(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 462 065 A1

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

(43) Date of publication:
13.11.2024 Bulletin 2024/46

(21) Application number: **24742812.1**

(22) Date of filing: **26.03.2024**

(51) International Patent Classification (IPC):
F28F 13/08 *(2006.01)* ***F25B 1/00*** *(2006.01)*
F28D 9/00 *(2006.01)* ***F28F 3/08*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F28D 9/0062; F28F 3/025; F28F 3/048

(86) International application number:
PCT/JP2024/012112

(87) International publication number:
WO 2024/204281 (03.10.2024 Gazette 2024/40)

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **31.03.2023 JP 2023057844**

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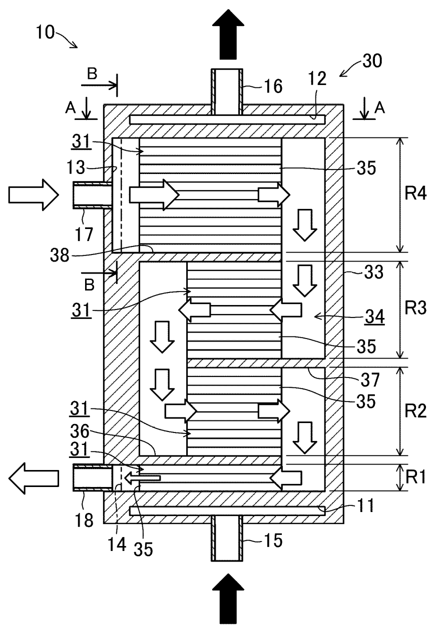
(54) **HEAT EXCHANGER AND REFRIGERATION DEVICE**

(57) A second fluid that undergoes a phase change flows through a second fluid layer (30). A second fluid passage (31) is divided into at least a first channel section (R1) and a second channel section (R2) different from the first channel section (R1) by a structure that makes the second fluid turn around at least one time. The first channel section (R1) is near a condensation outlet or an evaporation inlet. A channel cross-sectional area of the first channel section (R1) is smaller than a channel cross-sectional area of the second channel section (R2).

FIG.4



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a heat exchanger and a refrigeration apparatus.

BACKGROUND ART

[0002] Patent Document 1 discloses a plate heat exchanger in which the efficiency of the heat exchange is improved by making a channel for refrigerant as a heated fluid longer by a structure that makes the refrigerant turn around several times, thereby ensuring the heat transfer area.

CITATION LIST

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Unexamined Patent Publication No. 2002-267289

SUMMARY

TECHNICAL PROBLEM

[0004] When the plate heat exchanger of Patent Document 1 is used as a condenser, the refrigerant as a heated fluid condenses as it is closer to the downstream side, and hence the refrigerant has a lower degree of dryness. This means that the density changes from a gas refrigerant to a liquid refrigerant, causing a reduction in the flow velocity of the heated fluid on the downstream side. As a result, the heat transfer coefficient decreases.

[0005] It is an object of the present disclosure to reduce a decrease in the heat transfer coefficient due to a decrease in the flow velocity of a fluid at an end portion of a fluid passage in a flow direction.

SOLUTION TO THE PROBLEMS

[0006] A first aspect of the present disclosure is directed to a heat exchanger. The heat exchanger includes: a first fluid layer (20) having a first fluid passage (21) through which a first fluid flows; and a second fluid layer (30) having a second fluid passage (31) through which a second fluid that undergoes a phase change flows, the first fluid layer (20) and the second fluid layer (30) being alternately stacked, the heat exchanger exchanging heat between the first fluid and the second fluid, the second fluid passage (31) being divided into a plurality of channel sections from a first channel section (R1) to an N-th channel section (RN) by a structure that makes the second fluid turn around (N - 1) times, where N is a natural number greater than or equal to two, the first channel section (R1) being near a condensation outlet or an evaporation inlet, the N-th channel section (RN) being near a condensation inlet or an evaporation outlet, a channel cross-sectional area of the first channel section (R1) being smaller than a channel cross-sectional area of the N-th channel section (RN).

[0007] According to the first aspect, the channel cross-sectional area of the first channel section (R1) is small, thereby making it possible to increase the flow velocity of the second fluid flowing through the first channel section (R1) and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

[0008] A second aspect of the present disclosure is an embodiment of the heat exchanger of the first aspect. In the second aspect, the channel cross-sectional area of the first channel section (R1) is 25% or less of the channel cross-sectional area of the N-th channel section (RN).

[0009] According to the second aspect, the channel cross-sectional area of the first channel section (R1) is appropriately set, thereby making it possible to increase the flow velocity of the second fluid flowing through the first channel section (R1) and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

[0010] A third aspect of the present disclosure is an embodiment of the heat exchanger of the first or second aspect. In the third aspect, the first channel section (R1) has a plurality of first unit passages (r1) having a substantially constant channel cross-sectional area and extending along a direction of flow of the second fluid, the N-th channel section (RN) has a plurality of N-th unit passages (rN) having a substantially constant channel cross-sectional area and extending along the direction of flow of the second fluid, a channel cross-sectional area of each of the first unit passages (r1) is substantially equal to a channel cross-sectional area of each of the N-th unit passages (rN), and the number of the first unit passages (r1) is less than the number of the N-th unit passages (rN).

[0011] According to the third aspect, the channel cross-sectional area of the respective first unit passages (r1) is substantially equal to that of the respective N-th unit passages (rN), and the number of the first unit passages (r1) is smaller than that of the N-th unit passages (rN). It is thus possible to reduce the channel cross-sectional area of the first channel section (R1).

[0012] A fourth aspect of the present disclosure is an embodiment of the heat exchanger of the first or second aspect. In the fourth aspect, the first channel section (R1) has a plurality of first unit passages (r1) having a substantially constant channel cross-sectional area and extending along a direction of flow of the second fluid, the N-th channel section (RN) has a plurality of N-th unit passages (rN) having a substantially constant channel cross-sectional area and extending along the direction of flow of the second fluid, the number of the first unit passages (r1) is substantially equal to the number of the N-th unit passages (rN), and a channel cross-sectional area of each of the first unit passages (r1) is smaller than a channel cross-sectional area of each of the N-th unit passages (rN).

[0013] According to the fourth aspect, the number of the first unit passages (r1) is substantially equal to that of the N-th unit passages (rN), and the channel cross-sectional area of the respective first unit passages (r1) is smaller than the channel cross-sectional area of the respective N-th unit passages (rN). It is thus possible to reduce the channel cross-sectional area of the first channel section (R1).

[0014] A fifth aspect of the present disclosure is an embodiment of the heat exchanger of the first or second aspect. In the fifth aspect, the first channel section (R1) has a plurality of first unit passages (r1) having a substantially constant channel cross-sectional area and extending along a direction of flow of the second fluid, the N-th channel section (RN) has a plurality of N-th unit passages (rN) having a substantially constant channel cross-sectional area and extending along the direction of flow of the second fluid, a channel cross-sectional area of each of the first unit passages (r1) is smaller than a channel cross-sectional area of each of the N-th unit passages (rN), and the number of the first unit passages (r1) is less than the number of the N-th unit passages (rN).

[0015] According to the fifth aspect, the channel cross-sectional area of the respective first unit passages (r1) is smaller than that of the respective N-th unit passages (rN), and the number of the first unit passages (r1) is smaller than that of the N-th unit passages (rN). It is thus possible to reduce the channel cross-sectional area of the first channel section (R1).

[0016] A sixth aspect of the present disclosure is an embodiment of the heat exchanger of any one of the first to fifth aspects. In the sixth aspect, N is a natural number greater than or equal to three, and a channel cross-sectional area decreases gradually from the N-th channel section (RN) toward the first channel section (R1).

[0017] According to the sixth aspect, the flow velocity of the second fluid from the N-th channel section (RN) toward the first channel section (R1) is increased to improve the heat transfer coefficient, thereby making it possible to perform heat exchange efficiently.

[0018] A seventh aspect of the present disclosure is directed to a refrigeration apparatus. The refrigeration apparatus includes: the heat exchanger (10) of any one of the first to sixth aspects; and a fluid circuit (1a) to which the heat exchanger (10) is connected and through which the second fluid flows.

[0019] According to the seventh aspect, it is possible to provide a refrigeration apparatus including the heat exchanger (10).

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a refrigerant circuit diagram of a refrigeration cycle device according to a first embodiment.

FIG. 2 is a front sectional view illustrating a configuration of a plate heat exchanger.

FIG. 3 is a side sectional view illustrating a configuration of a first fluid layer.

FIG. 4 is a side sectional view illustrating a configuration of a second fluid layer.

FIG. 5 is a cross-sectional view taken along line A-A in FIG. 4 and viewed in the direction of arrows.

FIG. 6 is a cross-sectional view taken along line B-B in FIG. 4 and viewed in the direction of arrows.

FIG. 7 is a front sectional view illustrating the channel cross-sectional area of a first channel section and the channel cross-sectional area of a second channel section.

FIG. 8 is a diagram illustrating configurations of a first fluid layer and a second fluid layer according to a variation of the first embodiment, and corresponds to FIG. 5.

FIG. 9 is a diagram illustrating the configurations of the first fluid layer and the second fluid layer, and corresponds to FIG. 6.

FIG. 10 is a front sectional view illustrating the channel cross-sectional area of a first channel section and the channel cross-sectional area of a second channel section.

FIG. 11 is a side sectional view illustrating a configuration of a second fluid layer according to a second embodiment.

FIG. 12 is a front sectional view illustrating the channel cross-sectional area of a first channel section and the channel cross-sectional area of a second channel section.

FIG. 13 is a front sectional view illustrating the channel cross-sectional area of a first channel section and the channel cross-sectional area of a second channel section according to a variation of the second embodiment.

FIG. 14 is a side sectional view illustrating a configuration of a second fluid layer according to a third embodiment.

FIG. 15 is a front sectional view illustrating the channel cross-sectional area of a first channel section and the channel cross-sectional area of a second channel section.

FIG. 16 is a front sectional view illustrating the channel cross-sectional area of a first channel section and the channel cross-sectional area of a second channel section according to a variation of the third embodiment.

FIG. 17 is a side sectional view illustrating a configuration of a second fluid layer according to a fourth embodiment.

FIG. 18 is a side sectional view illustrating a configuration of a second fluid layer according to a fifth embodiment.

FIG. 19 is a side sectional view illustrating a configuration of a second fluid layer according to a sixth embodiment.

DESCRIPTION OF EMBODIMENT

<<First Embodiment>>

[0021] As illustrated in FIG. 1, a refrigeration apparatus (1) transfers heat between a first fluid and a second fluid that undergoes a phase change. The first fluid is, for example, water. The second fluid is a refrigerant that undergoes a phase change between a gas refrigerant and a liquid refrigerant. The second fluid is, for example, propane.

[0022] The refrigeration apparatus (1) includes a fluid circuit (1a) serving as a fluid circuit filled with the refrigerant. The fluid circuit (1a) includes a compressor (2), a four-way switching valve (3), a decompression mechanism (4), an air heat exchanger (5), and a plate heat exchanger (10).

[0023] The decompression mechanism (4) is, for example, an expansion valve. The air heat exchanger (5) is, for example, a cross-fin type fin-and-tube heat exchanger. The fluid circuit (1a) performs a vapor compression refrigeration cycle.

[0024] The four-way switching valve (3) switches the direction of circulation of the refrigerant. When the four-way switching valve (3) is in the state indicated by the solid curves in FIG. 1, the air heat exchanger (5) functions as an evaporator, and the plate heat exchanger (10) functions as a condenser. When the four-way switching valve (3) is in the state indicated by the dashed curves in FIG. 1, the air heat exchanger (5) functions as a condenser, and the plate heat exchanger (10) functions as an evaporator.

[0025] A situation where the air heat exchanger (5) functions as an evaporator and the plate heat exchanger (10) functions as a condenser will be described below.

[0026] The refrigeration apparatus (1) is, for example, a water heater. A water circuit (6) is connected to the plate heat exchanger (10). The water circuit (6) has a tank (7). In the plate heat exchanger (10), heat is transferred between the refrigerant flowing through the plate heat exchanger (10) and water flowing through the water circuit (6). The water that has undergone heat exchange in the plate heat exchanger (10) is stored in the tank (7). An inflow pipe (8) and an outflow pipe (9) are connected to the tank (7). The inflow pipe (8) allows water to flow into the tank (7). The outflow pipe (9) allows the water stored in the tank (7) to flow out.

<Plate Heat Exchanger>

[0027] As illustrated in FIGS. 2 to 4, the plate heat exchanger (10) includes first fluid layers (20) and second fluid layers (30). The first fluid layers (20) and the second fluid layers (30) are alternately stacked in the thickness direction. The plate heat exchanger (10) transfers heat between the first fluid and the second fluid.

[0028] The first fluid layers (20) each have a first fluid passage (21). Water as the first fluid flows through the first fluid passage (21). In each of the drawings, the flow of the first fluid is indicated by the black solid arrows. The first fluid passage (21) extends in the vertical direction in FIG. 3.

[0029] The second fluid layers (30) each have a second fluid passage (31). The refrigerant as the second fluid that undergoes a phase change flows through the second fluid passage (31). In each of the drawings, the flow of the second fluid is indicated by the hollow arrows. The second fluid passage (31) extends in the lateral direction in FIG. 4.

[0030] The second fluid passage (31) is divided into a plurality of channel sections from a first channel section (R1) to an N-th channel section (RN) by a structure that makes the refrigerant turn around (N - 1) times, where N is a natural number greater than or equal to two. In the example illustrated in FIG. 4, N = 4. The second fluid passage (31) will be described in detail later.

[0031] The plate heat exchanger (10) is provided with a first inlet header (11), a first outlet header (12), a second inlet header (13), and a second outlet header (14).

[0032] The first inlet header (11) is configured as a hole extending in the stacking direction at a lower portion of the plate heat exchanger (10) in FIG. 3. A first inlet pipe (15) is connected to the first inlet header (11). The first inlet pipe (15) allows water as the first fluid to flow into the plate heat exchanger (10).

[0033] The first outlet header (12) is configured as a hole extending in the stacking direction at an upper portion of the plate heat exchanger (10) in FIG. 3. A first outlet pipe (16) is connected to the first outlet header (12). The first outlet pipe (16) allows water that has passed through the first inlet header (11), the first fluid passages (21), and the first outlet header (12) to flow out of the plate heat exchanger (10).

[0034] The second inlet header (13) is configured as a hole extending in the stacking direction at an upper left portion of the plate heat exchanger (10) in FIG. 4. A second inlet pipe (17) is connected to the second inlet header (13). The second inlet pipe (17) allows the refrigerant as the second fluid to flow into the plate heat exchanger (10).

[0035] The second outlet header (14) is configured as a hole extending in the stacking direction at a lower left portion of the plate heat exchanger (10) in FIG. 4. A second outlet pipe (18) is connected to the second outlet header (14). The second outlet pipe (18) allows the refrigerant that has passed through the second inlet header (13), the second fluid passages (31), and the second outlet header (14) to flow out of the plate heat exchanger (10).

<First Fluid Layer>

[0036] As illustrated also in FIGS. 5 and 6, the first fluid layers (20) each include a pair of partition plates (22), a first frame-shaped member (23), and a first spacer member (25).

[0037] The pair of partition plates (22) are spaced apart from each other in the thickness direction. The first frame-shaped member (23) has a rectangular first internal space (24) extending in the vertical direction in FIG. 3. The first frame-shaped member (23) is disposed between the pair of partition plates (22). The first internal space (24) is sealed by the partition plates (22).

[0038] The first spacer member (25) is disposed in the first internal space (24). The first spacer member (25) is configured as a corrugated board. The first spacer member (25) is disposed in the first internal space (24) in such a posture that the crests and troughs of the corrugation are continuous in the lateral direction in FIG. 5. The tops of the crests and the bottoms of the troughs of the corrugation of the first spacer member (25) are in contact with the partition plates (22). Thus, spaces defined by the first spacer member (25) and the partition plates (22) form the first fluid passages (21).

[0039] The partition plates (22), the first frame-shaped member (23), and second frame-shaped member (33) to be described later have through holes at positions facing the first inlet header (11), the first outlet header (12), the second inlet header, and the second outlet header (14), respectively. The partition plates (22) which form the outer wall surfaces of the plate heat exchanger (10) have no through holes. These through holes successively joined together in the stacking direction form the first inlet header (11), the first outlet header (12), the second inlet header, and the second outlet header (14).

<Second Fluid Layer>

[0040] The second fluid layers (30) each include a pair of partition plates (22), a second frame-shaped member (33), and a second spacer member (35).

[0041] The pair of partition plates (22) are spaced apart from each other in the thickness direction. In this embodiment, each second fluid layer (30) shares the partition plates (22) with the first fluid layers (20) adjacent to the second fluid layer (30).

[0042] The second frame-shaped member (33) has a rectangular second internal space (34) extending in the vertical direction in FIG. 4. The second frame-shaped member (33) is disposed between the pair of partition plates (22). The second internal space (34) is sealed by the pair of partition plates (22).

[0043] The second internal space (34) includes a first turnaround portion (36), a second turnaround portion (37), and a third turnaround portion (38). The first turnaround portion (36), the second turnaround portion (37), and the third turnaround portion (38) are spaced apart from one another in the vertical direction in FIG. 4.

[0044] The first turnaround portion (36) extends rightward from the left inner wall surface of the second internal space (34) in FIG. 4. A gap is formed between the right end of the first turnaround portion (36) and the right inner wall surface of the second internal space (34). A space between the first turnaround portion (36) and the lower inner wall surface of the second internal space (34) communicates with the second outlet header (14).

[0045] The second turnaround portion (37) is disposed above the first turnaround portion (36). The second turnaround portion (37) extends leftward from the right inner wall surface of the second internal space (34) in FIG. 4. A gap is formed between the left end of the second turnaround portion (37) and the left inner wall surface of the second internal space (34).

[0046] The third turnaround portion (38) is disposed above the second turnaround portion (37). The third turnaround portion (38) extends rightward from the left inner wall surface of the second internal space (34) in FIG. 4. A gap is formed between the right end of the third turnaround portion (38) and the right inner wall surface of the second internal space (34). A space between the third turnaround portion (38) and the upper inner wall surface of the second internal space (34) communicates with the second inlet header (13).

[0047] Thus, the second fluid passage (31) is divided into the first channel section (R1), the second channel section (R2), the third channel section (R3), and the fourth channel section (R4) by the structure that makes the refrigerant turn around and which is formed by the first turnaround portion (36), the second turnaround portion (37), and the third turnaround portion (38). The second fluid passage (31) with a structure that makes the refrigerant turn around can increase the heat transfer area.

[0048] The first channel section (R1) is a space between the lower inner wall surface of the second internal space (34) and the first turnaround portion (36). Thus, the first channel section (R1) is near a condensation outlet of the plate heat exchanger (10) functioning as a condenser. At this time, the fourth channel section (R4) is near a condensation inlet of the plate heat exchanger (10).

[0049] When the plate heat exchanger (10) functions as an evaporator, the first channel section (R1) is near an evaporation inlet. At this time, the fourth channel section (R4) is near an evaporation outlet of the plate heat exchanger (10).

[0050] The second channel section (R2) is a space between the first turnaround portion (36) and the second turnaround portion (37) in the second internal space (34). The third channel section (R3) is a space between the second turnaround portion (37) and the third turnaround portion (38) in the second internal space (34). The fourth channel section (R4) is a space between the upper inner wall surface of the second internal space (34) and the third turnaround portion (38).

[0051] The second spacer member (35) is disposed in the second internal space (34). The second spacer member (35) is configured as a corrugated board. The second spacer member (35) is disposed in the second internal space (34) in such a posture that the crests and troughs of the corrugation are continuous in the vertical direction in FIG. 6. The tops of the crests and the bottoms of the troughs of the corrugation forming the second spacer member (35) are in contact with the partition plates (22). Thus, spaces defined by the second spacer member (35) and the partition plates (22) form the second fluid passages (31).

[0052] The second spacer member (35) is disposed in the first channel section (R1), the second channel section (R2), the third channel section (R3), and the fourth channel section (R4). In the second spacer member (35), the refrigerant flows in the lateral direction in FIG. 4.

[0053] Thus, the refrigerant that has flowed in from the second inlet pipe (17) and the second inlet header (13) passes through the second fluid passage (31) in the fourth channel section (R4), and then passes through the gap between the third turnaround portion (38) and the inner wall surface of the second internal space (34) toward the third channel section (R3).

[0054] The refrigerant that has passed through the second fluid passage (31) in the third channel section (R3) passes through the gap between the second turnaround portion (37) and the inner wall surface of the second internal space (34) toward the second channel section (R2).

[0055] The refrigerant that has passed through second fluid passage (31) in the second channel section (R2) passes through the gap between the first turnaround portion (36) and the inner wall surface of the second internal space (34) toward the first channel section (R1).

[0056] The refrigerant that has passed through the second fluid passage (31) in the first channel section (R1) passes through the second outlet header (14) and the second outlet pipe (18) to flow out of the plate heat exchanger (10).

<Channel Cross-Sectional Area of First Channel Section>

[0057] When the plate heat exchanger (10) is used as a condenser, the refrigerant as a heated fluid condenses as it is closer to the downstream side, and hence the refrigerant has a lower degree of dryness. This means that the density changes from a gas refrigerant to a liquid refrigerant, causing a reduction in the flow velocity of the heated fluid on the downstream side. As a result, the heat transfer coefficient decreases.

[0058] To address this problem, in this embodiment, it is possible to reduce a decrease in the heat transfer coefficient due to a decrease in the flow velocity of the refrigerant at the condensation outlet of the second fluid passage (31).

[0059] Specifically, as illustrated in FIG. 7, the first channel section (R1) has a smaller channel cross-sectional area than a channel cross-sectional area of the second channel section (R2) different from the first channel section (R1). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the second channel section (R2).

[0060] The first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The first unit passages (r1) are formed in a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0061] The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second unit passages (r2) are formed in a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0062] The channel cross-sectional area of the respective first unit passages (r1) is substantially equal to the channel cross-sectional area of the respective second unit passages (r2). The number of the first unit passages (r1) is less than the number of the second unit passages (r2).

[0063] As can be seen, the channel cross-sectional area of the first channel section (R1) is smaller than that of the second channel section (R2), thereby making it possible to increase the flow velocity of the refrigerant flowing through the first channel section (R1), and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

[0064] In this embodiment, the passage is divided to include the first channel section (R1), the second channel section (R2), the third channel section (R3), and the fourth channel section (R4) by the structure that makes the refrigerant turn around two or more times. Thus, it is preferable that the channel cross-sectional area of the first channel section (R1) is 25% or less of the channel cross-sectional area of the fluid section having the largest channel cross-sectional area among the second channel section (R2), the third channel section (R3), and the fourth channel section (R4).

- Advantages of First Embodiment -

[0065] According to a feature of this embodiment, the channel cross-sectional area of the first channel section (R1) is small, thereby making it possible to increase the flow velocity of the second fluid flowing through the first channel section (R1) and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

[0066] According to a feature of this embodiment, the channel cross-sectional area of the first channel section (R1) is appropriately set, thereby making it possible to increase the flow velocity of the second fluid flowing through the first channel section (R1) and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

[0067] According to a feature of this embodiment, the channel cross-sectional area of the respective first unit passages (r1) is substantially equal to that of the respective second unit passages (r2), and the number of the first unit passages (r1) is smaller than that of the second unit passages (r2). It is thus possible to reduce the channel cross-sectional area of the first channel section (R1).

[0068] According to a feature of this embodiment, the heat exchanger (10), and the fluid circuit (1a) to which the heat exchanger (10) is connected and through which the second fluid flows are provided. It is therefore possible to provide a refrigeration apparatus (1) including the heat exchanger (10).

<<Variation of First Embodiment>>

[0069] In the following description, the same reference characters designate the same components as those of the first embodiment, and the description is focused only on the difference.

[0070] As illustrated in FIGS. 8 and 9, the first fluid layers (20) each include a pair of partition plates (22), a first frame-shaped member (23), and a first spacer member (25). The pair of partition plates (22) are spaced apart from each other in the thickness direction. The first frame-shaped member (23) is disposed between the pair of partition plates (22).

[0071] The first spacer member (25) is configured as a plurality of protrusions integrally formed with one of the partition plates (22) adjacent to each other. The protrusions as the first spacer member (25) are spaced apart from one another in the lateral direction in FIG. 8. The distal ends of the protrusions as the first spacer member (25) are in contact with the other one of the adjacent partition plates (22). Thus, spaces defined by the first spacer member (25) and the partition plates (22) form the first fluid passages (21).

[0072] The second fluid layers (30) each include a pair of partition plates (22), a second frame-shaped member (33), and a second spacer member (35).

[0073] The pair of partition plates (22) are spaced apart from each other in the thickness direction. In this embodiment, each second fluid layer (30) shares the partition plates (22) with the first fluid layers (20) adjacent to the second fluid layer (30). The second frame-shaped member (33) is disposed between the pair of partition plates (22).

[0074] The second spacer member (35) is configured as a board with a plurality of grooves. The plurality of grooves are spaced apart from one another in the vertical direction in FIG. 9. The second spacer member (35) is in contact with the partition plates (22). Thus, spaces defined by the grooves of the second spacer member (35) and the partition plates (22) form second fluid passages (31).

[0075] As illustrated in FIG. 10, the first channel section (R1) has a smaller channel cross-sectional area than a channel cross-sectional area of the second channel section (R2) different from the first channel section (R1). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the second channel section (R2).

[0076] Specifically, the first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The first unit passage (r1) is a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0077] The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second unit passage (r2) is a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0078] Here, the channel cross-sectional area of the respective first unit passages (r1) is substantially equal to the channel cross-sectional area of the respective second unit passages (r2). The number of the first unit passages (r1) is less than the number of the second unit passages (r2).

[0079] As can be seen, the channel cross-sectional area of the first channel section (R1) is smaller than that of the second channel section (R2), thereby making it possible to increase the flow velocity of the refrigerant flowing through the first channel section (R1), and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

<<Second Embodiment>>

[0080] In the following description, the same reference characters designate the same components as those of the first embodiment, and the description is focused only on the difference.

[0081] As illustrated in FIG. 11 and 12, the first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The first unit passages (r1) are formed in a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0082] The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second unit passages (r2) are formed in a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0083] Here, the number of the first unit passages (r1) is substantially equal to that of the second unit passages (r2). The channel cross-sectional area of the respective first unit passages (r1) is smaller than the channel cross-sectional area of the respective second unit passages (r2).

[0084] Thus, the channel cross-sectional area of the first channel section (R1) can be smaller than the channel cross-sectional area of the second channel section (R2) different from the first channel section (R1). The channel cross-sectional area of the second channel section (R2) is smaller than the channel cross-sectional area of the third channel section (R3). The channel cross-sectional area of the third channel section (R3) is smaller than the channel cross-sectional area of the fourth channel section (R4). That is, the channel cross-sectional area decreases gradually from the fourth channel section (R4) toward the first channel section (R1). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the fourth channel section (R4).

[0085] The third channel section (R3) may have a channel cross-sectional area that is substantially equal to that of the second channel section (R2).

[0086] The first channel section (R1) may have a channel cross-sectional area that is substantially equal to that of the second channel section (R2). In this configuration, it is possible to increase the flow velocity of the second fluid in the first channel section (R1) and the second channel section (R2). Heat can be exchanged with the first fluid efficiently, particularly in a case in which the supercooled second fluid occupies a large proportion in the plate heat exchanger (10).

[0087] The channel cross-sectional areas of the first channel section (R1) and the second channel section (R2) may be reduced by making the number of the first unit passages (r1) and the number of the second unit passages (r2) substantially equal to the number of fourth unit passages (r4), and making the channel cross-sectional area of the respective first unit passages (r1) and the channel cross-sectional area of the respective second unit passages (r2) smaller than that of the respective fourth unit passages (r4).

[0088] The channel cross-sectional area of the first channel section (R1) may be reduced by making the channel cross-sectional area of the respective first unit passages (r1) and the channel cross-sectional area of the respective second unit passages (r2) smaller than that of the respective fourth unit passages (r4), and making the number of the first unit passages (r1) and the number of the second unit passages (r2) smaller than the number of the fourth unit passages (r4).

- Advantages of Second Embodiment -

[0089] According to a feature of this embodiment, the number of the first unit passages (r1) is substantially equal to that of the second unit passages (r2), and the channel cross-sectional area of the respective first unit passages (r1) is smaller than the channel cross-sectional area of the respective second unit passages (r2). It is thus possible to reduce the channel cross-sectional area of the first channel section (R1).

[0090] Further, the flow velocity of the second fluid from the fourth channel section (R4) toward the first channel section (R1) is increased to improve the heat transfer coefficient, thereby making it possible to perform heat exchange efficiently.

[0091] Further, for example, heat can be transferred efficiently in a gas-liquid two-phase region by changing the channel cross-sectional area according to changes in the degree of dryness of the second fluid that has flowed into the second internal space (34) in the gas-liquid two-phase state.

<<Variation of Second Embodiment>>

[0092] In the following description, the same reference characters designate the same components as those of a variation of the first embodiment, and the description is focused only on the difference.

[0093] As illustrated in FIG. 13, the first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The first unit passage (r1) is a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0094] The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second unit passage (r2) is a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0095] Here, the number of the first unit passages (r1) is substantially equal to that of the second unit passages (r2). The channel cross-sectional area of the respective first unit passages (r1) is smaller than the channel cross-sectional area of the respective second unit passages (r2).

[0096] Thus, the channel cross-sectional area of the first channel section (R1) can be smaller than the channel cross-sectional area of the second channel section (R2) different from the first channel section (R1). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the second channel section (R2).

<<Third Embodiment>>

[0097] In the following description, the same reference characters designate the same components as those of the first embodiment, and the description is focused only on the difference.

[0098] As illustrated in FIG. 14 and 15, the first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The first unit passages (r1) are formed in a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0099] The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second unit passages (r2) are formed in a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0100] Here, the channel cross-sectional area of the respective first unit passages (r1) is smaller than the channel cross-sectional area of the respective second unit passages (r2). The number of the first unit passages (r1) is less than the number of the second unit passages (r2).

[0101] Thus, the channel cross-sectional area of the first channel section (R1) can be smaller than the channel cross-sectional area of the second channel section (R2) different from the first channel section (R1). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the second channel section (R2).

- Advantages of Third Embodiment -

[0102] According to a feature of this embodiment, the channel cross-sectional area of the respective first unit passages (r1) is smaller than that of the respective second unit passages (r2), and the number of the first unit passages (r1) is smaller than that of the second unit passages (r2). It is thus possible to reduce the channel cross-sectional area of the first channel section (R1).

<<Variation of Third Embodiment>>

[0103] In the following description, the same reference characters designate the same components as those of a variation of the third embodiment, and the description is focused only on the difference.

[0104] As illustrated in FIG. 16, the first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The first unit passage (r1) is a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0105] The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second unit passage (r2) is a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0106] Here, the channel cross-sectional area of the respective first unit passages (r1) is smaller than the channel cross-sectional area of the respective second unit passages (r2). The number of the first unit passages (r1) is less than the number of the second unit passages (r2).

[0107] Thus, the channel cross-sectional area of the first channel section (R1) can be smaller than the channel cross-sectional area of the second channel section (R2) different from the first channel section (R1). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the second channel section (R2).

<<Fourth Embodiment>>

[0108] As illustrated in FIG. 17, the second fluid passage (31) is divided into a plurality of channel sections from a first channel section (R1) to an N-th channel section (RN) by a structure that makes the refrigerant turn around (N - 1) times, where N is a natural number greater than or equal to two. In the example illustrated in FIG. 17, N = 2.

[0109] The second internal space (34) includes a first turnaround portion (36). The first turnaround portion (36) extends rightward from the left inner wall surface of the second internal space (34) in FIG. 4. A gap is formed between the right end of the first turnaround portion (36) and the right inner wall surface of the second internal space (34).

[0110] A space between the first turnaround portion (36) and the lower inner wall surface of the second internal space (34) is the first channel section (R1). The first channel section (R1) communicates with the second outlet header (14). A space between the first turnaround portion (36) and the upper inner wall surface of the second internal space (34) is the second channel section (R2). The second channel section (R2) communicates with the second inlet header (13).

[0111] Thus, the second fluid passage (31) is divided into the first channel section (R1) and the second channel section (R2) by the structure that makes the refrigerant turn around one time and which is formed by the first turnaround portion (36).

[0112] The first channel section (R1) is near a condensation outlet of the plate heat exchanger (10) functioning as a condenser. At this time, the second channel section (R2) is near a condensation inlet of the plate heat exchanger (10).

[0113] When the plate heat exchanger (10) functions as an evaporator, the first channel section (R1) is near an evaporation inlet. At this time, the second channel section (R2) is near an evaporation outlet of the plate heat exchanger (10).

[0114] The first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant.

[0115] Here, as described in the first embodiment (see FIG. 7), the first unit passages (r1) and the second unit passages (r2) merely need to be a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0116] As described in the variation of the first embodiment (see FIG. 10), the first unit passages (r1) and the second unit passages (r2) may be each a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0117] In the example illustrated in FIG. 17, the channel cross-sectional area of the respective first unit passages (r1) is substantially equal to the channel cross-sectional area of the respective second unit passages (r2). The number of the first unit passages (r1) is less than the number of the second unit passages (r2).

[0118] Thus, the channel cross-sectional area of the first channel section (R1) can be smaller than the channel cross-sectional area of the second channel section (R2). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the second channel section (R2).

[0119] The channel cross-sectional areas of the first channel section (R1) may be reduced by making the number of the first unit passages (r1) substantially equal to the number of the second unit passages (r2), and making the channel cross-sectional area of the respective first unit passages (r1) smaller than that of the respective second unit passages (r2).

[0120] The channel cross-sectional areas of the first channel section (R1) may be reduced by making the channel cross-sectional area of the respective first unit passages (r1) smaller than the channel cross-sectional area of the respective second unit passages (r2), and making the number of the first unit passages (r1) smaller than that of the second unit passages (r2).

- Advantages of Fourth Embodiment -

[0121] According to a feature of this embodiment, the channel cross-sectional area of the first channel section (R1) is smaller than that of the second channel section (R2), thereby making it possible to increase the flow velocity of the refrigerant flowing through the first channel section (R1), and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

<<Fifth Embodiment>>

[0122] As illustrated in FIG. 18, the second fluid passage (31) is divided into a plurality of channel sections from a first channel section (R1) to an N-th channel section (RN) by a structure that makes the refrigerant turn around (N - 1) times, where N is a natural number greater than or equal to two. In the example illustrated in FIG. 18, N = 4.

[0123] The second internal space (34) includes a first turnaround portion (36), a second turnaround portion (37), and a third turnaround portion (38). The first turnaround portion (36), the second turnaround portion (37), and the third turnaround portion (38) are spaced apart from one another in the vertical direction in FIG. 18.

[0124] Thus, the second fluid passage (31) is divided into the first channel section (R1), the second channel section (R2), the third channel section (R3), and the fourth channel section (R4) by the structure that makes the refrigerant turn around three times and which is formed by the first turnaround portion (36), the second turnaround portion (37), and the third turnaround portion (38).

[0125] The first channel section (R1) is near a condensation outlet of the plate heat exchanger (10) functioning as a condenser. At this time, the fourth channel section (R4) is near a condensation inlet of the plate heat exchanger (10).

[0126] When the plate heat exchanger (10) functions as an evaporator, the first channel section (R1) is near an evaporation inlet. At this time, the fourth channel section (R4) is near an evaporation outlet of the plate heat exchanger (10).

[0127] The first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant.

[0128] The third channel section (R3) has a plurality of third unit passages (r3). Each of the third unit passages (r3) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The fourth channel section (R4) has a plurality of fourth unit passages (r4). Each of the fourth unit passages (r4) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant.

[0129] Here, as described in the first embodiment (see FIG. 7), the first unit passages (r1), the second unit passages (r2), the third unit passages (r3), and the fourth unit passages (r4) merely need to be a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0130] As described in the variation of the first embodiment (see FIG. 10), the first unit passages (r1), the second unit passages (r2), the third unit passages (r3), and the fourth unit passages (r4) may be each a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0131] In the example illustrated in FIG. 18, the channel cross-sectional area of the respective first unit passages (r1) is substantially equal to the channel cross-sectional area of the respective second unit passages (r2), the third unit passages (r3), and the fourth unit passages (r4). The number of the first unit passages (r1) is less than the number of the second unit passages (r2), the number of the third unit passages (r3), and the number of the fourth unit passages (r4).

[0132] Thus, the channel cross-sectional area of the first channel section (R1) can be smaller than the channel cross-sectional areas of the second channel section (R2), the third channel section (R3), and the fourth channel section (R4). In the example illustrated in FIG. 18, the second channel section (R2), the third channel section (R3), and the fourth channel section (R4) have substantially the same channel cross-sectional area. For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the fourth channel section (R4).

[0133] The channel cross-sectional areas of the first channel section (R1) may be reduced by making the number of the first unit passages (r1) substantially equal to the number of the fourth unit passages (r4), and making the channel cross-sectional area of the respective first unit passages (r1) smaller than that of the respective fourth unit passages (r4).

[0134] The channel cross-sectional area of the first channel section (R1) may be reduced by making the channel cross-sectional area of the respective first unit passages (r1) smaller than that of the respective fourth unit passages (r4), and making the number of the first unit passages (r1) smaller than the number of the fourth unit passages (r4).

- Advantages of Fifth Embodiment -

[0135] According to a feature of this embodiment, the channel cross-sectional area of the first channel section (R1) is smaller than that of the fourth channel section (R4), thereby making it possible to increase the flow velocity of the refrigerant flowing through the first channel section (R1), and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

<<Sixth Embodiment>>

[0136] As illustrated in FIG. 19, the second fluid passage (31) is divided into a plurality of channel sections from a first channel section (R1) to an N-th channel section (RN) by a structure that makes the refrigerant turn around (N - 1) times, where N is a natural number greater than or equal to two. In the example illustrated in FIG. 19, N = 6.

[0137] The second internal space (34) includes a first turnaround portion (36), a second turnaround portion (37), a third turnaround portion (38), a fourth turnaround portion (39), and a fifth turnaround portion (40). The first turnaround portion (36), the second turnaround portion (37), the third turnaround portion (38), the fourth turnaround portion (39), and the fifth turnaround portion (40) are spaced apart from one another in the vertical direction in FIG. 19.

[0138] Thus, the second fluid passage (31) is divided into a first channel section (R1), a second channel section (R2), a third channel section (R3), a fourth channel section (R4), a fifth channel section (R5), and a sixth channel section (R6) by the structure that makes the refrigerant turn around five times and which is formed by the first turnaround portion (36), the second turnaround portion (37), the third turnaround portion (38), the fourth turnaround portion (39), and the fifth turnaround portion (40).

[0139] The first channel section (R1) is near a condensation outlet of the plate heat exchanger (10) functioning as a condenser. At this time, the sixth channel section (R6) is near a condensation inlet of the plate heat exchanger (10).

[0140] When the plate heat exchanger (10) functions as an evaporator, the first channel section (R1) is near an evaporation inlet. At this time, the sixth channel section (R6) is near an evaporation outlet of the plate heat exchanger (10).

[0141] The first channel section (R1) has a plurality of first unit passages (r1). Each of the first unit passages (r1) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The second channel section (R2) has a plurality of second unit passages (r2). Each of the second unit passages (r2) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant.

[0142] The third channel section (R3) has a plurality of third unit passages (r3). Each of the third unit passages (r3) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The fourth channel section (R4) has a plurality of fourth unit passages (r4). Each of the fourth unit passages (r4) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant.

[0143] The fifth channel section (R5) has a plurality of fifth unit passages (r5). Each of the fifth unit passages (r5) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant. The sixth channel section (R1) has a plurality of sixth unit passages (r6). Each of the sixth unit passages (r6) has a substantially constant channel cross-sectional area, and extends along the direction of flow of the refrigerant.

[0144] Here, as described in the first embodiment (see FIG. 7), the first unit passages (r1), the second unit passages (r2), the third unit passages (r3), the fourth unit passages (r4), the fifth unit passages (r5), and the sixth unit passages (r6) merely need to be a space surrounded by the corrugated second spacer member (35) between the tops of adjacent crests and by the partition plate (22), and a space surrounded by the corrugated second spacer member (35) between the bottoms of adjacent troughs and by the partition plate (22).

[0145] As described in the variation of the first embodiment (see FIG. 10), the first unit passages (r1), the second unit passages (r2), the third unit passages (r3), the fourth unit passages (r4), the fifth unit passages (r5), and the sixth unit passages (r6) may be each a space surrounded by the groove of the second spacer member (35) and the partition plate (22).

[0146] In the example illustrated in FIG. 19, the channel cross-sectional area of the respective first unit passages (r1) is substantially equal to the channel cross-sectional area of the respective second unit passages (r2), the third unit passages (r3), the fourth unit passages (r4), the fifth unit passages (r5), and the sixth unit passages (r6). The number of the first unit passages (r1) is less than the number of the second unit passages (r2), the number of the third unit passages (r3), the number of the fourth unit passages (r4), the number of the fifth unit passages (r5), and the number of the sixth unit passages (r6).

[0147] Thus, the channel cross-sectional area of the first channel section (R1) can be smaller than the channel cross-sectional areas of the second channel section (R2), the third channel section (R3), the fourth channel section (R4), the fifth channel section (R5), and the sixth channel section (R6).

[0148] The channel cross-sectional area of the second channel section (R2) is smaller than the channel cross-sectional area of the third channel section (R3). The channel cross-sectional area of the third channel section (R3) is smaller than the channel cross-sectional area of the fourth channel section (R4). The channel cross-sectional area of the fourth channel section (R4) is smaller than the channel cross-sectional area of the fifth channel section (R5). The channel cross-sectional area of the fifth channel section (R5) is smaller than the channel cross-sectional area of the sixth channel section (R6).

[0149] That is, the channel cross-sectional area decreases gradually from the sixth channel section (R6) toward the first channel section (R1). For example, it is preferable that the first channel section (R1) has a channel cross-sectional area that is 25% or less of the channel cross-sectional area of the sixth channel section (R6).

[0150] The channel cross-sectional areas of the first channel section (R1) may be reduced by making the number of the first unit passages (r1) substantially equal to the number of the sixth unit passages (r6), and making the channel cross-sectional area of the respective first unit passages (r1) smaller than that of the respective sixth unit passages (r6).

[0151] The channel cross-sectional area of the first channel section (R1) may be reduced by making the channel cross-sectional area of the respective first unit passages (r1) smaller than that of the respective sixth unit passages (r6), and making the number of the first unit passages (r1) smaller than the number of the sixth unit passages (r6).

[0152] The second channel section (R2), the third channel section (R3), the fourth channel section (R4), the fifth channel section (R5), and the sixth channel section (R6) may have substantially the same channel cross-sectional area.

[0153] The first channel section (R1) may have a channel cross-sectional area that is substantially equal to that of the second channel section (R2). In this configuration, it is possible to increase the flow velocity of the second fluid in the first channel section (R1) and the second channel section (R2). Heat can be exchanged with the first fluid efficiently, particularly in a case in which the supercooled second fluid occupies a large proportion in the plate heat exchanger (10).

- Advantages of Sixth Embodiment -

[0154] According to a feature of this embodiment, the channel cross-sectional area of the first channel section (R1) is smaller than that of the sixth channel section (R6), thereby making it possible to increase the flow velocity of the refrigerant flowing through the first channel section (R1), and reduce a decrease in the heat transfer coefficient in the first channel section (R1).

[0155] Further, the flow velocity of the second fluid from the sixth channel section (R6) toward the first channel section (R1) is increased to improve the heat transfer coefficient, thereby making it possible to perform heat exchange efficiently.

<<Other Embodiments>>

[0156] While the embodiments and variations have been described above, it will be understood that various changes in form and details can be made without departing from the spirit and scope of the claims. The elements according to embodiments, the variations thereof, and the other embodiments may be combined and replaced with each other. In addition, the expressions of "first," "second," "third," ... , in the specification and claims are used to distinguish the terms to which these expressions are given, and do not limit the number and order of the terms.

INDUSTRIAL APPLICABILITY

[0157] As can be seen from the foregoing description, the present disclosure is useful for a heat exchanger and a refrigeration apparatus.

DESCRIPTION OF REFERENCE CHARACTERS

[0158]

1	Refrigeration Apparatus
1a	Refrigerant Circuit (Fluid Circuit)
10	Plate Heat Exchanger (Heat Exchanger)
20	First Fluid Layer
21	First Fluid Passage
30	Second Fluid Layer
31	Second Fluid Passage
r1	First Unit Passage
r2	Second Unit Passage
r3	Third Unit Passage
r4	Fourth Unit Passage
R1	First Channel Section
R2	Second Channel Section

Claims

1. A heat exchanger comprising: a first fluid layer (20) having a first fluid passage (21) through which a first fluid flows; and a second fluid layer (30) having a second fluid passage (31) through which a second fluid that undergoes a phase change flows, the first fluid layer (20) and the second fluid layer (30) being alternately stacked, the heat exchanger exchanging heat between the first fluid and the second fluid,

the second fluid passage (31) being divided into a plurality of channel sections from a first channel section (R1) to an N-th channel section (RN) by a structure that makes the second fluid turn around (N - 1) times, where N is a natural number greater than or equal to two,
the first channel section (R1) being near a condensation outlet or an evaporation inlet,
the N-th channel section (RN) being near a condensation inlet or an evaporation outlet,
a channel cross-sectional area of the first channel section (R1) being smaller than a channel cross-sectional area of the N-th channel section (RN).

2. The heat exchanger of claim 1, wherein
the channel cross-sectional area of the first channel section (R1) is 25% or less of the channel cross-sectional area of the N-th channel section (RN).

3. The heat exchanger of claim 1 or 2, wherein

the first channel section (R1) has a plurality of first unit passages (r1) having a substantially constant channel cross-sectional area and extending along a direction of flow of the second fluid,
the N-th channel section (RN) has a plurality of N-th unit passages (rN) having a substantially constant channel cross-sectional area and extending along the direction of flow of the second fluid,
a channel cross-sectional area of each of the first unit passages (r1) is substantially equal to a channel cross-sectional area of each of the N-th unit passages (rN), and
the number of the first unit passages (r1) is less than the number of the N-th unit passages (rN).

4. The heat exchanger of claim 1 or 2, wherein

the first channel section (R1) has a plurality of first unit passages (r1) having a substantially constant channel cross-sectional area and extending along a direction of flow of the second fluid,
the N-th channel section (RN) has a plurality of N-th unit passages (rN) having a substantially constant channel cross-sectional area and extending along the direction of flow of the second fluid,
the number of the first unit passages (r1) is substantially equal to the number of the N-th unit passages (rN), and
a channel cross-sectional area of each of the first unit passages (r1) is smaller than a channel cross-sectional area of each of the N-th unit passages (rN).

5. The heat exchanger of claim 1 or 2, wherein

the first channel section (R1) has a plurality of first unit passages (r1) having a substantially constant channel cross-sectional area and extending along a direction of flow of the second fluid,
the N-th channel section (RN) has a plurality of N-th unit passages (rN) having a substantially constant channel cross-sectional area and extending along the direction of flow of the second fluid,

a channel cross-sectional area of each of the first unit passages (r1) is smaller than a channel cross-sectional area of each of the N-th unit passages (rN), and
the number of the first unit passages (r1) is less than the number of the N-th unit passages (rN).

6. The heat exchanger of any one of claims 1 to 5, wherein

N is a natural number greater than or equal to three, and
a channel cross-sectional area decreases gradually from the N-th channel section (RN) toward the first channel section (R1).

7. A refrigeration apparatus comprising:

the heat exchanger (10) of any one of claims 1 to 6; and
a fluid circuit (1a) to which the heat exchanger (10) is connected and through which the second fluid flows.

FIG.1

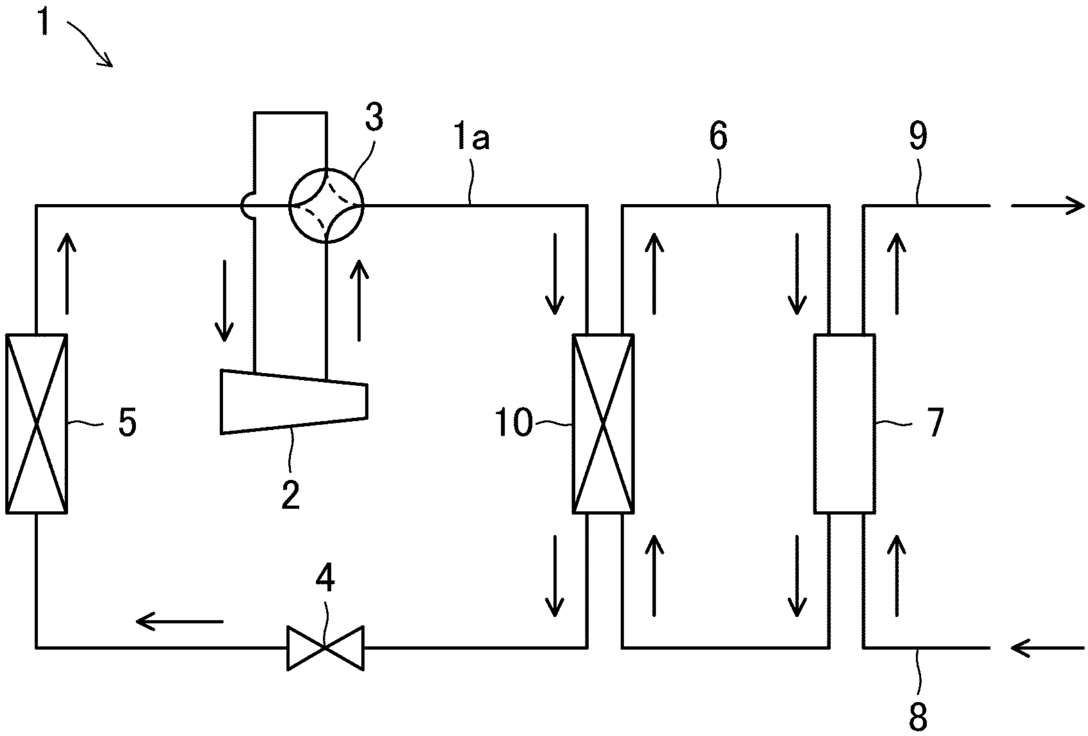


FIG.2

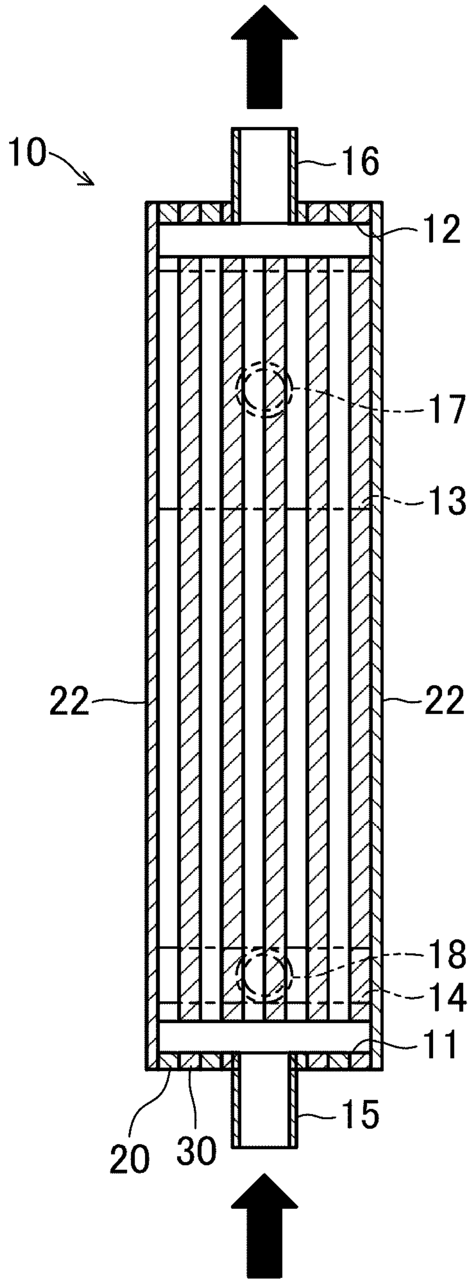


FIG.3

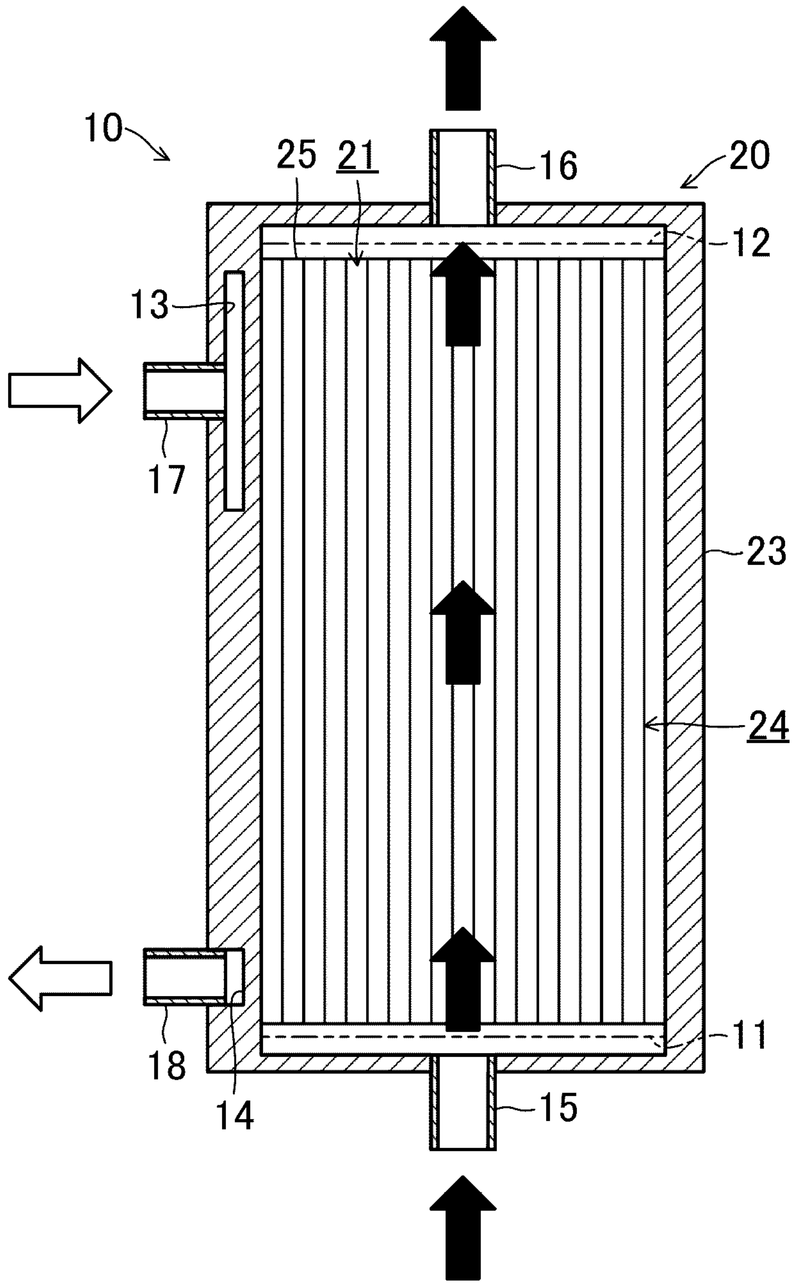
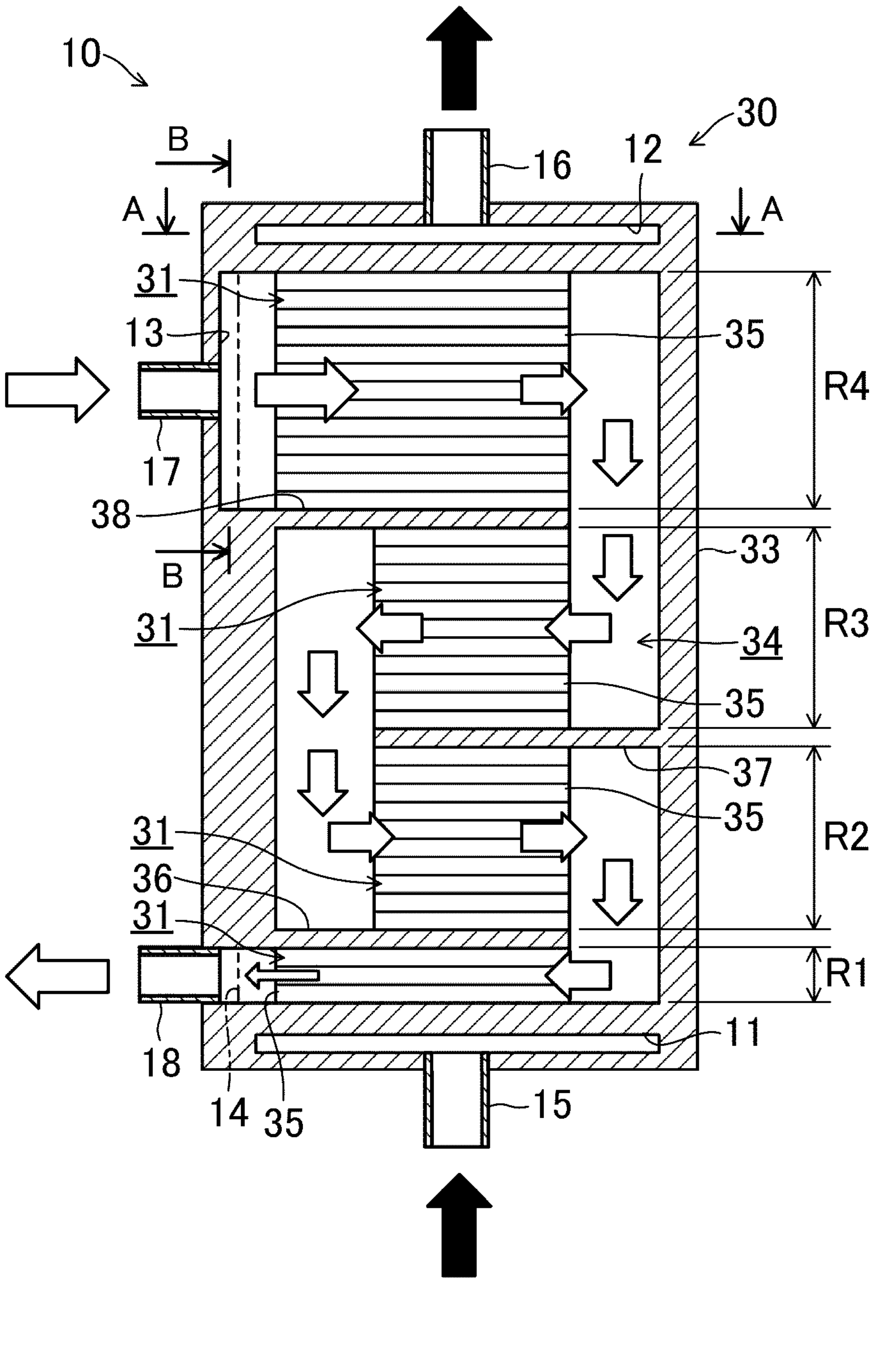


FIG.4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B
A
A
16
12
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R4
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R3
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R2
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R1
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FIG.5

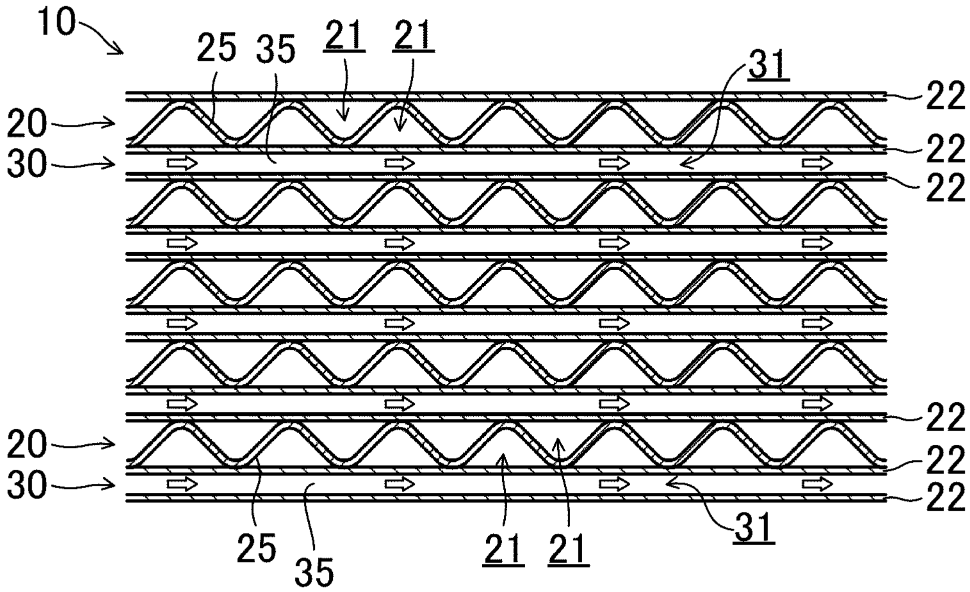
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FIG.6

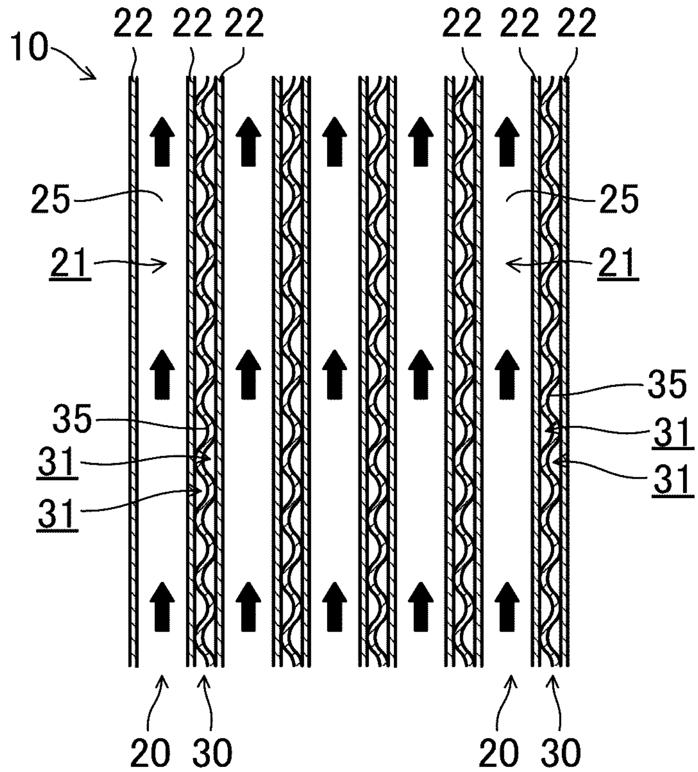
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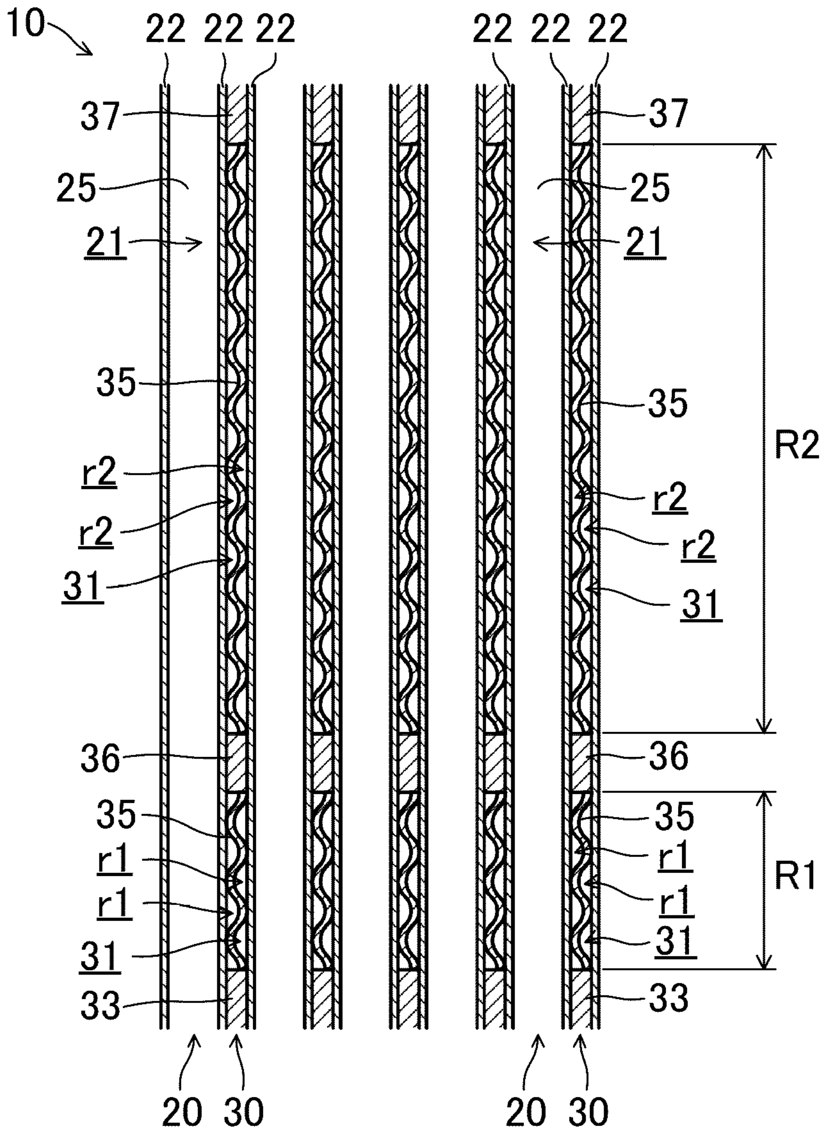
FIG.7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R2
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r1
R1
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FIG.8

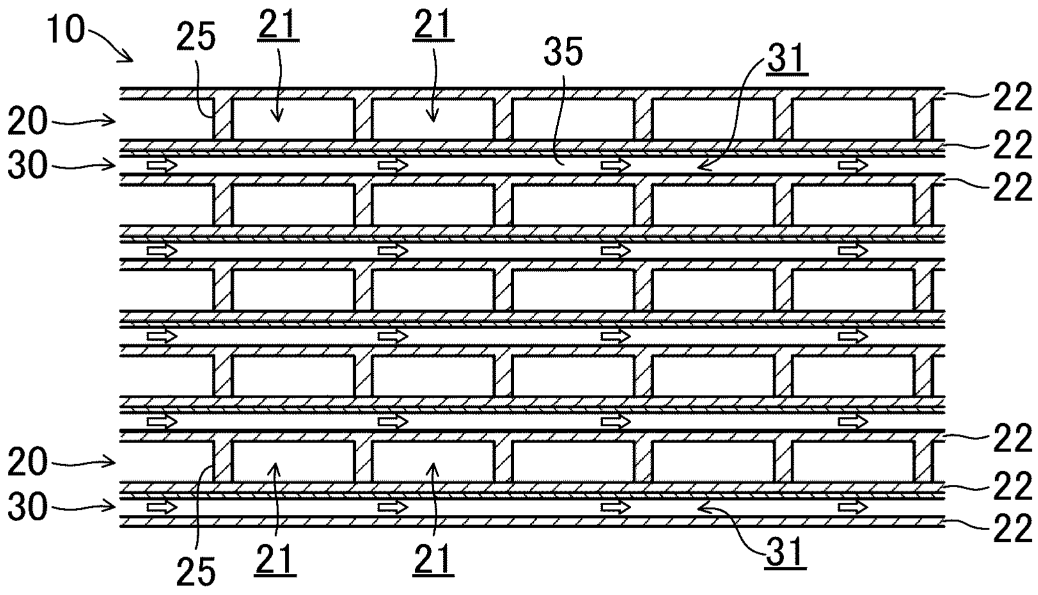
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FIG.9

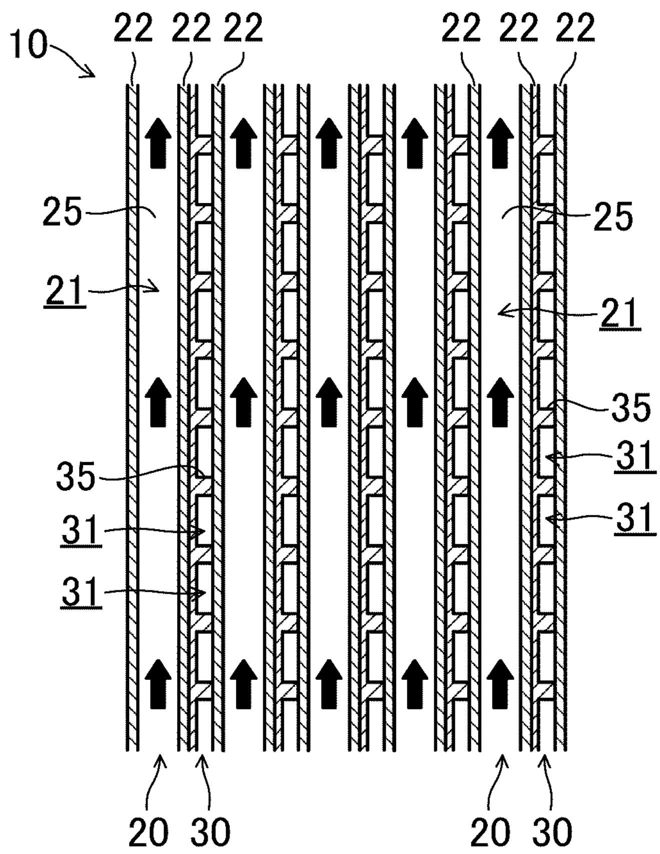
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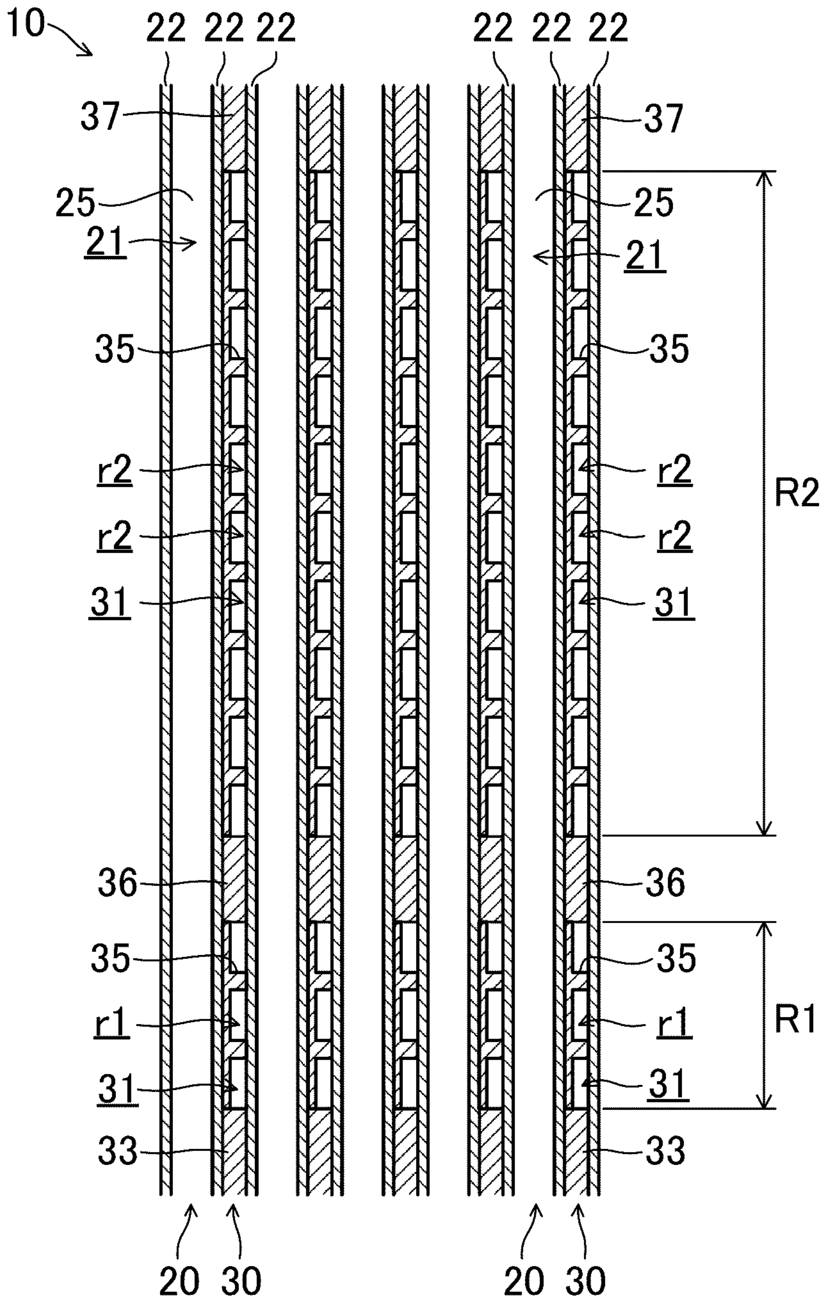
FIG.10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R2
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r1
r1
R1
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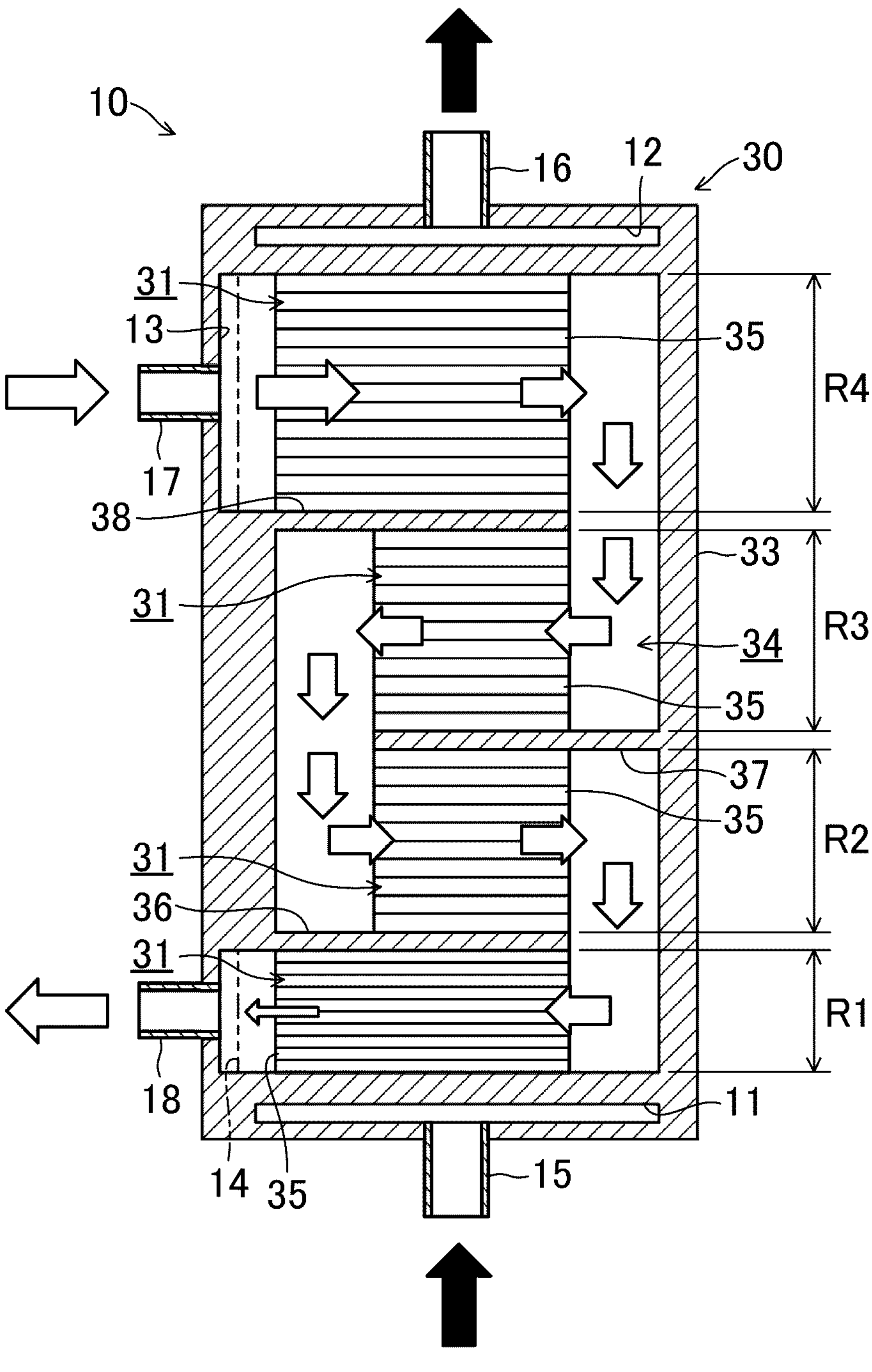
FIG.11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R4
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R1
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FIG.12

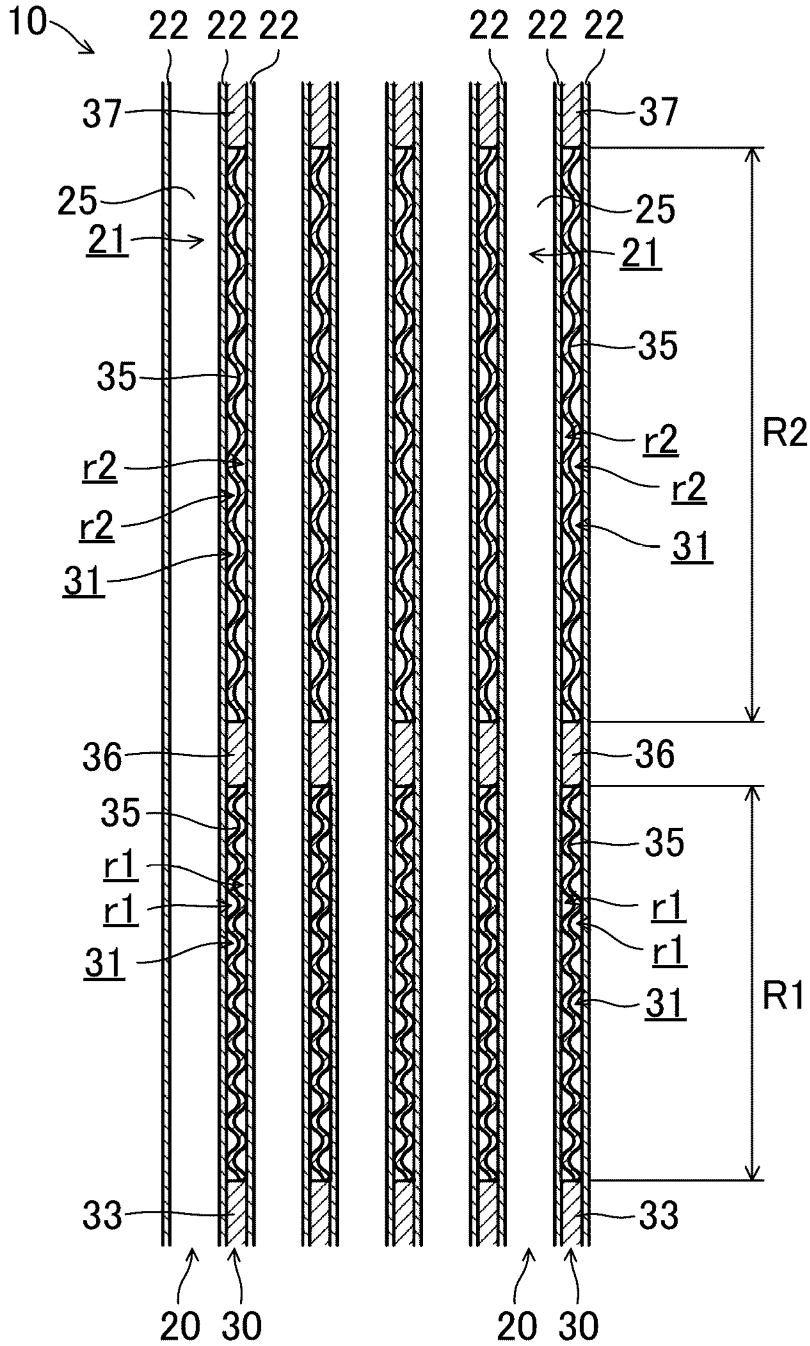
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FIG.13

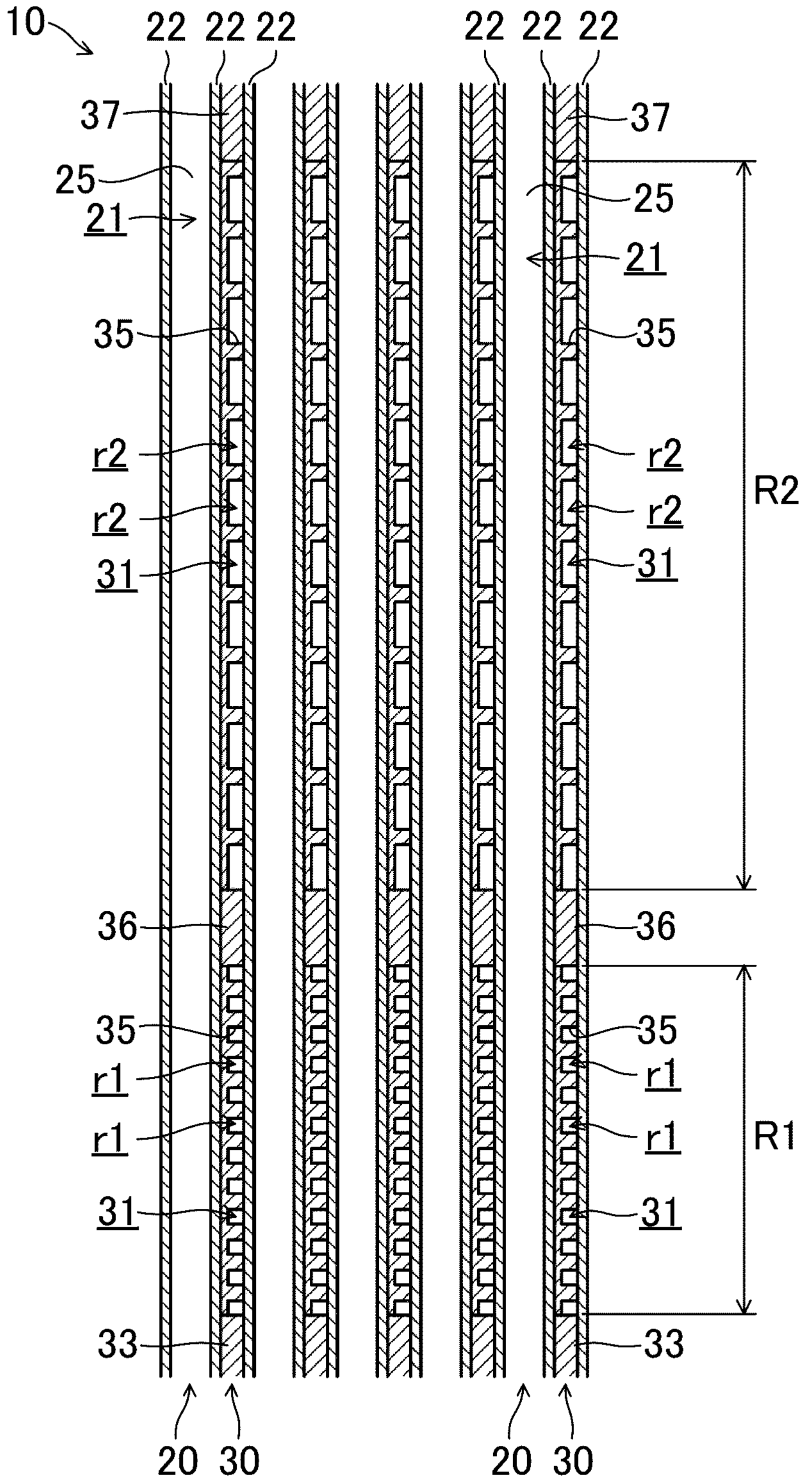
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FIG.14

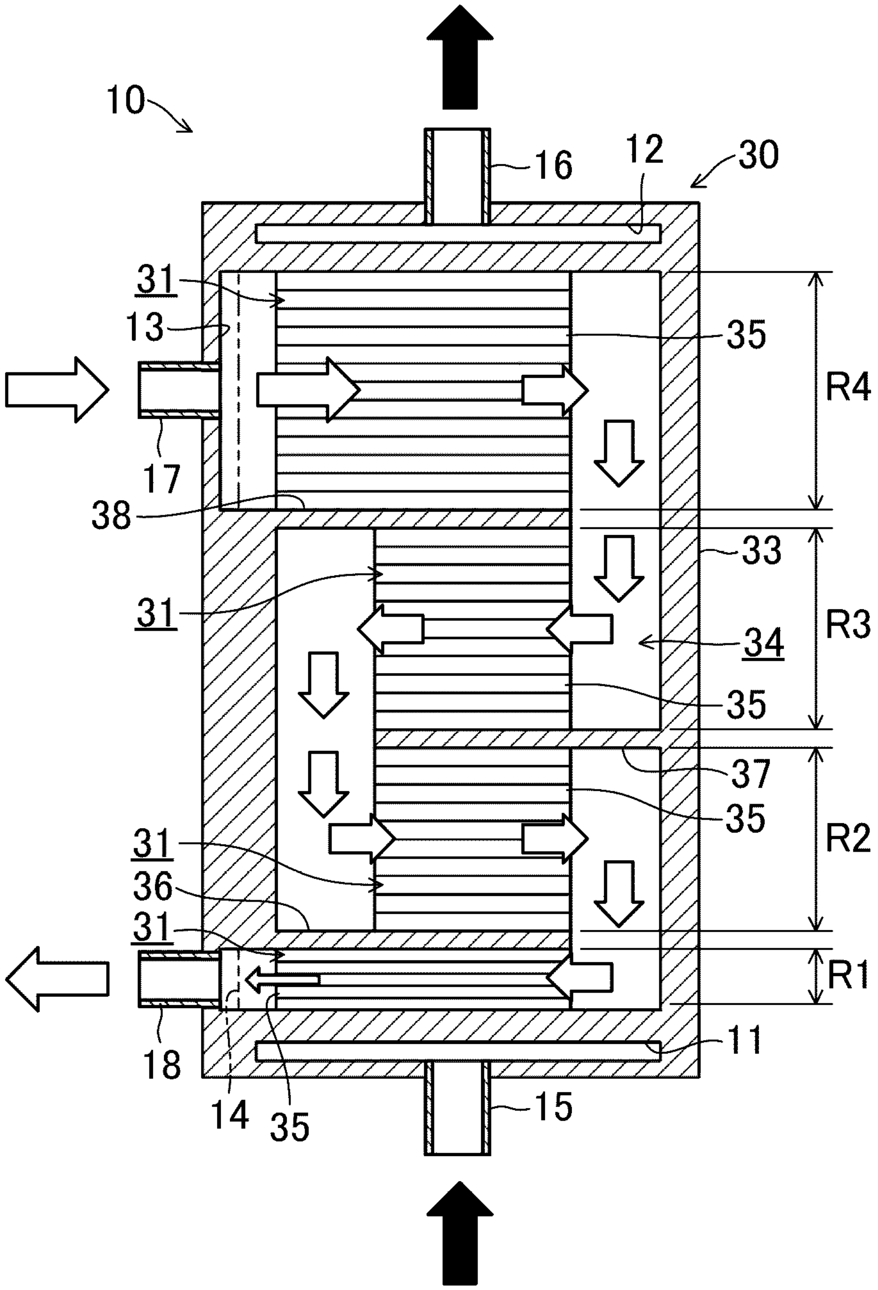
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FIG.15

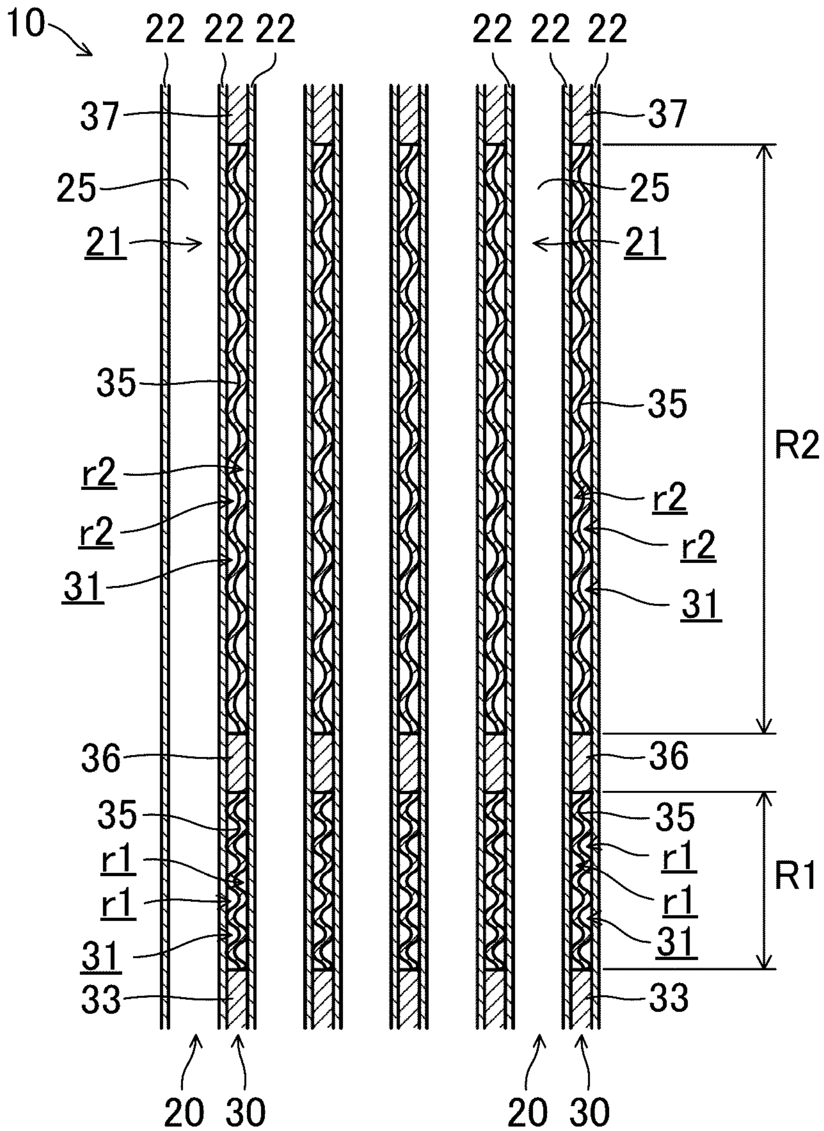
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FIG.16

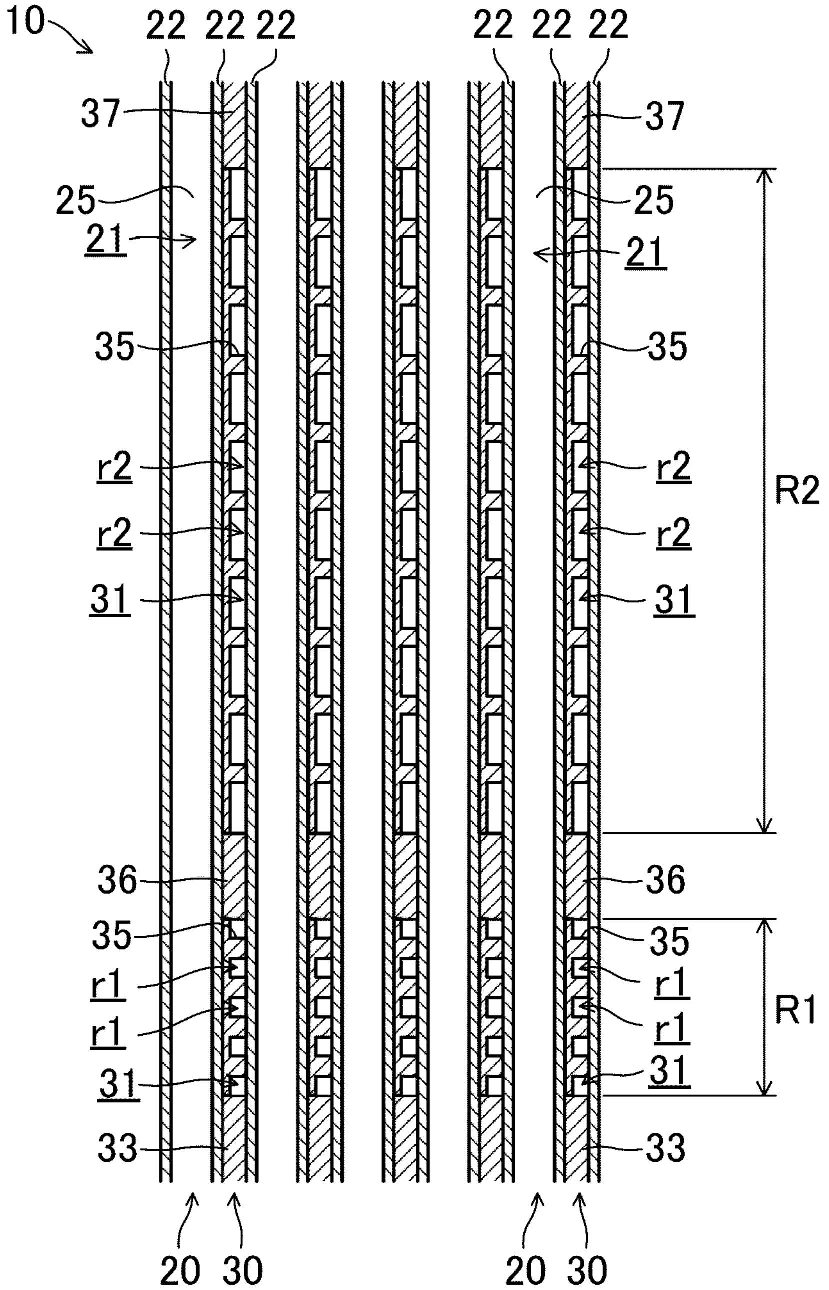
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FIG.17

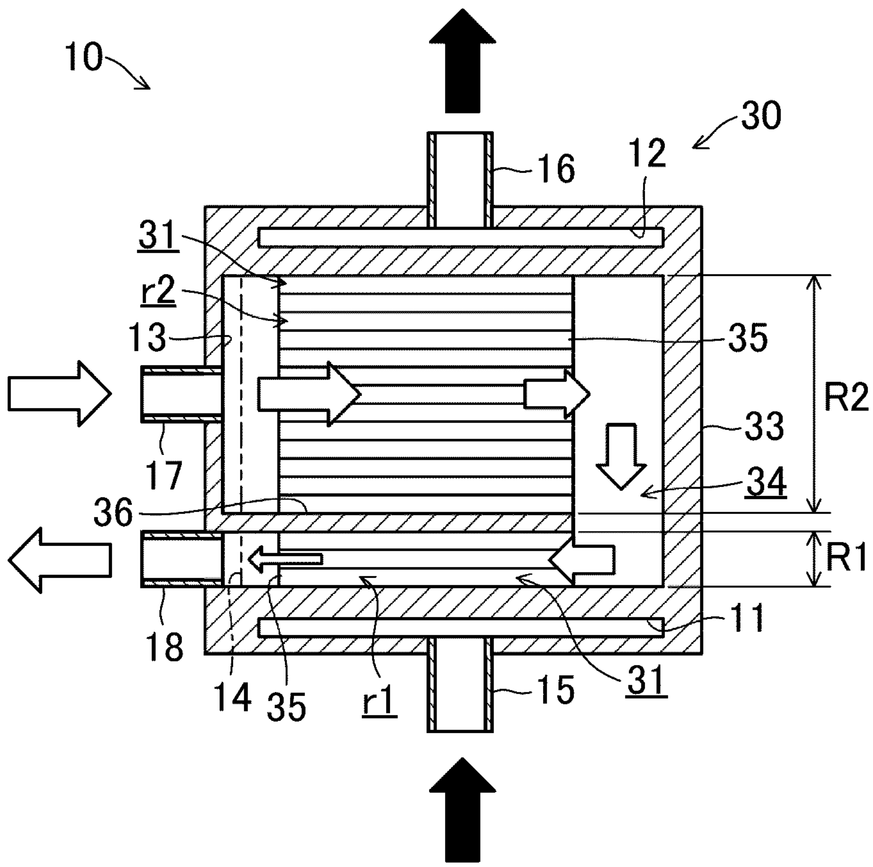
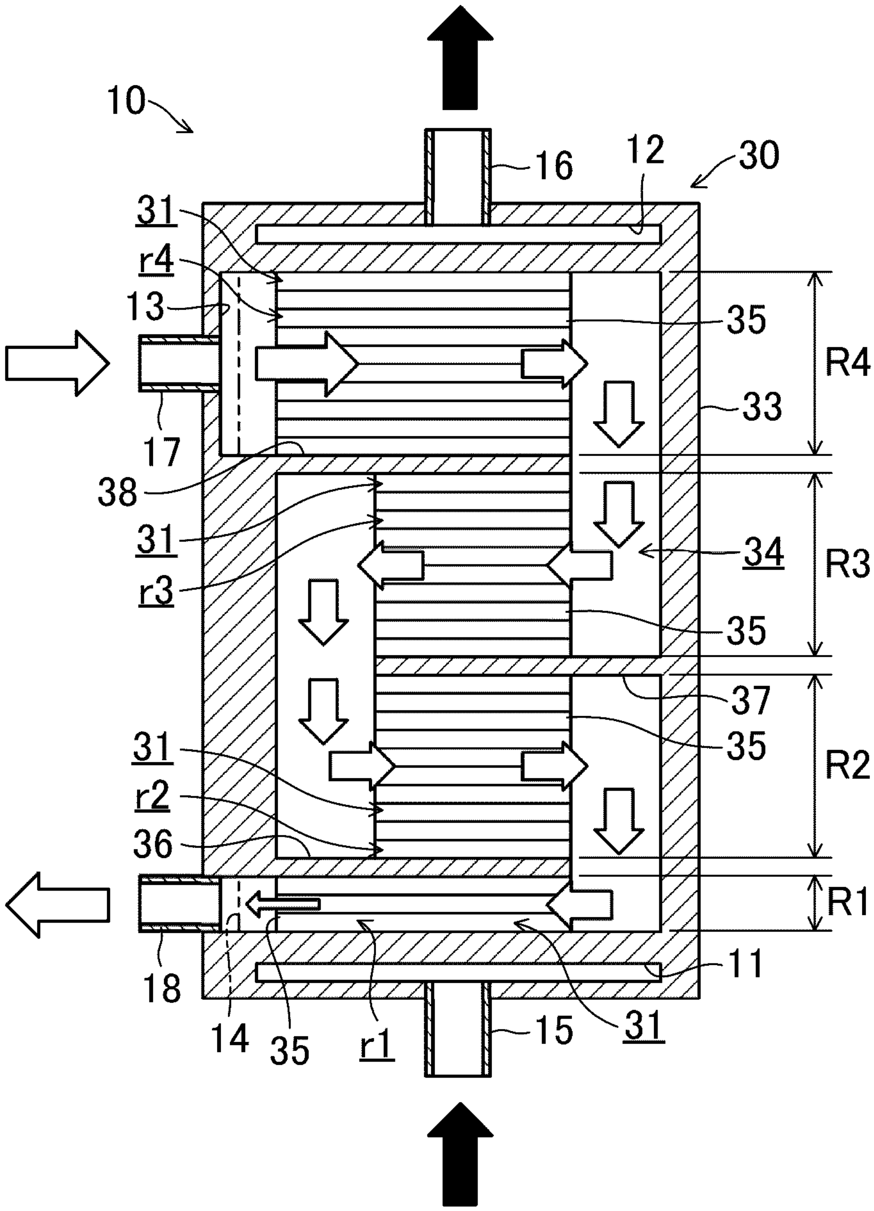


FIG.18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r1
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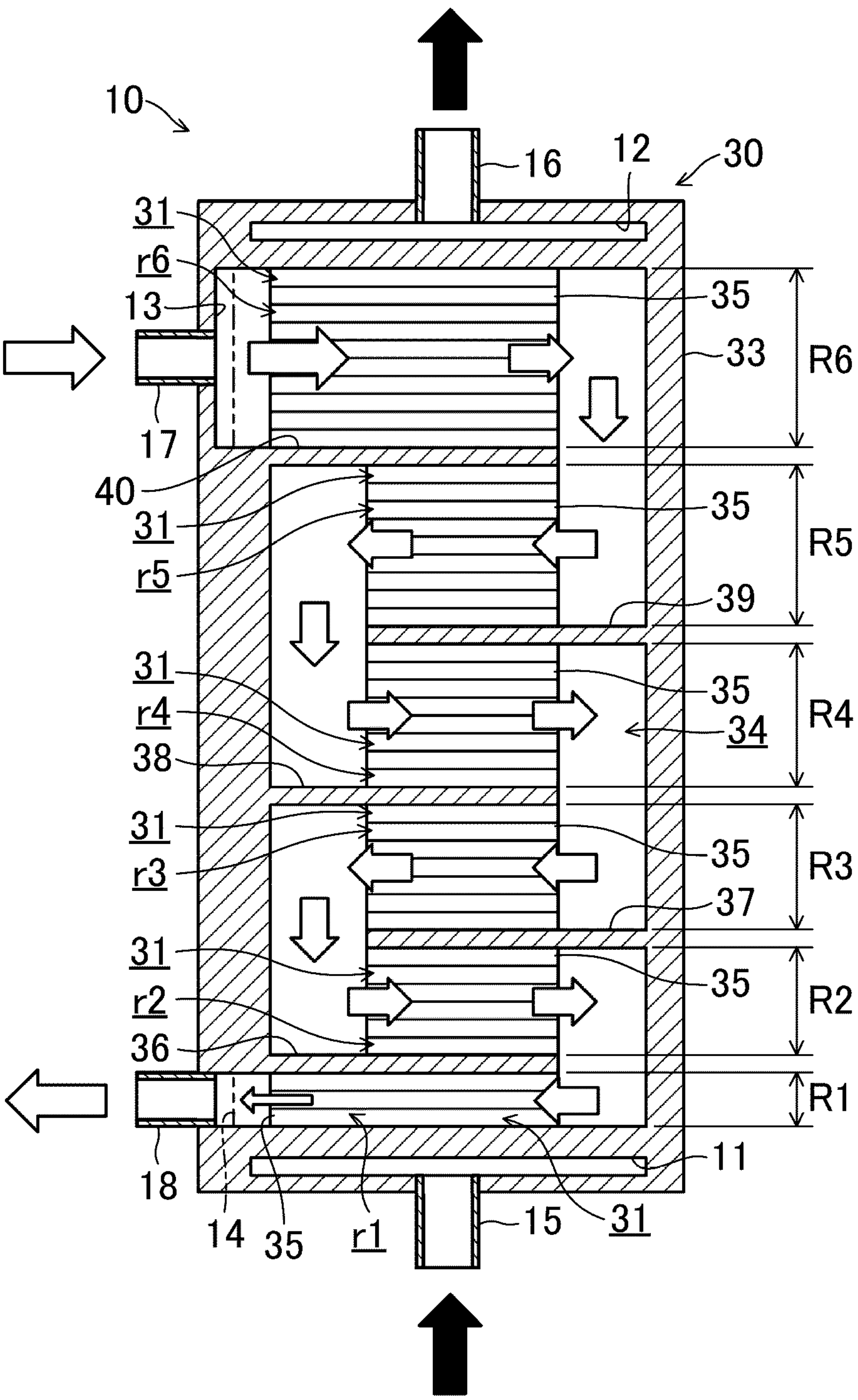
FIG.19



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2024/012112

A. CLASSIFICATION OF SUBJECT MATTER

F28F 13/08(2006.01)i; ***F25B 1/00***(2006.01)i; ***F28D 9/00***(2006.01)i; ***F28F 3/08***(2006.01)i
FI: F28F13/08; F25B1/00 399Y; F28D9/00; F28F3/08 301A

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)

F28F13/08; F25B1/00; F28D9/00; F28F3/08

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 1971-2024
Registered utility model specifications of Japan 1996-2024
Published registered utility model applications of Japan 1994-2024

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 3-140795 A (HITACHI, LTD.) 14 June 1991 (1991-06-14) page 2, upper left column, lines 7-9, page 3, upper right column, line 18 to lower left column, line 15, page 5, lower right column, line 7 to page 6, upper left column, line 7, fig. 1-4, 12	1-2, 6-7
Y		3-7
X	JP 2014-524560 A (THE ABELL FOUNDATION, INC.) 22 September 2014 (2014-09-22) paragraphs [0123]-[0124], [0179], fig. 11-13, 30	1-2, 3, 6
Y		3-7

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 June 2024	**18 June 2024**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/012112

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 3-140795 A	14 June 1991	(Family: none)	
JP 2014-524560 A	22 September 2014	US 2013/0042996 A1 paragraphs [0155]-[0156], [0220], fig. 11-13, 30A WO 2013/025802 A2 EP 2758662 A2 KR 10-2014-0056343 A CN 103890388 A CN 107830761 A BR 112014003511 A2 KR 10-2019-0126187 A	

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Patent documents cited in the description

- JP 2002267289 A **[0003]**