an inlet of a second fluid to the second flow passage, and a downstream-side passage hole serving as an outlet of the first fluid from the first flow passage or as an outlet of the second fluid from the second flow passage, a sheet-like flow straightening plate is disposed in each of the first flow passages and the second flow passages so as to separate between the upstream-side passage hole and the inner fin, and the flow straightening plate has a plurality of opening parts serving as a flow passage for the first fluid or the second fluid, and opening areas of the plurality of opening parts are designed so that a flow passage resistance decreases from a side on which a distance to the upstream-side passage hole is smaller toward a side on which the distance is larger in the flow straightening plate.

Advantageous Effects of Invention

[0009] According to the plate-type heat exchanger of the present invention, a low-cost plate-type heat exchanger can be obtained which can uniformize flow velocity distribution with a simple structure by virtue of the disposition of the flow straightening plate.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a view showing a typical inner-finned plate-type heat exchanger in an embodiment of the present invention.

[Fig. 2] Fig. 2 is a view showing one example of inner fins 2 of Fig. 1.

[Fig. 3] Fig. 3 is an enlarged perspective view of the major part of Fig. 1.

[Fig. 4] Fig. 4 is a view illustrating a flow straightening plate 30 of Fig. 3.

[Fig. 5] Fig. 5 is a view illustrating Modified Example 1 of the flow straightening plate 30 of Fig. 1.

[Fig. 6] Fig. 6 is a view illustrating Modified Example

2 of the flow straightening plate 30 of Fig. 1.

[Fig. 7] Fig. 7 is a view illustrating Modified Example 3 of the flow straightening plate 30 of Fig. 1.

[Fig. 8] Fig. 8 is a view illustrating Modified Example 4 of the flow straightening plate 30 of Fig. 1.

[Fig. 9] Fig. 9 is a view illustrating Modified Example 5 of the flow straightening plate 30 of Fig. 1.

[Fig. 10] Fig. 10 is an enlarged perspective view of the major part of a plate-type heat exchanger according to Embodiment 2 of the present invention.

[Fig. 11] Fig. 11 is a perspective view of a plate-type heat exchanger according to Embodiment 3 of the present invention.

[Fig. 12] Fig. 12 is a perspective view of a modified example of the plate-type heat exchanger according to Embodiment 3 of the present invention.

[Fig. 13] Fig. 13 is a view showing a refrigerant circuit of a refrigeration cycle apparatus according to Embodiment 4 of the present invention.

Description of Embodiments

Embodiment 1.

[0011] Fig. 1 is a view showing a typical inner-finned plate-type heat exchanger in an embodiment of the present invention. Fig. 2 is a view showing one example of inner fins 2 of Fig. 1. Fig. 3 is an enlarged perspective view of the major part of Fig. 1. In Fig. 1 to Fig. 3 and other drawings to be described later, components given the same reference signs are the same or equivalent components, and this applies throughout the entire text of the specification. The forms of the components represented in the entire text of the specification are mere examples, and the forms of the components are not limited to those described herein.

[0012] The inner-finned plate-type heat exchanger (hereinafter simply referred to as a "plate heat exchanger") has a plurality of heat transfer plates 1 which are flat heat transfer surfaces. The plurality of heat transfer plates 1 are provided at predetermined intervals, and first flow passages A through which a first fluid flows and second flow passages B through which a second fluid flows are alternately formed between the plurality of heat transfer plates 1. In Fig. 1, the flow direction of the first fluid and the flow direction of the second fluid are indicated by the reference signs x and y, respectively. Each of the first flow passages A and the second flow passages B is provided with an inner fin 2 which promotes heat transfer. At both ends in the stacking direction of the plurality of heat transfer plates 1, side plates 3 functioning as a reinforcement are provided, and these side plates 3, the plurality of heat transfer plates 1, and the inner fins 2 are joined integrally as a whole.

[0013] In this example, an offset fin is used as the inner fin 2. The offset fin has a configuration in which ridges and valleys in a plate width direction of a corrugated fin are formed in a staggered manner by being shifted by a

half ridge in the plate width direction at a predetermined pitch in the longitudinal direction of the plate.

[0014] The plurality of heat transfer plates 1 and the two side plates 3 are formed of a substantially rectangular metal flat plate, and a first fluid inflow pipe 4, a first fluid outflow pipe 5, a second fluid inflow pipe 6, and a second fluid outflow pipe 7 are provided at four corners of one of the two side plates 3.

[0015] Each heat transfer plate 1 has a first opening 11, a second opening 12, a third opening 13, and a fourth opening 14 formed at positions corresponding to the first fluid inflow pipe 4, the first fluid outflow pipe 5, the second fluid inflow pipe 6, and the second fluid outflow pipe 7. These first opening 11, second opening 12, third opening 13, and fourth opening 14 form an inflow port of the first flow passage A, an outflow port of the first flow passage A, an inflow port of the second flow passage B, and an outflow port of the second flow passage B, respectively.

[0016] In the heat transfer plate 1, a cover part 21 (see Fig. 3) is provided around the first opening 11 and the second opening 12 or around the third opening 13 and the fourth opening 14. This cover part 21 seals the third opening 13 and the fourth opening 14 in the first flow passage A where the first fluid flows, and seals the first opening 11 and the second opening 12 in the second flow passage B where the second fluid flows. Thus, inflow of the second fluid into the first flow passage A is blocked, as well as inflow of the first fluid into the second flow passage B is blocked.

[0017] Hereinafter, of the four openings formed in the heat transfer plate 1, openings communicating with the inner fin 2 will be referred to as passage holes. Accordingly, the third opening 13 and the fourth opening 14 are the passage holes in the first flow passage A, while the first opening 11 and the second opening 12 are passage holes in the second flow passage B. Hereinafter, of the two passage holes provided in one heat transfer plate 1, the passage hole serving as a fluid inlet will be referred to as an upstream-side passage hole 20a, and the passage hole serving as a fluid outlet will be referred to as a downstream-side passage hole 20b. Hereinafter, where no distinction is made between the first flow passage A and the second flow passage B, these will be simply referred to as flow passages. Similarly, where no distinction is made between the first fluid and the second fluid, these will be simply referred to as fluids.

[0018] The fluid flowing into the flow passage from the upstream-side passage hole 20a flows generally at a higher velocity in the vicinity of the upstream-side passage hole 20a and at a lower velocity at a distance from the upstream-side passage hole 20a. As a result, the fluid does not flow easily to a region M which is at a large distance from the upstream-side passage hole 20a, so that the fluid stagnates in the region M. Thus, as the flow rate of the fluid flowing from the region M toward the downstream side decreases, the effective heat transfer area decreases.

[0019] To remedy such non-uniformity in flow rate dis-

tribution due to the unevenness of the flow velocity distribution in the short direction (X-Y direction in Fig. 3) of the heat transfer plate 1, the present invention has adopted the following configuration. That is, a sheet-like flow straightening plate 30 for uniformizing flow velocity is disposed in each of the first flow passages A and the second flow passages B between the upstream-side passage hole 20a and the inner fin 2. The flow straightening plate 30 is disposed in the heat transfer plate 1 so as to separate between the upstream-side passage hole 20a and the inner fin 2.

[0020] Fig. 4 is a view illustrating the flow straightening plate 30 of Fig. 3, in which Fig. 4(a) is a front view, Fig. 4(b) is a cross-sectional view along the line A-A of Fig. 4(a), and Fig. 4(c) is a side view. Fig. 4 is a view illustrating the features of the flow straightening plate 30 of Fig. 3, and the number, scale, etc. of opening parts 31 do not exactly correspond to those of Fig. 3. The same applies to the drawings illustrating the flow straightening plate 30 to be described later.

[0021] In the flow straightening plate 30, the plurality of opening parts 31 are formed at intervals in the separation direction of the flow straightening plate 30 (longitudinal direction of the flow straightening plate 30). In the flow straightening plate 30, the opening areas of the plurality of opening parts 31 are designed so that the flow passage resistance of the flow straightening plate 30 decreases from the side on which the distance to the upstream-side passage hole 20a is smaller toward the side on which the distance is larger. More specifically, the opening areas of the plurality of opening parts 31 increase in the order of their positions from the side on which the distance to the upstream-side passage hole 20a is smaller toward the side on which the distance is larger in the flow straightening plate 30.

[0022] In Fig. 4, the plurality of opening parts 31 (31 a, 31 b) are circular in this example, and the diameter of the opening parts 31 a on the side of a region A1 which is farther away from the upstream-side passage hole 20a is larger than the diameter of the opening parts 31 b on the side of a region A2 which is closer to the upstream-side passage hole 20a. While the opening areas are designed in two stages in this example, the number of stages is not limited to two and may be made in a larger number of stages.

[0023] Due to this configuration, the opening area of the opening parts 31 a located on the side of the region A1 farther away from the upstream-side passage hole 20a is larger than the opening area of the opening parts 31 b located on the side of the region A2 closer to the upstream-side passage hole 20a. Accordingly, in the flow straightening plate 30, the flow passage resistance on the side of the region A1 where the flow velocity is lower is smaller than the flow passage resistance on the side of the region A2 where the flow velocity is higher, so that the fluid flows more easily to the region M. Thus, it is possible to uniformize the flow velocity in the X-Y direction and remedy the fluid stagnation in the region M. As

a result, since the portion downstream from the region M in the heat transfer plate 1 is allowed to function as a heat transfer surface, the effective heat transfer area can be increased.

[0024] Here, a length L1 in the X-Y direction of the region A1 where the opening parts 31 are larger should be shorter than a length L2 in the same direction of the cover part 21. Since the flow passage formed by the cover part 21 and the flow straightening plate 30 is narrower than the flow passage between the upstream-side passage hole 20a and the flow straightening plate 30, the fluid does not flow easily to the region M. For this reason, the flow straightening plate 30 is provided with the region of the length L1 having a smaller resistance; however, if the length L1 is larger than the length L2, the fluid flows out of the opening parts 31 inside the region of the length L1 on the near side before flowing into the region M, which makes it difficult to uniformize the velocity. If the length L1 is smaller than the length L2, the velocity can be further uniformized compared with the case of $L1 > L2$.

[0025] While the cover part 21 creates a resistance to the fluid flowing toward the region M, in the present invention, the opening areas in the flow straightening plate 30 can be designed so as to reduce the increase in pressure loss due to this resistance. This is effective for the remedy of unevenness in flow velocity distribution. The shapes of the opening parts 31 are not limited to circular but may be square, rectangular, etc. In Fig. 4, the diameters of the opening parts 31 a in the region A1 are all the same, and the diameters of the opening parts 31 b in the region A2 are all the same as well, but the diameters may be gradually increased as the distance from the upstream-side passage hole 20a increases.

[0026] Here, if the flow straightening plate 30 is not provided, an increase in flow velocity due to the uneven flow would contribute to an increase in pressure loss. However, it is possible to reduce the pressure loss by disposing the flow straightening plate 30 since an increase in flow velocity due to the uneven flow can be suppressed.

[0027] As has been described so far, in Embodiment 1, the sheet-like flow straightening plate 30 is disposed between the upstream-side passage hole 20a and the inner fin 2 provided in the heat transfer plate 1 so as to separate between them. The plurality of opening parts 31 are provided at intervals in the separation direction in the flow straightening plate 30. Moreover, the opening areas of the plurality of opening parts 31 are designed so that the flow passage resistance to the fluid while passing through the flow straightening plate 30 is smaller on the side farther away from the upstream-side passage hole 20a than on the side closer to the upstream-side passage hole 20a. Thus, it is possible to uniformize the flow velocity distribution, remedy the unevenness in flow rate on the inlet side of the inner fin 2, and achieve an increase of the effective heat transfer area and a reduction of the pressure loss.

[0028] Since the flow straightening plate 30 is simply

structured with a sheet-like member having holes bored therein, the production is easy and the effect of the increased effective heat transfer area and the reduced pressure loss can be obtained at low cost, as well as a weight reduction can be achieved.

[0029] Moreover, since the flow straightening plate 30 is simply structured with a sheet-like member having holes bored therein, the size of each opening part 31 can also be easily adjusted to uniformize the flow velocity distribution. While producing the flow straightening plate 30 as a single part is also inexpensive, molding the flow straightening plate 30 integrally with the inner fin 2 is more inexpensive, as the number of parts is reduced in that way. The flow straightening plate 30 can be joined on the heat transfer plate 1 by brazing, and the plate-type heat exchanger can be manufactured inexpensively by integral brazing.

[0030] In the flow straightening plate 30, partition walls, which are portions between each two opening parts 31, have an effect of mixing the fluid passing through the opening parts 31, which in turn has a favorable effect on uniformization of the flow velocity.

[0031] Since the flow straightening plate 30 is disposed upright so as to separate between the upstream-side passage hole 20a and the inner fin 2, the flow straightening plate 30, which functions as a distribution improving mechanism, requires no large space for installation but can be installed in a small space.

[0032] The region M where stagnation is likely to occur is a portion where the flow velocity of a fluid is low if the flow straightening plate 30 is not provided. Therefore, when the fluid is water and the plate-type heat exchanger is used as an evaporator, the temperature decreases locally and the region M becomes a freezing starting point. In Embodiment 1, by contrast, freezing can be suppressed since the flow velocity of the fluid in the region M can be increased, so that quality improvement can be achieved.

[0033] Thus, since the plate-type heat exchanger of Embodiment 1 has advantages such as high heat transfer efficiency, low pressure loss, and high reliability, CO₂ refrigerant having a low evaporation capacity, hydrocarbon refrigerant having a large pressure loss, and flammable refrigerant such as a low GWP refrigerant become also available.

[0034] Since the offset fin is used as the inner fin 2, the following effects can be obtained. The offset fin is a heat transfer promotion body having low pressure loss, and due to its small resistance, the fluid flows easily in a linear manner. Therefore, if the flow straightening plate 30 is not provided and the fluid does not flow into the region M, almost no fluid would flow to the region downstream from the region M. In this case, the effective heat transfer area is reduced as described above. However, it is possible to achieve a reduction of the pressure loss and an increase of the effective heat transfer area by using the offset fin having low pressure loss as a heat transfer surface, and further combining it with the flow

straightening plate 30.

[0035] On the other hand, a leading edge effect of the offset fin allows enhanced heat transfer as well as suppression of increase in pressure loss. The leading edge effect refers to an effect that is realized by preferentially using a leading edge portion of a flat plate as a heat transfer part based on the property that the heat transfer rate is favorable at the leading edge portion of the flat plate. That is, when a flat plate is placed in a flow, the boundary layer is thin at the leading edge of the flat plate, and the thickness increases toward the downstream side. Accordingly, the heat transfer is favorable at the leading edge portion of the flat plate where the boundary layer is thin.

[0036] Since each of the flow straightening plate 30, the offset fin, the heat transfer plate 1 being a flat heat transfer surface can be produced by pressing, a plate-type heat exchanger having low pressure loss and high heat transfer performance can be manufactured inexpensively. If the plate-type heat exchanger has low pressure loss, the power required for activating a fluid is reduced. Accordingly, the capacity of a pump and a compressor serving as a power source for circulating the fluid into the plate-type heat exchanger can be reduced.

[0037] While the above-described effects can be obtained when the offset fin is used as the inner fin 2, the inner fin of the present invention is not limited to the offset fin. The inner fin 2 of the present invention is not limited to the fin which is formed separately from the heat transfer plate 1, but also includes a fin which is formed, for example, by corrugating the surface of the heat transfer plate 1.

[0038] An equal distribution of the flow rate is required on the inlet side of the flow passage, and is not required on the outlet side. Therefore, instead of providing the flow straightening plate 30 on both inlet side and outlet side, providing the flow straightening plate 30 only on the inlet side can reduce the cost.

[0039] The number, shape, and disposition of the opening parts 31 of the flow straightening plate 30 are not limited to those in the structure shown in Fig. 1, and various modifications can be made, for example, as shown in the following Modified Examples 1 to 4. Each of these modified examples has a configuration in which the plurality of or one opening part 31 is formed so that the flow passage resistance to a fluid while passing through the flow straightening plate 30 is smaller on the side farther away from the upstream-side passage hole 20a than on the side closer to the upstream-side passage hole 20a. Each of the modified examples has an effect of uniformizing the flow velocity.

(Modified Example 1)

[0040] Fig. 5 is a view illustrating Modified Example 1 of the flow straightening plate 30 of Fig. 3, in which Fig. 5(a) is a front view, Fig. 5(b) is a cross-sectional view along the line A-A of Fig. 5(a), and Fig. 5(c) is a side view.

[0041] While in Fig. 4 the plurality of opening parts 31 are provided in each of the region A1 and the region A2, only one opening part 31 (31 a, 31 b) may be provided in each of the region A1 and the region A2. Fig. 5 shows an example in which the shape of the opening part 31 is rectangular. In this configuration, as with in Fig. 4, the opening area of the opening part 31 a on the side of the region A1 farther away from the upstream-side passage hole 20a is larger than the opening area of the opening part 31 b on the side of the region A2 closer to the upstream-side passage hole 20a.

(Modified Example 2)

[0042] Fig. 6 is a view illustrating Modified Example 2 of the flow straightening plate 30 of Fig. 3, in which Fig. 6(a) is a front view, Fig. 6(b) is a cross-sectional view along the line A-A of Fig. 6(a), and Fig. 6(c) is a side view.

[0043] While in Fig. 4 the diameters of the opening parts 31 are different between the region A1 and the region A2, in Fig. 6, the diameters are all the same and the number of the opening parts 31 disposed increases as the distance to the upstream-side passage hole 20a increases. In the above-described embodiment, the opening areas of the opening parts 31 are increased in two stages, from the side on which the distance to the upstream-side passage hole 20a is smaller toward the side on which the distance is larger. However, the number of stages is not limited to two, and Fig. 6 shows an example of three stages.

(Modified Example 3)

[0044] Fig. 7 is a view illustrating Modified Example 3 of the flow straightening plate 30 of Fig. 3, in which Fig. 7(a) is a front view, Fig. 7(b) is a cross-sectional view along the line A-A of Fig. 7(a), and Fig. 7(c) is a side view.

[0045] In Fig. 7, the number of the opening parts 31 is one, and the opening area increases from the side on which the distance to the upstream-side passage hole 20a is smaller toward the side on which the distance is larger in the flow straightening plate 30.

(Modified Example 4)

[0046] In Modified Example 4, by virtue of the external shape of the flow straightening plate 30, the flow passage resistance to a fluid while passing through the portion of the flow straightening plate 30 is smaller on the side farther away from the upstream-side passage hole 20a than on the side closer to the upstream-side passage hole 20a.

[0047] Fig. 8 is a view illustrating Modified Example 4 of the flow straightening plate 30 of Fig. 3, in which Fig. 8(a) is a front view, Fig. 8(b) is a plan view, and Fig. 8(c) is a side view.

[0048] The flow straightening plate 30 of Fig. 8 is formed so that the height of the flow straightening plate 30 in the stacking direction (left-right direction in Fig. 1)

decreases from the side on which the distance to the upstream-side passage hole 20a is smaller toward the side on which the distance is larger in the flow straightening plate 30.

[0049] While the flow straightening plates 30 shown in Fig. 3 to Fig. 8 have a simple sheet-like shape, the flow straightening plate 30 may be configured as in Modified Example 5 shown in Fig. 9.

(Modified Example 5)

[0050] Fig. 9 is a view illustrating Modified Example 5 of the flow straightening plate 30 of Fig. 3, in which Fig. 9(a) is a front view, Fig. 9(b) is a cross-sectional end view along the line A-A of Fig. 9(a), and Fig. 9(c) is a side view.

[0051] This flow straightening plate 30 has a pair of leg portions 32 which extend parallel to each other in a direction orthogonal to the flow straightening plate 30 from both ends in the short direction (direction orthogonal to the separation direction) of the flow straightening plate 30.

[0052] As each of the pair of leg portions 32 serves a joint surface between the flow straightening plate 30 and the heat transfer plate 1, the flow straightening plate 30 serves as a support column. Then, it is possible to adjust the area of the joint surface between the pair of leg portions 32 and the heat transfer plate 1 according to the required strength by adjusting the lengths of the pair of leg portions 32. Thus, it is possible to enhance the strength around the upstream-side passage hole 20a to the required strength by adjusting the lengths of the pair of leg portions 32 according to the strength required for the area around the passage hole where the strength against detachment is low, and using the adjusted pair of leg portions 32 as the joint surface.

[0053] When molding the flow straightening plate 30 into the shape shown in Fig. 9, pressing allows low-cost manufacturing since the flow straightening plate 30 can be produced by one pressing.

Embodiment 2.

[0054] Embodiment 2 is different from Embodiment 1 in terms of the disposition of the flow straightening plate 30. Embodiment 2 is otherwise the same as Embodiment 1. The modified examples applicable to the same component parts as those of Embodiment 1 shall be similarly applicable to Embodiment 2.

[0055] Fig. 10 is an enlarged perspective view of the major part of the plate-type heat exchanger according to Embodiment 2 of the present invention.

[0056] In Embodiment 2, the flow straightening plate 30 is provided at an angle on the heat transfer plate 1 so that the clearance between the flow straightening plate 30 and the inner fin 2 decreases from the side closer to the upstream-side passage hole 20a toward the side farther away from the upstream-side passage hole 20a.

[0057] With this configuration, the same effects as in

Embodiment 1 can be obtained, as well as the fluid flowing into the flow passage from the upstream-side passage hole 20a can be guided to the region M. Thus, the fluid flows more easily to the region M than in the case where the flow straightening plate 30 is disposed orthogonally to the flow direction as in Embodiment 1. Therefore, a finer adjustment of the flow velocity distribution is made possible by the adjustment of the inclination angle of the flow straightening plate 30 of Embodiment 2 in addition to the designing of the opening areas of the opening parts 31 of Embodiment 1.

Embodiment 3.

[0058] In Embodiments 1 and 2 described above, the flow straightening plate 30 is disposed in each of the first flow passages A and the second flow passages B between the upstream-side passage hole 20a and the inner fin 2. In Embodiment 3, the flow straightening plate 30 is disposed between the downstream-side passage hole 20b and the inner fin 2 as well. Embodiment 3 is otherwise the same as Embodiments 1 and 2. The modified examples applicable to the same component parts as those of Embodiment 1 shall be similarly applicable to Embodiment 3.

[0059] Fig. 11 is a perspective view of the plate-type heat exchanger according to Embodiment 3 of the present invention.

[0060] As shown in Fig. 11, the flow straightening plate 30 is disposed between the downstream-side passage hole 20b and the inner fin 2 as well.

[0061] According to Embodiment 3, the same effects as Embodiments 1 and 2 can be obtained, and since the flow straightening plate 30 is disposed on both of the upstream side and the downstream side, the distribution is improved not only on the inlet side but also on the outlet side. Therefore, compared with the case where the flow straightening plate 30 is disposed only at the inlet, higher effects can be obtained in terms of an increase of the effective heat transfer area, a reduction of the pressure loss, and suppression of freezing.

[0062] Moreover, since the flow straightening plates 30 are located at the outlet and the inlet of the flow passage, this plate-type heat exchanger is effective when applied to a device in which the flow direction of a fluid inside a heat exchanger switches to the opposite direction, such as an air-conditioning device capable of switching between cooling and heating or an air-conditioning device capable of cooling and heating simultaneous operation.

[0063] In a case where a fluid undergoes a phase change inside the plate-type heat exchanger and the density of the fluid changes between the inlet side and the outlet side, the total opening area of the opening parts 31 (the total of the opening areas of all the opening parts 31) may be varied according to the change in density between the flow straightening plate 30 on the inlet side and the flow straightening plate 30 on the outlet side. For

example, in a case where the fluid on the inlet side is a liquid and the fluid on the outlet side is steam (that is, the density is lower than the liquid and a large pressure loss is likely to occur during passage through the opening parts 31), as shown in Fig. 12, the total opening area of the flow straightening plate 30 on the outlet side (on the left side in Fig. 12) may be larger than the total opening area of the flow straightening plate 30 on the inlet side (on the right side in Fig. 12). Thus, the pressure loss can be reduced.

Embodiment 4.

[0064] Embodiment 4 relates to a refrigeration cycle apparatus to which the plate-type heat exchanger of any one of Embodiment 1 to Embodiment 3 is applied.

[0065] Fig. 13 is a view showing a refrigerant circuit of a refrigeration cycle apparatus 40 according to Embodiment 4 of the present invention.

[0066] The refrigeration cycle apparatus 40 is a typical refrigeration cycle apparatus which includes a compressor 41, a condenser (including a gas cooler) 42, an expansion device 43, and an evaporator 44. As one or both of the condenser 42 and the evaporator 44 of the refrigeration cycle apparatus 40, the plate-type heat exchanger of any one of Embodiment 1 to Embodiment 3 is applied.

[0067] According to Embodiment 4, it is possible to obtain the low-cost refrigeration cycle apparatus 40, which has high reliability and energy saving performance, by including the plate-type heat exchanger of Embodiment 1 to Embodiment 3. The refrigerant circuit shown in Fig. 13 is an example, and the refrigerant circuit to which the plate-type heat exchanger of the present invention is applied is not limited to the configuration of Fig. 13. For example, the refrigerant circuit may be a circuit which is provided with a four-way valve and can switch between cooling and heating, or a circuit which is capable of cooling and heating simultaneous operation.

[0068] Examples of applications of the present invention include many industrial and household appliances equipped with a plate-type heat exchanger, such as an air-conditioner, a power generator, and a heat-sterilization treatment apparatus for food.

Reference Signs List

[0069] 1 heat transfer plate 2 inner fin 3 side plate 4 inflow pipe 5 outflow pipe 6 inflow pipe 7 outflow pipe 11 first opening 12 second opening 13 third opening 14 fourth opening 20a upstream-side passage hole 20b downstream-side passage hole 21 cover part 30 flow straightening plate 31 opening part 31 a opening part 31 b opening part 32 leg portion 40 refrigeration cycle apparatus 41 compressor 42 condenser 43 expansion device 44 evaporator A first flow passage A1 region A2 region B second flow passage M region

Claims

1. A plate-type heat exchanger in which first flow passages and second flow passages are alternately formed between a plurality of heat transfer plates provided at predetermined intervals, and the first flow passages and the second flow passages are each provided with an inner fin, wherein each of the plurality of heat transfer plates includes an upstream-side passage hole serving as an inlet of a first fluid to the first flow passage or as an inlet of a second fluid to the second flow passage, and a downstream-side passage hole serving as an outlet of the first fluid from the first flow passage or as an outlet of the second fluid from the second flow passage, a sheet-like flow straightening plate is disposed in each of the first flow passages and the second flow passages so as to separate between the upstream-side passage hole and the inner fin, and the flow straightening plate has a plurality of opening parts serving as a flow passage for the first fluid or the second fluid, and opening areas of the plurality of opening parts are designed so that a flow passage resistance decreases from a side on which a distance to the upstream-side passage hole is smaller toward a side on which the distance is larger in the flow straightening plate.
2. The plate-type heat exchanger of claim 1, wherein the flow straightening plate is disposed in the first flow passages and the second flow passages so that a clearance between the flow straightening plate and the inner fin decreases from a side on which a distance between the flow straightening plate and the upstream-side passage hole is smaller toward a side on which the distance is larger.
3. The plate-type heat exchanger of claim 1 or 2, wherein the opening areas of the plurality of opening parts increase in an order of their positions from a side on which a distance between the plurality of opening parts and the upstream-side passage hole is smaller toward a side on which the distance is larger.
4. The plate-type heat exchanger of claim 1 or 2, wherein the plurality of opening parts have the same size, and the number of the plurality of opening parts disposed in the flow straightening plate increases from the side on which the distance between the flow straightening plate and the upstream-side passage hole is smaller toward the side on which the distance is larger in the flow straightening plate.
5. The plate-type heat exchanger of any one of claims 1 to 4, wherein the inner fin is an offset fin.
6. The plate-type heat exchanger of any one of claims 1 to 5, further comprising an additional flow straightening plate between the downstream-side passage hole and the inner fin.
7. The plate-type heat exchanger of any one of claims 1 to 5, further comprising an additional flow straightening plate in which shapes of the plurality of opening parts are the same as those of the flow straightening plate, while a total opening area is different from that of the flow straightening plate, between the downstream-side passage hole and the inner fin.
8. The plate-type heat exchanger of claim 7, wherein a total opening area of one flow straightening plate of the two flow straightening plates through which a fluid passes at a lower density is larger than a total opening area of an other flow straightening plate through which a fluid passes at a higher density.
9. The plate-type heat exchanger of any one of claims 1 to 8, wherein the flow straightening plate further includes a pair of leg portions extending parallel to each other in a direction orthogonal to the flow straightening plate from both ends in a direction orthogonal to a separation direction of the flow straightening plate, and the pair of leg portions serve as a joint surface between the flow straightening plate and each of the heat transfer plates.
10. A plate-type heat exchanger in which first flow passages and second flow passages are alternately formed between a plurality of stacked heat transfer plates, and the first flow passages and the second flow passages are each provided with an inner fin, wherein each of the plurality of heat transfer plates includes an upstream-side passage hole serving as an inlet of a first fluid to the first flow passage or as an inlet of a second fluid to the second flow passage, and a downstream-side passage hole serving as an outlet of the first fluid from the first flow passage or as an outlet of the second fluid from the second flow passage, a flow straightening plate is disposed in each of the first flow passages and the second flow passages so as to separate between the upstream-side passage hole and the inner fin, the flow straightening plate has one opening part extending in a separation direction of the flow straightening plate, and an opening area of the opening part is designed so that a flow passage resistance decreases from a side on which a distance to the upstream-side passage hole is smaller toward a side on which the distance is larger in the flow straightening plate.
11. A plate-type heat exchanger in which first flow pas-

sages and second flow passages are alternately formed between a plurality of stacked heat transfer plates, and the first flow passages and the second flow passages are each provided with an inner fin, wherein

each of the plurality of heat transfer plates includes an upstream-side passage hole serving as an inlet of a first fluid to the first flow passage or as an inlet of a second fluid to the second flow passage, and a downstream-side passage hole serving as an outlet of the first fluid from the first flow passage or as an outlet of the second fluid from the second flow passage,

a flow straightening plate is disposed in each of the first flow passages and the second flow passages so as to separate between the upstream-side passage hole and the inner fin, and

a height of the flow straightening plate decreases from a side on which a distance to the upstream-side passage hole is smaller toward a side on which the distance is larger in the flow straightening plate.

12. A refrigeration cycle apparatus comprising the plate-type heat exchanger of any one of claims 1 to 11.

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

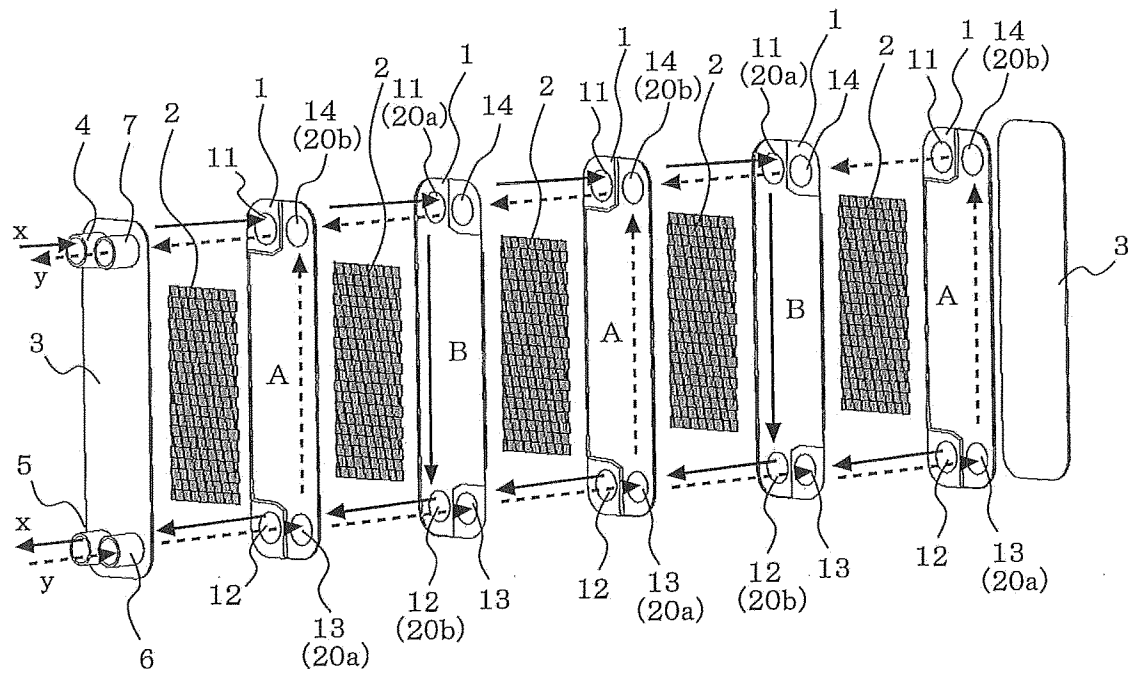


FIG. 2

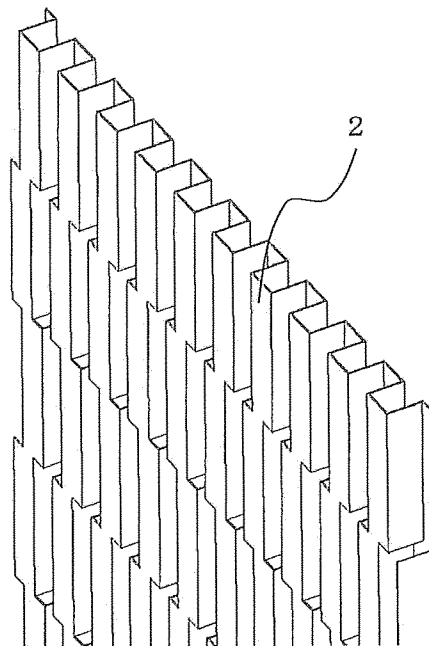


FIG. 3

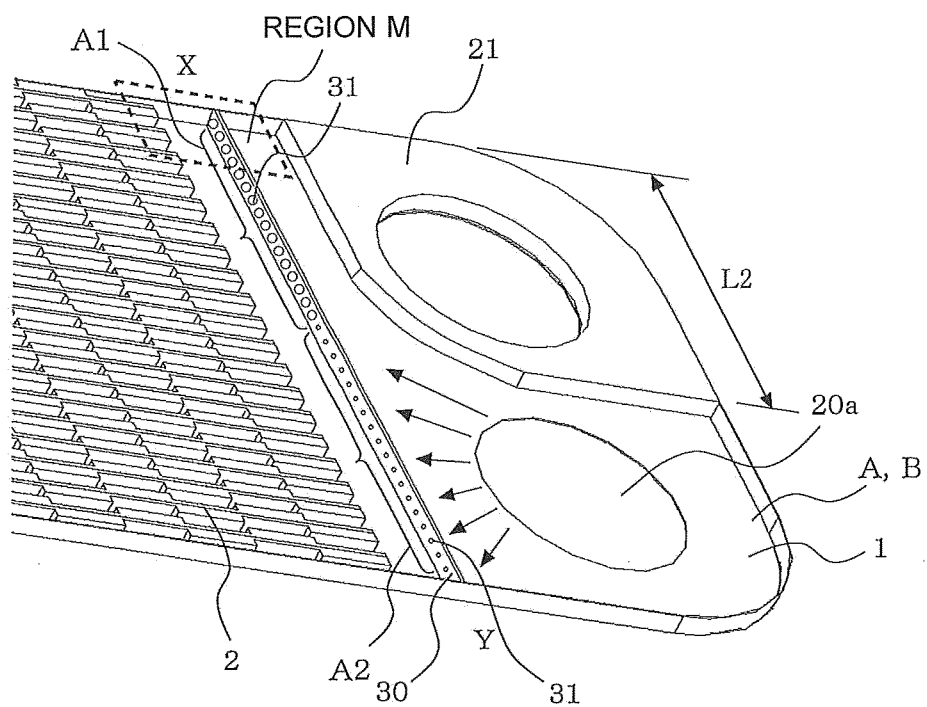


FIG. 4

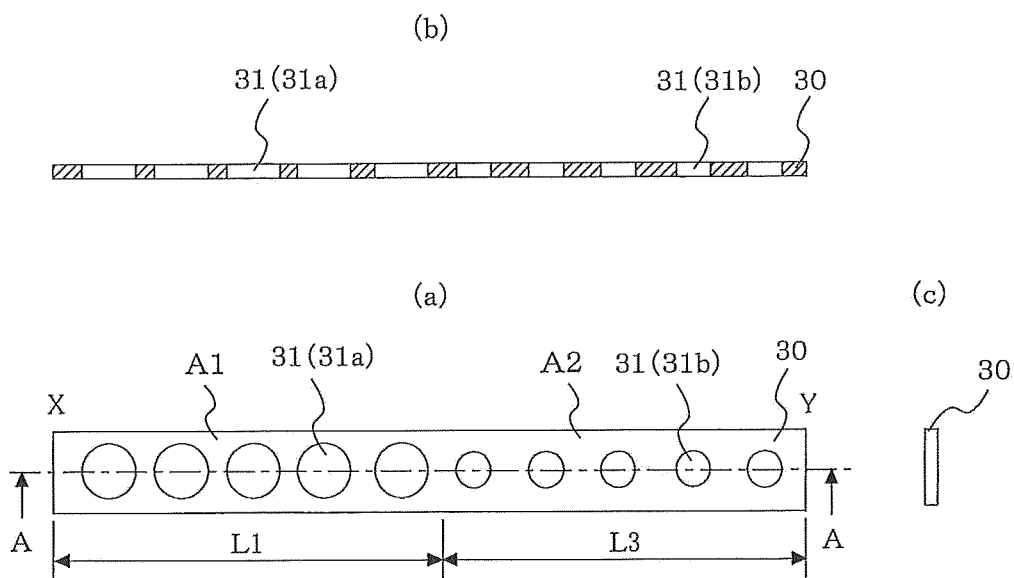


FIG. 5

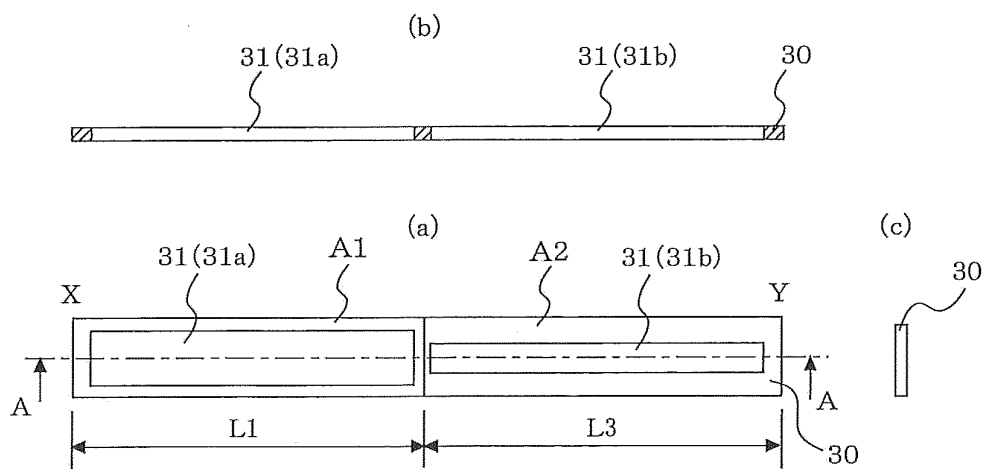


FIG. 6

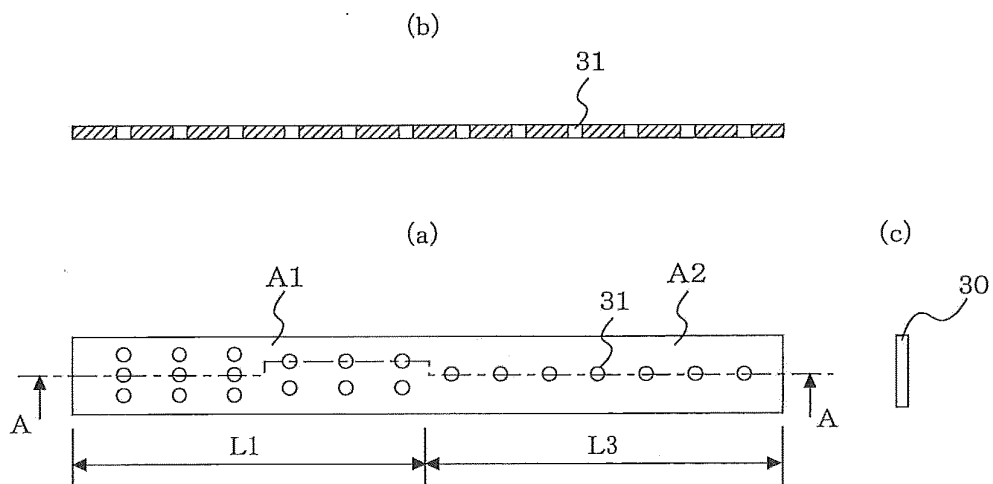


FIG. 7

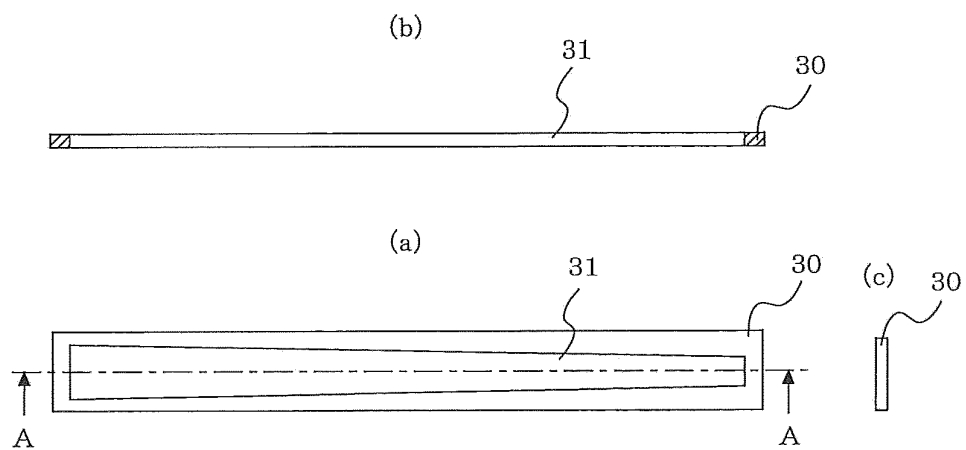


FIG. 8

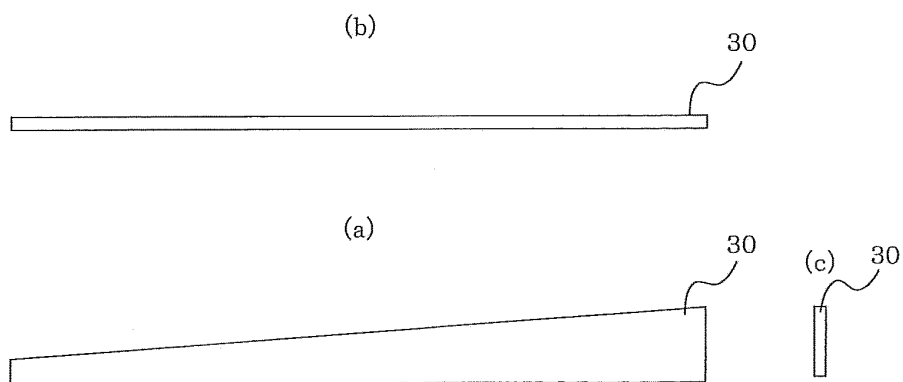


FIG. 9

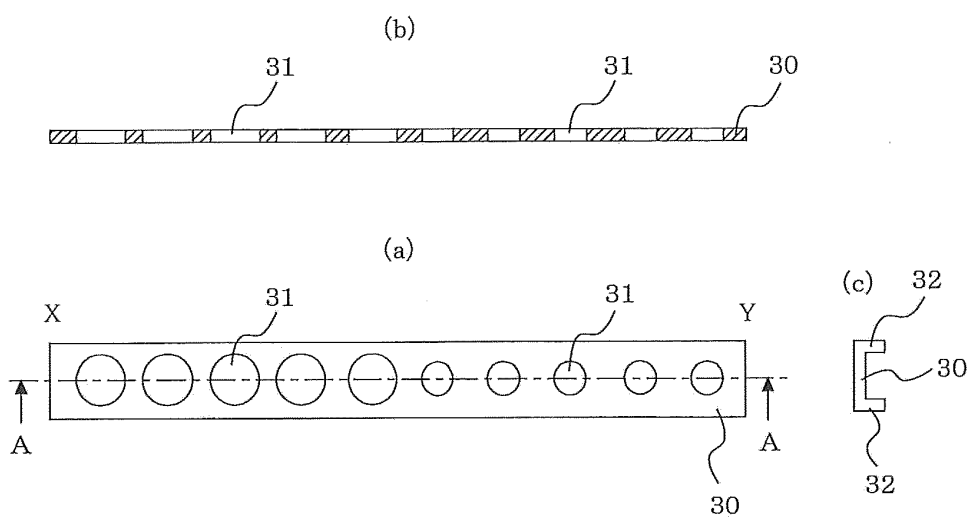


FIG. 10

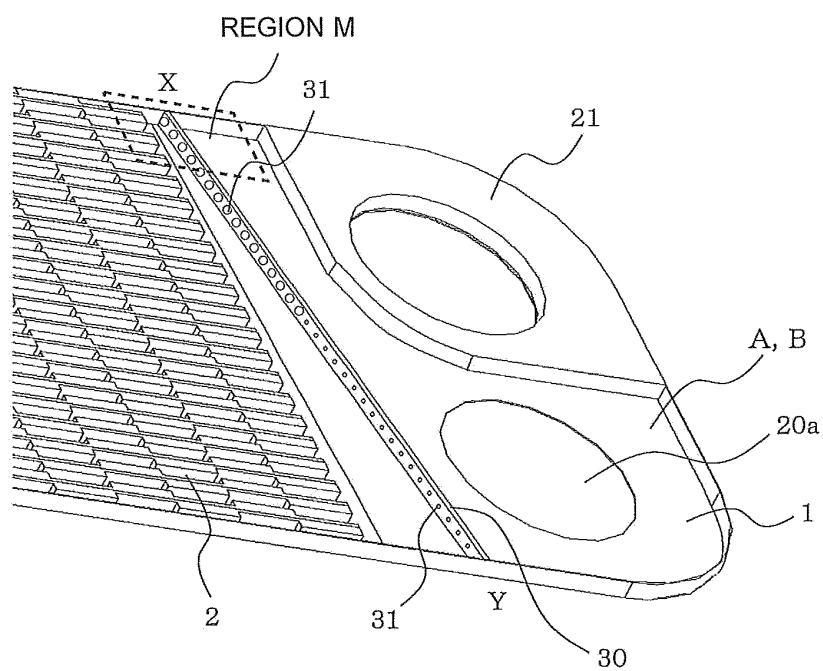


FIG. 11

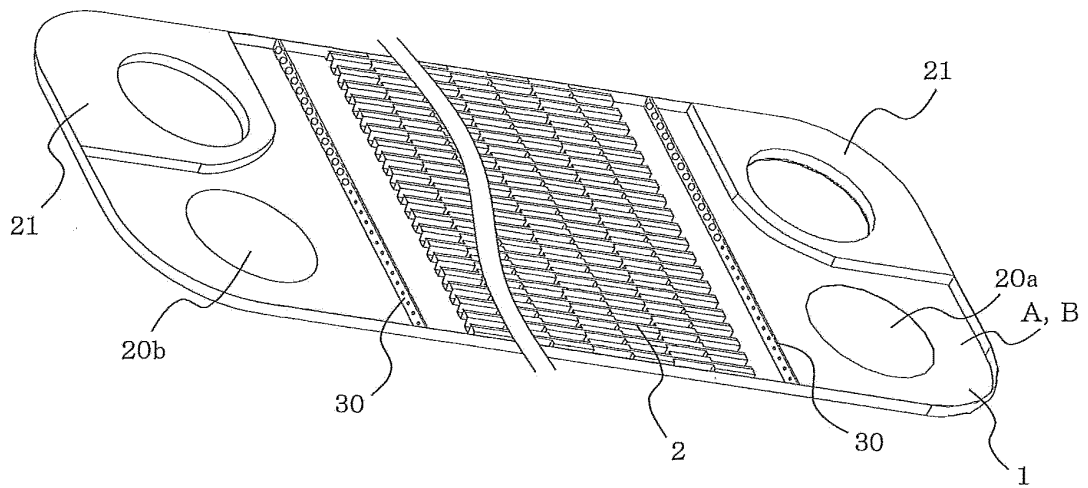


FIG. 12

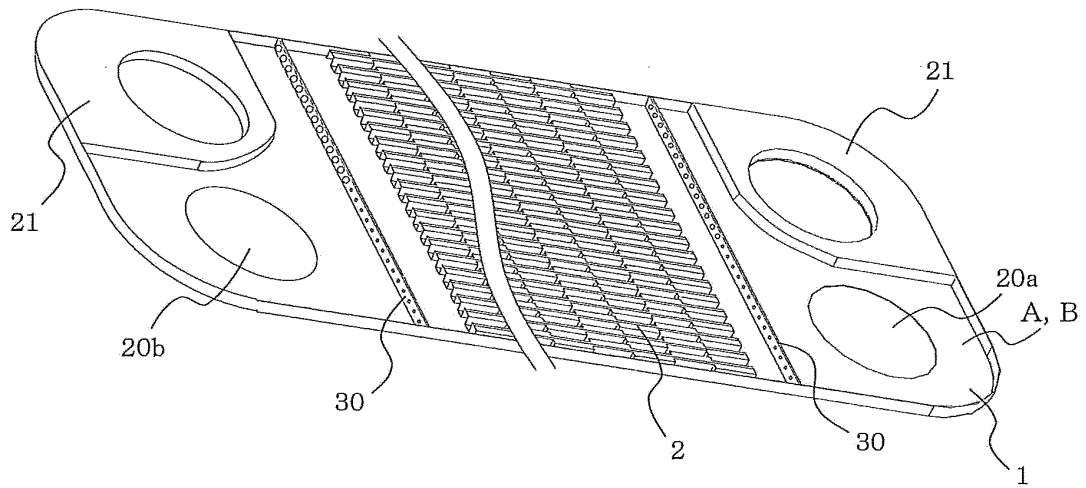
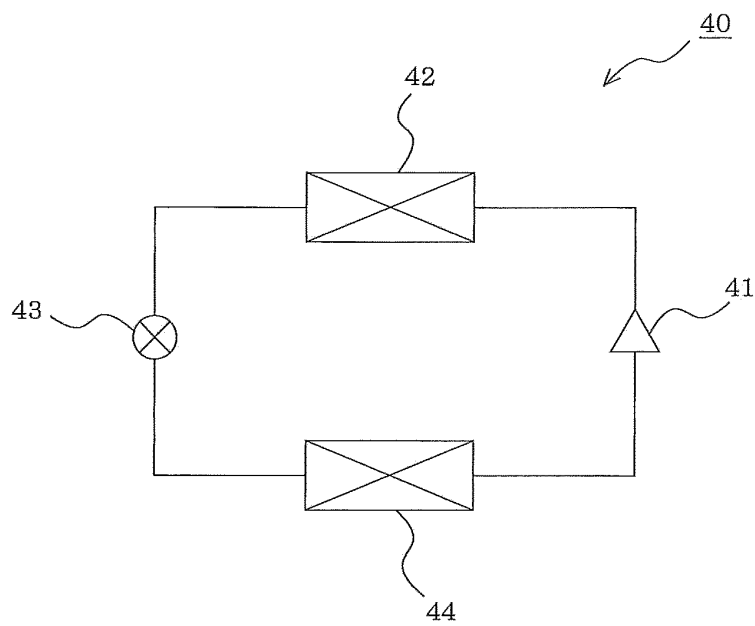


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/058210

A. CLASSIFICATION OF SUBJECT MATTER

F28F3/06(2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F28F3/06

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2013

Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
Y A	JP 62-18867 Y2 (Hisaka Works, Ltd.), 14 May 1987 (14.05.1987), page 1, right column, line 10 to page 2, right column, line 14; fig. 2 to 4 (Family: none)	1-6, 9-12 7, 8
Y	JP 2008-82650 A (Sanyo Electric Co., Ltd.), 10 April 2008 (10.04.2008), paragraph [0021]; fig. 1, 2 & US 2010/0025025 A1 & EP 2068108 A1 & WO 2008/038666 A1 & CN 101517347 A	1-6, 9-12
Y	JP 2002-66265 A (Honda Motor Co., Ltd.), 05 March 2002 (05.03.2002), paragraphs [0010], [0021] to [0023]; fig. 1 to 3 (Family: none)	1-6, 9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

07 May, 2013 (07.05.13)

Date of mailing of the international search report

14 May, 2013 (14.05.13)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/058210

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 62-237678 A (Hitachi, Ltd.), 17 October 1987 (17.10.1987), page 2, lower left column, line 5 to page 3, upper right column, line 4; fig. 1, 3, 4 (Family: none)	1-6, 9
Y	JP 2008-89223 A (Mitsubishi Heavy Industries, Ltd.), 17 April 2008 (17.04.2008), paragraph [0044]; fig. 8 (Family: none)	2
Y	JP 51-53658 A (Sharp Corp.), 12 May 1976 (12.05.1976), page 2, upper left column, lines 8 to 16; fig. 1, 2 (Family: none)	10
Y	JP 2007-303762 A (Mitsubishi Electric Corp.), 22 November 2007 (22.11.2007), paragraphs [0011] to [0016]; fig. 1, 2 (Family: none)	12
A	JP 2003-526070 A (Alfa Laval Corporate AB.), 02 September 2003 (02.09.2003), paragraph [0037] & US 2003/0047303 A1 & EP 1261832 A & WO 2001/067021 A1 & DE 60110757 D & SE 516178 C & SE 763 A & AU 3787901 A & AT 295523 T & CN 1411547 A	7, 8
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 64968/1988 (Laid-open No. 167543/1989) (Kabushiki Kaisha Kyoritsu), 24 November 1989 (24.11.1989), page 8, lines 18 to 20; fig. 4, 6 (Family: none)	9
A	JP 2011-179712 A (Ahresty Corp.), 15 September 2011 (15.09.2011), fig. 2, 4 (Family: none)	9
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 42255/1988 (Laid-open No. 144678/1989) (Hisaka Works, Ltd.), 04 October 1989 (04.10.1989), page 5, line 8 to page 6, line 20; fig. 1, 2 (Family: none)	11

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/058210

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 54-59656 A (Hisaka Works, Ltd.), 14 May 1979 (14.05.1979), page 2, upper left column, line 9 to lower right column, line 16; fig. 2 to 5 (Family: none)	1, 3

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 59229193 A [0004]
- JP 63140295 A [0004]
- JP 2001041676 A [0004]