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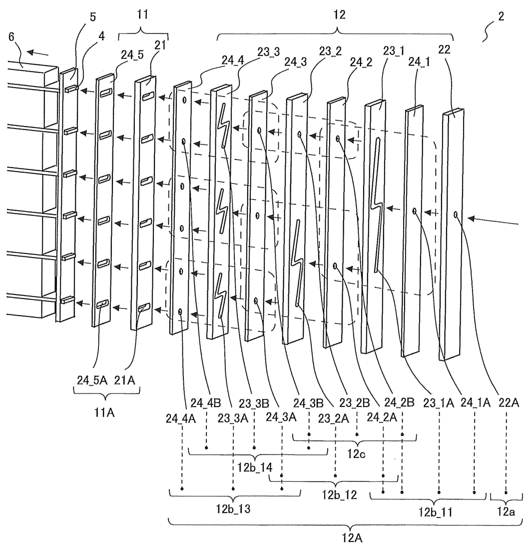
(54) **LAMINATED HEADER, HEAT EXCHANGER, AND AIR-CONDITIONER**

(57) A laminated header 2 according to the present invention includes a first plate-like body 11 including a plurality of outlet passages 11A, and also includes a second plate-like body 12 attached to the first plate-like body 11 and including at least part of a distribution passage 12A configured to distribute and deliver refrigerant inflowing from an inlet passage 12a to the plurality of outlet passages 11 A. A plurality of outflow passages in a branching passage of the distribution passage 12A include a first outflow passage and a second outflow passage. The number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage passes via the first outflow passage before reaching the outlet passages 11 A is smaller than the number of curves in a flow path through which the refrigerant inflowing from the inflow passage passes via the second outflow passage before reaching the outlet passages 11 A. The equivalent diameter of at least part of the first outflow passage is smaller than the equivalent diameter of at least part of the second outflow passage.

FIG. 2



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Description

Technical Field

[0001] The present invention relates to laminated headers, heat exchangers, and air-conditioning apparatuses.

Background Art

[0002] A header in the related art includes, for example, a plate-like body including a distribution passage configured to distribute and deliver refrigerant inflowing from an inlet passage to a plurality of outlet passages. In such a header, the distribution passage includes a plurality of branching passages, each having a branching portion, an inflow passage communicating with the branching portion, and two outflow passages communicating with the branching portion. In the distribution passage, the refrigerant is repeatedly branched off into two paths a plurality of times in the branching passages, subsequently flows into a plurality of distribution chambers, and is distributed to the plurality of outlet passages from the distribution chambers (e.g., see Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 10-267468 (paragraphs [0033] to [0037], Fig. 6)

Summary of Invention

Technical Problem

[0004] In such a header, the number of branching passages through which the refrigerant passes before flowing into each distribution chamber and the number of branch paths in each branching passage are the same so that evenness in the refrigerant to be distributed to the outlet passages is achieved. Thus, the number of outlet passages is limited to multiples of powers of 2. In other words, in a case where such a header is used in a device, such as a heat exchanger, there is a problem in that the number of outlet passages cannot be changed freely in accordance with the number of passages formed in the device.

[0005] The present invention has been made in view of the problem mentioned above, and an object thereof is to obtain a laminated header in which the degree of freedom in the number of outlet passages is increased. Another object of the present invention is to obtain a heat exchanger equipped with such a laminated header. Another object of the present invention is to obtain an air-conditioning apparatus equipped with such a heat exchanger.

Solution to Problem

[0006] A laminated header according an embodiment of the present invention includes a first plate-like body including a plurality of outlet passages, and also includes a second plate-like body attached to the first plate-like body and including at least part of a distribution passage configured to distribute and deliver refrigerant inflowing from an inlet passage to the plurality of outlet passages. The distribution passage includes a branching passage having a branching portion, an inflow passage communicating with the branching portion, and a plurality of outflow passages communicating with the branching portion. The plurality of outflow passages include a first outflow passage and a second outflow passage. The number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage passes via the first outflow passage before reaching the outlet passages is smaller than the number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage passes via the second outflow passage before reaching the outlet passages. The equivalent diameter of at least part of the first outflow passage is smaller than the equivalent diameter of at least part of the second outflow passage.

Advantageous Effects of Invention

[0007] In the laminated header according to the embodiment of the present invention, the plurality of outflow passages include the first outflow passage and the second outflow passage. The number of curves, at which flow separation of the refrigerant is to occur, in the flow path through which the refrigerant inflowing from the inflow passage passes via the first outflow passage before reaching the outlet passages is smaller than the number of curves, at which flow separation of the refrigerant is to occur, in the flow path through which the refrigerant inflowing from the inflow passage passes via the second outflow passage before reaching the outlet passages. Moreover, the equivalent diameter of at least part of the first outflow passage is smaller than the equivalent diameter of at least part of the second outflow passage. Accordingly, reduction in the evenness of the distribution of the refrigerant is suppressed, while the number of outlet passages can be changed to a number other than multiples of powers of 2, thereby allowing for an increased degree of freedom in the number of outlet passages in the laminated header.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 illustrates the configuration of a heat exchanger according to Embodiment 1.
[Fig. 2] Fig. 2 is a perspective view illustrating a state where a laminated header of the heat exchanger according to Embodiment 1 is disassembled.
[Fig. 3] Fig. 3 is a perspective view of a relevant part of a distribution passage, illustrating a state where the laminated header of the heat exchanger according to Embodiment 1 is disassembled.
[Fig. 4] Fig. 4 is a diagram illustrating an overlapped state of passages of a branching passage in the heat exchanger according to Embodiment 1.
[Fig. 5] Fig. 5 is a Baker diagram illustrating the relationship between a flow state and a flow pattern of refrigerant.
[Fig. 6] Fig. 6 illustrates the configuration of an air-conditioning apparatus to which the heat exchanger according to Embodiment 1 is applied.
[Fig. 7] Fig. 7 is a perspective view illustrating a state where a laminated header of a heat exchanger according to Embodiment 2 is disassembled.
[Fig. 8] Fig. 8 is a perspective view of a relevant part of a distribution passage, illustrating a state where the laminated header of the heat exchanger according to Embodiment 2 is disassembled.
[Fig. 9] Fig. 9 is a diagram illustrating an overlapped state of passages of a branching passage in the heat exchanger according to Embodiment 2.
[Fig. 10] Fig. 10 is a perspective view illustrating a state where the laminated header in a modification of the heat exchanger according to Embodiment 2 is disassembled.
[Fig. 11] Fig. 11 is a perspective view illustrating a state where the laminated header in a modification of the heat exchanger according to Embodiment 2 is disassembled.

Description of Embodiments

[0009] A laminated header according to the present invention will be described below with reference to the drawings.
[0010] Although the laminated header according to the present invention is described below as being configured to distribute refrigerant flowing into a heat exchanger, the laminated header according to the present invention may alternatively be configured to distribute refrigerant flowing into another device. Furthermore, for example, the configuration and the operation to be described below are merely examples, and the laminated header according to the present invention is not limited to the case of such a configuration or operation. Moreover, identical reference signs are given to identical or similar components among the drawings or such reference signs are omitted therefrom. Furthermore, the illustrations of detailed structures are simplified or omitted, where appropriate. Moreover, redundant or similar descriptions are simplified or omitted, where appropriate.

Embodiment 1

[0011] A heat exchanger according to Embodiment 1 will be described.

<Configuration of Heat Exchanger>

[0012] The configuration of the heat exchanger according to Embodiment 1 will be described below.
[0013] Fig. 1 illustrates the configuration of the heat exchanger according to Embodiment 1.
[0014] As shown in Fig. 1, a heat exchanger 1 has a laminated header 2, a header 3, a plurality of heat-transfer tubes 4, a support member 5, and a plurality of fins 6.
[0015] The laminated header 2 has a refrigerant inflow section 2A and a plurality of refrigerant outflow sections 2B. The header 3 has a plurality of refrigerant inflow sections 3A and a refrigerant outflow section 3B. The refrigerant inflow section 2A of the laminated header 2 and the refrigerant outflow section 3B of the header 3 are connected to a refrigerant

pipe. The heat-transfer tubes 4 are connected between the refrigerant outflow sections 2B of the laminated header 2 and the refrigerant inflow sections 3A of the header 3.

[0016] A plurality of heat-transfer tubes 4 are flat tubes each having a passages. The heat-transfer tubes 4 are composed of, for example, aluminum. The laminated-header-2-side ends of the heat-transfer tubes 4 are connected to the refrigerant outflow sections 2B of the laminated header 2 in a state where the ends are supported by the support member 5, which is plate-like. The support member 5 is composed of, for example, aluminum. The heat-transfer tubes 4 are joined to the plurality of fins 6. The fins 6 are composed of, for example, aluminum. Although Fig. 1 illustrates a case where there are six heat-transfer tubes 4, the number thereof is not limited to such a case. For example, the number may be two. Furthermore, the heat-transfer tubes 4 do not have to be flat tubes.

<Flow of Refrigerant in Heat Exchanger>

[0017] The flow of the refrigerant in the heat exchanger according to Embodiment 1 will be described below.

[0018] The refrigerant flowing through the refrigerant pipe is distributed by flowing into the laminated header 2 via the refrigerant inflow section 2A, and outflows to the plurality of heat-transfer tubes 4 via the corresponding plurality of refrigerant outflow sections 2B. In the plurality of heat-transfer tubes 4, the refrigerant exchanges heat with, for example, air supplied from a fan. The refrigerant flowing through the plurality of heat-transfer tubes 4 merges together by flowing into the header 3 via the plurality of refrigerant inflow sections 3A, and outflows to the refrigerant pipe via the refrigerant outflow section 3B. The refrigerant can be flowed backward.

<Configuration of Laminated Header>

[0019] The configuration of the laminated header of the heat exchanger according to Embodiment 1 will be described below.

[0020] Fig. 2 is a perspective view illustrating a state where the laminated header of the heat exchanger according to Embodiment 1 is disassembled.

[0021] As shown in Fig. 2, the laminated header 2 includes a first plate-like body 11 and a second plate-like body 12. The first plate-like body 11 is laminated at the outflow side of the refrigerant. The second plate-like body 12 is laminated at the inflow side of the refrigerant.

[0022] The first plate-like body 11 has a first plate-like member 21 and a cladding member 24_5. The second plate-like body 12 has a second plate-like member 22, a plurality of third plate-like members 23_1 to 23_3, and a plurality of cladding members 24_1 to 24_4. A brazing material is applied to both surfaces or one surface of each of the cladding members 24_1 to 24_5. The first plate-like member 21 is laminated on the support member 5 with the cladding member 24_5 interposed therebetween. The plurality of third plate-like members 23_1 to 23_3 respectively intervened by the cladding members 24_2 to 24_4 are laminated on the first plate-like member 21. The second plate-like member 22 is laminated on the third plate-like member 23_1 with the cladding member 24_1 interposed therebetween. For example, the first plate-like member 21, the second plate-like member 22, and the third plate-like members 23_1 to 23_3 each have a thickness of 1 mm to 10 mm and are composed of aluminum.

[0023] In the following description, the support member 5, the first plate-like member 21, the second plate-like member 22, the third plate-like members 23_1 to 23_3, and the cladding members 24_1 to 24_5 are sometimes collectively referred to as plate-like members. Furthermore, the third plate-like members 23_1 to 23_3 are sometimes collectively referred to as third plate-like members 23. Moreover, the cladding members 24_1 to 24_5 are sometimes collectively referred to as cladding members 24.

[0024] By joining the first plate-like member 21 to the cladding member 24_5, passages 21 A formed in the first plate-like member 21 and passages 24_5A formed in the cladding member 24_5 communicate with each other, whereby a plurality of outlet passages 11 A are formed. The passages 21 A and the passages 24_5A are through-holes whose inner peripheral surfaces conform in shape to the outer peripheral surfaces of the heat-transfer tubes 4. The ends of the heat-transfer tubes 4 are supported by being joined to the support member 5 by brazing. When the first plate-like body 11 and the support member 5 are joined to each other, the ends of the heat-transfer tubes 4 and the outlet passages 11 A are connected to each other. Alternatively, the outlet passages 11 A and the heat-transfer tubes 4 may be directly joined to each other without providing the support member 5. In that case, for example, the component cost is reduced. The plurality of outlet passages 11 A correspond to the plurality of refrigerant outflow sections 2B in Fig. 1.

[0025] By joining the second plate-like member 22, the third plate-like members 23_1 to 23_3, and the cladding members 24_1 to 24_4, a passage 22A formed in the second plate-like member 22, passages 23_1 A to 23_3A, 23_2B, and 23_3B formed in the third plate-like members 23_1 to 23_3, and passages 24_1 A to 24_4A and 24_2B to 24_4B formed in the cladding members 24_1 to 24_4 communicate with one another, whereby a distribution passage 12A is formed.

[0026] The distribution passage 12A has an inlet passage 12a, branching passages 12b_11 to 12b_14, and a through-passage 12c. The number and the order of the branching passages 12b_11 to 12b_14 and the through-passage 12c are changed, where appropriate, in accordance with, for example, the number of heat-transfer tubes 4. In the following description, the branching passages 12b_11 to 12b_14 are sometimes collectively referred to as branching passages 12b.

[0027] By joining the second plate-like member 22 to the cladding member 24_1, the passage 22A formed in the second plate-like member 22 and the passage 24_1 A formed in the cladding member 24_1 communicate with each other, whereby the inlet passage 12a is formed. The passage 22A and the passage 24_1 A are circular through-holes. The inlet passage 12a is connected to the refrigerant pipe. The inlet passage 12a corresponds to the refrigerant inflow section 2A in Fig. 1.

[0028] By joining the third plate-like member 23_1 to the cladding members 24_1 and 24_2, the passage 24_1 A formed in the cladding member 24_1, the passage 23_1A formed in the third plate-like member 23_1, and the one passage 24_2A and the one passage 24_2B formed in the cladding member 24_2 communicate with one another, whereby the branching passage 12b_11 is formed. The passage 23_1A is a linear through-groove. The passages 24_2A and 24_2B are circular through-holes.

[0029] By joining the third plate-like member 23_2 to the cladding members 24_2 and 24_3, the passage 24_2A formed in the cladding member 24_2, the passage 23_2A formed in the third plate-like member 23_2, and the two passages 24_3A formed in the cladding member 24_3 communicate with one another, whereby the branching passage 12b_12 is formed. The passage 23_2A is a linear through-groove. The passages 24_3A are circular through-holes.

[0030] By joining the third plate-like member 23_3 to the cladding members 24_3 and 24_4, the passages 24_3A formed in the cladding member 24_3, the passages 23_3A formed in the third plate-like member 23_3, and the two pairs of passages 24_4A formed in the cladding member 24_4 communicate with one another, whereby the branching passages 12b_13 are formed. The passages 23_3A are linear through-grooves. The passages 24_4A are circular through-holes.

[0031] By joining the third plate-like member 23_2 to the cladding members 24_2 and 24_3, the passage 24_2B formed in the cladding member 24_2, the passage 23_2B formed in the third plate-like member 23_2, and the one passage 24_3B formed in the cladding member 24_3 communicate with one another, whereby the through-passage 12c is formed. The passage 23_2B and the passage 24_3B are circular through-holes.

[0032] By joining the third plate-like member 23_3 to the cladding members 24_3 and 24_4, the passage 24_3B formed in the cladding member 24_3, the passage 23_3B formed in the third plate-like member 23_3, and the two passages 24_4B formed in the cladding member 24_4 communicate with one another, whereby the branching passage 12b_14 is formed. The passage 23_3B is a linear through-groove. The passages 24_4B are circular through-holes.

[0033] Parts located between ends of the passages 23_1A to 23_3A and 23_3B being linear through-grooves formed in the third plate-like members 23 and the passages 24_1 A to 24_3A and 24_3B being circular through-holes formed in the cladding members 24 laminated on the refrigerant inflow surfaces of the third plate-like members 23 are formed at positions facing each other. Therefore, the passages 23_1 A to 23_3A and 23_3B being linear through-grooves formed in the third plate-like members 23 are blocked, except for the parts between the ends, by the cladding members 24 laminated on the refrigerant inflow surfaces of the third plate-like members 23.

[0034] The ends of the passages 23_1 A to 23_3A and 23_3B being linear through-grooves formed in the third plate-like members 23 and the passages 24_2A to 24_4A and 24_4B being circular through-holes formed in the cladding members 24 laminated on the refrigerant outflow surfaces of the third plate-like members 23 are formed at positions facing each other. Therefore, the passages 23_1 A to 23_3A and 23_3B being linear through-grooves formed in the third plate-like members 23 are blocked, except for the ends, by the cladding members 24 laminated on the refrigerant outflow surfaces of the third plate-like members 23.

[0035] The laminated header 2 may include a plurality of combinations of outlet passages 11 A and distribution passages 12A. Furthermore, the inlet passage 12a may be formed in a plate-like member other than the second plate-like member 22. In other words, the inlet passage 12a may be formed in, for example, the first plate-like member 21 or the third plate-like member 23.

<Flow of Refrigerant in Laminated Header>

[0036] The flow of the refrigerant in the laminated header of the heat exchanger according to Embodiment 1 will be described below.

[0037] As shown in Fig. 2, the refrigerant passing through the inlet passage 12a flows into the branching passage 12b_11. In the branching passage 12b_11, the refrigerant passing through the passage 24_1 A flows into the part between the ends of the passage 23_1 A, branches off into two paths by hitting against the surface of the cladding member 24_2, reaches the opposite ends of the passage 23_1A, and flows into the branching passage 12b_12 and the through-passage 12c.

[0038] In the branching passage 12b_12, the refrigerant passing through the passage 24_2A flows into the part between the ends of the passage 23_2A, branches off into two paths by hitting against the surface of the cladding member 24_3, reaches the opposite ends of the passage 23_2A, and flows into the two branching passages 12b_13.

[0039] In each branching passage 12b_13, the refrigerant passing through the passage 24_3A flows into the part between the ends of the passage 23_3A, branches off into two paths by hitting against the surface of the cladding member 24_4, reaches the opposite ends of the passage 23_3A, and flows into the heat-transfer tubes 4 via the outlet passages 11 A.
[0040] In the through-passage 12c, the refrigerant passing through the passage 24_2B passes through the passage 23_2B and flows into the branching passage 12b_14.
[0041] In the branching passage 12b_14, the refrigerant passing through the passage 24_3B flows into the part between the ends of the passage 23_3B, branches off into two paths by hitting against the surface of the cladding member 24_4, reaches the opposite ends of the passage 23_3B, and flows into the heat-transfer tubes 4 via the outlet passages 11 A.

<Detailed Description of Branching Passages and Through-Passage>

[0042] The branching passages and the through-passage in the laminated header of the heat exchanger according to Embodiment 1 will be described in detail below.
[0043] Fig. 3 is a perspective view of a relevant part of the distribution passage, illustrating a state where the laminated header of the heat exchanger according to Embodiment 1 is disassembled. Fig. 4 is a diagram illustrating an overlapped state of the passages of a branching passage in the heat exchanger according to Embodiment 1.
[0044] As shown in Fig. 3, in the branching passage 12b_11, the equivalent diameter of the passage 24_2B communicating with the passage 23_2B being a circular through-hole of the through-passage 12c is smaller than the equivalent diameter of the passage 24_2A communicating with the passage 23_2A being a linear through-groove of the branching passage 12b_12.
[0045] In other words, as shown in Fig. 4, assuming that an intersection portion 31 where the passage 23_1A intersects the passage 24_1A is defined as a branching portion 41 of the branching passage 12b, the passage 24_1A is defined as an inflow passage 42 of the branching passage 12b, a connecting portion 33, connecting the intersection portion 31 and an upper end 32 of the passage 23_1 A, and the passage 24_2B are defined as a first outflow passage 43 of the branching passage 12b, a connecting portion 35, connecting the intersection portion 31 and a lower end 34 of the passage 23_1 A, and the passage 24_2A are defined as a second outflow passage 44 of the branching passage 12b, the equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44. In the branching portion 41 of the branching passage 12b, separation occurs in the flow of the refrigerant. Furthermore, the connecting portions 33 and 35 being linear through-grooves of the branching passage 12b each have a bent portion 36. At each bent portion 36, separation occurs in the flow of the refrigerant. Moreover, separation occurs in the flow of the refrigerant at the upper end 32 and the lower end 34 being linear through-grooves of the branching passage 12b. In other words, the branching portion 41, the bent portions 36, the upper end 32, and the lower end 34 correspond to "curves at which flow separation of the refrigerant is to occur".
[0046] Specifically, in the first outflow passage 43 of the branching passage 12b_11, the refrigerant outflowing from the end not communicating with the branching portion 41 passes through the through-passage 12c and the branching passage 12b_14 before reaching the outlet passages 11 A. Therefore, the number of times the refrigerant passes through the curves at which separation occurs in the flow of the refrigerant is small. In contrast, in the second outflow passage 44 of the branching passage 12b_11, the refrigerant outflowing from the end not communicating with the branching portion 41 passes through the branching passage 12b_12 and the branching passages 12b_13 before reaching the outlet passages 11 A. Therefore, the number of times the refrigerant passes through the curves at which separation occurs in the flow of the refrigerant is large. Thus, if the equivalent diameter of the first outflow passage 43 and the equivalent diameter of the second outflow passage 44 are equal to each other, a difference occurs between pressure loss in the refrigerant outflowing from the first outflow passage 43 and pressure loss in the refrigerant outflowing from the second outflow passage 44, causing the refrigerant distributed to the outlet passages 11A to become uneven. In contrast, when the equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44, unevenness in the refrigerant distributed to the outlet passages 11 A is suppressed.
[0047] An equivalent diameter is calculated based on Expression 1 below.

$$\text{Equivalent Diameter} = 4\times(\text{Cross-Sectional Area of Passage})/(\text{Length of Wetted Perimeter})$$

[0048] For example, the equivalent diameters of the passages 24_2A and 24_2B are set such that the flow pattern of the refrigerant is the same before and after passing through the passages 24_2A and 24_2B. If the flow pattern of the refrigerant changes before and after passing through the passages 24_2A and 24_2B, the pressure loss occurring in the refrigerant is dependent on the flow rate and fluctuates significantly. Thus, the balance in pressure loss in each of the passages 24_2A and 24_2B changes in accordance with fluctuations in the flow rate of the refrigerant flowing into the distribution passage 12A, causing the refrigerant distributed to the outlet passages 11 A to become uneven. In the case where, for example, the equivalent diameters of the passages 24_2A and 24_2B are set such that the flow pattern of the refrigerant is the same, unevenness in the refrigerant distributed to the outlet passages 11 A is suppressed.

[0049] For example, the hole diameters of the passages 24_2A and 24_2B may be set such that the flow pattern of the refrigerant does not change before and after passing through the passages 24_2A and 24_2B under a condition in which the refrigerant flows into the distribution passage 12A at the maximum flow rate and is uniformly distributed to the outlet passages 11 A.

[0050] In particular, for example, the equivalent diameters of the passages 24_2A and 24_2B may be set such that the flow pattern of the refrigerant becomes an annular flow pattern or an annular spray flow pattern before and after passing through the passages 24_2A and 24_2B. With this configuration, the flow state of the refrigerant after passing through the passages 24_2A and 24_2B is made uniform, thereby achieving improved evenness in the branching process in the subsequent branching passage 12b.

[0051] Fig. 5 is a Baker diagram illustrating the relationship between the flow state and the flow pattern of the refrigerant.

[0052] The flow pattern of the refrigerant before and after passing through the passages 24_2A and 24_2B can be calculated by using the Baker diagram shown in Fig. 5. The Baker diagram is a characteristic diagram showing the flow pattern of the refrigerant in a two-phase gas-liquid state. The ordinate axis and the abscissa axis indicate values expressing the flow state of the refrigerant. The ordinate axis is Gg/λ, whereas the abscissa axis is $\lambda \times \phi \times Gl/Gg$. The ordinate axis corresponds to the magnitude of the mass flow rate of the gaseous phase of the refrigerant. In Fig. 5, the mass flow rate of the gaseous phase of the refrigerant increases toward the upper side. The abscissa axis corresponds to the ratio of the mass flow rate between the gaseous phase and the liquid phase of the refrigerant, that is, the quality. In Fig. 5, the quality decreases toward the right side.

[0053] In detail, for example, the equivalent diameters of the passages 24_2A and 24_2B may be set such that the flow state of the refrigerant before and after passing through the passages 24_2A and 24_2B satisfies the relationship indicated by expression 2 or 3 below.

[0054] In expression 2 and expression 3 below, the mass velocity of the gaseous phase of the refrigerant is defined as Gg [$kg/(m^2 \cdot h)$], the mass velocity of the liquid phase of the refrigerant is defined as Gl [$kg/(m^2 \cdot h)$], the density of the gaseous phase of the refrigerant is defined as pg [kg/m^3], the density of the liquid phase of the refrigerant is defined as ρl [kg/m^3], the density of air is defined as pa [kg/m^3], the density of water is defined as ρw [kg/m^3], the surface tension of the liquid phase of the refrigerant is defined as σl [N/m], the surface tension of water is defined as σw [N/m], the viscosity coefficient of the liquid phase of the refrigerant is defined as μl [$\mu Pa \cdot s$], and the viscosity coefficient of water is defined as μw [$\mu Pa \cdot s$].

$$2 \times 10^4 < Gg/\lambda < 2 \times 10^5$$

$$1 < \lambda \times \phi \times Gl/Gg < 100$$

$$\lambda = \{(\rho g/\rho a) \times (\rho l/\rho w)\}^{1/2}$$

$$\phi = (\sigma w/\sigma l)^{1/4} \times \{(\mu l/\mu w) \times (\rho w/\rho l)^2\}^{1/3}$$

$$2 \times 10^5 < Gg/\lambda$$

$$1 < \lambda \times \phi \times Gl/Gg < 100$$

$$\lambda = \{(\rho g/\rho a) \times (\rho l/\rho w)\}^{1/2}$$

$$\phi = (\sigma w/\sigma l)^{1/4} \times \{(\mu l/\mu w)\times(\rho w/\rho l)^2\}^{1/3}$$

[0055] When calculating the flow pattern by using the Baker diagram, the maximum flow rate of the refrigerant flowing into the distribution passage 12A may be used as the flow rate, the equivalent diameter of the passage 23_1 A may be used as the equivalent diameter of a passage before the refrigerant passes through the passage 24_2A or 24_2B, and the equivalent diameter of the passage 24_2A or 24_2B may be used as the equivalent diameter of a passage before the refrigerant passes through the passage 24_2A or 24_2B.

[0056] Furthermore, in order to achieve evenness in the flow rate of the refrigerant distributed to the outlet passages 11 A to improve the heat exchanging efficiency of the heat exchanger 1, other passages constituting the distribution passage 12A may similarly be set to equivalent diameters with which the pressure loss occurring in the refrigerant becomes even. For example, as shown in Fig. 3, the equivalent diameter of the passage 24_3B may be smaller than the equivalent diameter of each passage 24_3A. Furthermore, for example, the equivalent diameters of the passage 23_3B and the passages 24_4B may be smaller than the equivalent diameters of the passages 23_3A and the passages 24_4A. If there are a plurality of branching passages 12b similar to the branching passage 12b_11, the above-described configuration may be employed in all of the branching passages, or the above-described configuration may be employed in one or more of the branching passages.

[0057] When the flow rate of the refrigerant flowing through a passage decreases, the pressure loss occurring in the refrigerant decreases, so that the effect on the evenness in the refrigerant as a result of changing the equivalent diameter is reduced. Thus, the branching passage 12b in which the equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44 may be the branching passage 12b at the upstream side of the distribution passage 12A. In other words, the refrigerant outflowing from at least one of the first outflow passage 43 and the second outflow passage 44 in the branching passage 12b in which the equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44 may be further branched off at another branching passage 12b.

[0058] Although the above description relates to a case where each branching passage 12b has different heights, in the direction of gravitational force, at the ends not communicating with the branching portion 41 between the first outflow passage 43 and the second outflow passage 44, the branching passage 12b is not limited to such a case. In the case where the branching passage 12b has different heights, in the direction of gravitational force, at the ends not communicating with the branching portion 41 between the first outflow passage 43 and the second outflow passage 44, the advantage of employing the above-described configuration is noteworthy since it is particularly difficult to evenly distribute the refrigerant.

[0059] Furthermore, although the above description relates to a case where the branching passages 12b each have the branching portion 41 in a linear region not parallel to the direction of gravitational force of the passages 23_1A to 23_3A and 23_3B, the branching passages 12b are not limited to such a case. In the case where the branching passages 12b each have the branching portion 41 in a linear region not parallel to the direction of gravitational force of the passages 23_1A to 23_3A and 23_3B, the refrigerant is evenly branched off at the branching portion 41. Moreover, in a case where the linear region is substantially orthogonal to the direction of gravitational force, the angles of branching directions relative to the direction of gravitational force are made even at the branching portion 41, so that unevenness in the distribution of the refrigerant due to the effect of gravitational force is suppressed. In particular, this advantage is noteworthy in the case where each branching passage 12b has different heights, in the direction of gravitational force, at the ends not communicating with the branching portion 41 between the first outflow passage 43 and the second outflow passage 44.

[0060] Furthermore, although the above description relates to a case where, in each branching passage 12b, the end of the first outflow passage 43 not communicating with the branching portion 41 is positioned at the upper side of the branching portion 41 in the direction of gravitational force and the end of the second outflow passage 44 not communicating with the branching portion 41 is positioned at the lower side of the branching portion 41 in the direction of gravitational force, the branching passages 12b are not limited to such a case. In the case where, in each branching passage 12b, the end of the first outflow passage 43 not communicating with the branching portion 41 is positioned at the upper side of the branching portion 41 in the direction of gravitational force and the end of the second outflow passage 44 not communicating with the branching portion 41 is positioned at the lower side of the branching portion 41 in the direction of gravitational force, the difference in passage length between the first outflow passage 43 and the second outflow passage 44 can be reduced, thereby achieving even distribution of the refrigerant without making the passage shapes of the first outflow passage 43 and the second outflow passage 44 complex.

[0061] Furthermore, although the above description relates to a case where, in each branching passage 12b, a line connecting the end of the first outflow passage 43 not communicating with the branching portion 41 and the end of the second outflow passage 44 not communicating with the branching portion 41 is parallel to the longitudinal direction of the plate-like member, the branching passages 12b are not limited to such a case. In the case where, in each branching passage 12b, the line connecting the end of the first outflow passage 43 not communicating with the branching portion 41 and the end of the second outflow passage 44 not communicating with the branching portion 41 is parallel to the longitudinal direction of the plate-like member, the plate-like member can be reduced in size in the lateral direction so that, for example, the component cost and the weight are reduced. Moreover, in a case where, in each branching passage 12b, the line connecting the end of the first outflow passage 43 not communicating with the branching portion 41 and the end of the second outflow passage 44 not communicating with the branching portion 41 is parallel to the direction in which the heat-transfer tubes 4 are arranged, a space-saving heat exchanger 1 can be achieved. The line connecting the end of the first outflow passage 43 not communicating with the branching portion 41 and the end of the second outflow passage 44 not communicating with the branching portion 41, the longitudinal direction of the plate-like member, and the direction in which the heat-transfer tubes 4 are arranged do not have to be parallel to the direction of gravitational force.

<Application of Heat Exchanger>

[0062] An application example of the heat exchanger according to Embodiment 1 will be described below.

[0063] Although the following description relates to a case where the heat exchanger according to Embodiment 1 is applied to an air-conditioning apparatus, the application is not limited thereto. For example, the heat exchanger according to Embodiment 1 may be applied to another refrigeration cycle apparatus having a refrigerant circuit. Furthermore, although the following description relates to a case where the air-conditioning apparatus is configured to switch between the cooling operation and the heating operation, the air-conditioning apparatus may alternatively be configured to only perform the cooling operation or the heating operation.

[0064] Fig. 6 illustrates the configuration of the air-conditioning apparatus to which the heat exchanger according to Embodiment 1 is applied. In Fig. 6, the flow of the refrigerant during the cooling operation is indicated by a solid arrow, whereas the flow of the refrigerant during the heating operation is indicated by a dotted arrow.

[0065] As shown in Fig. 6, an air-conditioning apparatus 91 has a compressor 92, a four-way valve 93, an outdoor heat exchanger (heat-source-side heat exchanger) 94, an expansion device 95, an indoor heat exchanger (load-side heat exchanger) 96, an outdoor fan (heat-source-side fan) 97, an indoor fan (load-side fan) 98, and a controller 99. The compressor 92, the four-way valve 93, the outdoor heat exchanger 94, the expansion device 95, and the indoor heat exchanger 96 are connected by a refrigerant pipe, so that a refrigerant circuit is formed.

[0066] The controller 99 is connected to, for example, the compressor 92, the four-way valve 93, the expansion device 95, the outdoor fan 97, the indoor fan 98, and various types of sensors. The controller 99 changes the passage of the four-way valve 93 to switch between the cooling operation and the heating operation.

[0067] The flow of the refrigerant during the cooling operation will be described.

[0068] The refrigerant in a high-pressure high-temperature gas state discharged from the compressor 92 flows into the outdoor heat exchanger 94 via the four-way valve 93 and condenses by exchanging heat with air supplied by the outdoor fan 97. The condensed refrigerant turns into a high-pressure liquid state, outflows from the outdoor heat exchanger 94, and is turned into a low-pressure two-phase gas-liquid state by the expansion device 95. The refrigerant in the low-pressure two-phase gas-liquid state flows into the indoor heat exchanger 96 and evaporates by exchanging heat with air supplied by the indoor fan 98, thereby cooling the interior. The evaporated refrigerant turns into a low-pressure gas state, outflows from the indoor heat exchanger 96, and is suctioned into the compressor 92 via the four-way valve 93.

[0069] The flow of the refrigerant during the heating operation will be described.

[0070] The refrigerant in a high-pressure high-temperature gas state discharged from the compressor 92 flows into the indoor heat exchanger 96 via the four-way valve 93 and condenses by exchanging heat with air supplied by the indoor fan 98, thereby heating the interior. The condensed refrigerant turns into a high-pressure liquid state, outflows from the indoor heat exchanger 96, and is turned into refrigerant in a low-pressure two-phase gas-liquid state by the expansion device 95. The refrigerant in the low-pressure two-phase gas-liquid state flows into the outdoor heat exchanger 94 and evaporates by exchanging heat with air supplied by the outdoor fan 97. The evaporated refrigerant turns into a low-pressure gas state, outflows from the outdoor heat exchanger 94, and is suctioned into the compressor 92 via the four-way valve 93.

[0071] The heat exchanger 1 is used as at least one of the outdoor heat exchanger 94 and the indoor heat exchanger 96. When functioning as an evaporator, the heat exchanger 1 is connected such that the refrigerant inflows from the laminated header 2 and the refrigerant outflows to the header 3. In other words, when the heat exchanger 1 functions as an evaporator, the refrigerant in a two-phase gas-liquid state flows into the laminated header 2 from the refrigerant pipe. When the heat exchanger 1 functions as a condenser, the refrigerant flows backward through the laminated header 2.

[0072] Since the laminated header 2 achieves improved evenness in the distribution of the refrigerant owing to the above-described configuration, evenness in the flow rate and the quality of the refrigerant outflowing to the plurality of heat-transfer tubes 4 can be achieved even when refrigerant in a two-phase gas-liquid state, which is relatively difficult to distribute evenly, flows in. In other words, the laminated header 2 is suitable for a refrigeration cycle apparatus, such as the air-conditioning apparatus 91.

<Advantageous Effects of Heat Exchanger>

[0073] The advantageous effects of the heat exchanger according to Embodiment 1 will be described below.
[0074] In the laminated header 2, each branching passage 12b has the first outflow passage 43 having a small number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage 42 passes before reaching the outlet passages 11 A, and also has the second outflow passage 44 having a large number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage 42 passes before reaching the outlet passages 11 A. The equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44. Therefore, reduction in the evenness of the distribution of the refrigerant is suppressed, while the number of outlet passages 11 A can be changed to a number other than multiples of powers of 2, thereby allowing for an increased degree of freedom in the number of outlet passages 11 A in the laminated header 2.
[0075] Furthermore, in the laminated header 2, the distribution passage 12A is formed by laminating plate-like members. Therefore, regardless of the fact that the laminated header 2 is capable of suppressing reduction in the evenness of the distribution of the refrigerant while also allowing for a change in the number of outlet passages 11 A to a number other than multiples of powers of 2, for example, the equivalent diameter of each passage, the shape of each passage, the number of distributions, and the number of branch paths in the branching portion 41 can be easily changed by changing, for example, the hole diameter of each plate-like member, the groove width of each plate-like member, the hole shape or the groove shape of each plate-like member, the number of plate-like members, and the thickness of each plate-like member.

Embodiment 2

[0076] A heat exchanger according to Embodiment 2 will now be described.
[0077] Redundant or similar descriptions as those in Embodiment 1 are simplified, where appropriate, or are omitted.

<Configuration of Laminated Header>

[0078] The configuration of a laminated header of the heat exchanger according to Embodiment 2 will be described below.
[0079] Fig. 7 is a perspective view illustrating a state where the laminated header of the heat exchanger according to Embodiment 2 is disassembled.
[0080] As shown in Fig. 7, by joining a second plate-like member 22, third plate-like members 23_1 and 23_2, and cladding members 24_1 to 24_3, a passage 22A formed in the second plate-like member 22, passages 23_1 A, 23_2A, and 23_2B formed in the third plate-like members 23_1 and 23_2, and passages 24_1A to 24_3A and 24_2B and 24_3B formed in the cladding members 24_1 to 24_3 communicate with one another, whereby a distribution passage 12A is formed.
[0081] The distribution passage 12A has an inlet passage 12a and branching passages 12b_21 to 12b_23. The number and the order of the branching passages 12b_21 to 12b_23 are changed, where appropriate, in accordance with, for example, the number of heat-transfer tubes 4. In the following description, the branching passages 12b_21 to 12b_23 are sometimes collectively referred to as branching passages 12b.
[0082] By joining the third plate-like member 23_1 to the cladding members 24_1 and 24_2, the passage 24_1 A formed in the cladding member 24_1, the passage 23_1 A formed in the third plate-like member 23_1, and the two passages 24_2A and the one passage 24_2B formed in the cladding member 24_2 communicate with one another, whereby a branching passage 12b_21 is formed. The passage 23_1A is a linear through-groove. The passages 24_2A and 24_2B are circular through-holes.
[0083] By joining the third plate-like member 23_2 to the cladding members 24_2 and 24_3, the passages 24_2A formed in the cladding member 24_2, the passages 23_2A formed in the third plate-like member 23_2, and the two pairs of passages 24_3A formed in the cladding member 24_3 communicate with one another, whereby branching passages 12b_22 are formed. The passages 23_2A are linear through-grooves. The passages 24_3A are circular through-holes.
[0084] By joining the third plate-like member 23_2 to the cladding members 24_2 and 24_3, the passage 24_2B formed in the cladding member 24_2, the passage 23_2B formed in the third plate-like member 23_2, and the two passages 24_3B formed in the cladding member 24_3 communicate with one another, whereby a branching passage 12b_23 is formed. The passage 23_2B is a linear through-groove. The passages 24_3B are circular through-holes.
[0085] Parts located between ends of the passages 23_1 A, 23_2A, and 23_2B being linear through-grooves formed

in the third plate-like members 23 and the passages 24_1 A, 24_2A, and 24_2B being circular through-holes formed in the cladding members 24 laminated on the refrigerant inflow surfaces of the third plate-like members 23 are formed at positions facing each other. Therefore, the passages 23_1 A, 23_2A, and 23_2B being linear through-grooves formed in the third plate-like members 23 are blocked, except for the parts between the ends, by the cladding members 24 laminated on the refrigerant inflow surfaces of the third plate-like members 23.

[0086] The ends of the passages 23_1A, 23_2A, and 23_2B being linear through-grooves formed in the third plate-like members 23 and the passages 24_2A, 24_3A, and 24_3B being circular through-holes formed in the cladding members 24 laminated on the refrigerant outflow surfaces of the third plate-like members 23 are formed at positions facing each other. Moreover, the passage 24_1 A being a circular through-hole formed in the cladding member 24_1 laminated on the refrigerant inflow surface of the third plate-like member 23_1 and the passage 24_2B being a circular through-hole formed in the cladding member 24_2 laminated on the refrigerant outflow surface of the third plate-like member 23_1 are formed at positions facing each other. Therefore, the passages 23_2A and 23_2B being linear through-grooves formed in the third plate-like members 23 excluding the third plate-like member 23_1 are blocked, except for the ends, by the cladding members 24 laminated on the refrigerant outflow surfaces of the relevant third plate-like members 23. Moreover, the passage 23_1A being a linear through-groove formed in the third plate-like member 23_1 is blocked, except for the part between the ends and the ends, by the cladding member 24_2 laminated on the refrigerant outflow surface of the third plate-like member 23_1.

<Flow of Refrigerant in Laminated Header>

[0087] The flow of the refrigerant in the laminated header of the heat exchanger according to Embodiment 2 will be described below.

[0088] As shown in Fig. 7, the refrigerant passing through the inlet passage 12a flows into the branching passage 12b_21. In the branching passage 12b_21, the refrigerant passing through the passage 24_1 A passes through the part between the ends of the passage 23_1 A, reaches the opposite ends of the passage 23_1A, and flows into the two branching passages 12b_22 and the one branching passage 12b_23.

[0089] In each branching passage 12b_22, the refrigerant passing through the passage 24_2A flows into the part between the ends of the passage 23_2A, branches off into two paths by hitting against the surface of the cladding member 24_3, reaches the opposite ends of the passage 23_2A, and flows into the heat-transfer tubes 4 via the outlet passages 11 A.

[0090] In the branching passage 12b_23, the refrigerant passing through the passage 24_2B flows into the part between the ends of the passage 23_2B, branches off into two paths by hitting against the surface of the cladding member 24_3, reaches the opposite ends of the passage 23_2B, and flows into the heat-transfer tubes 4 via the outlet passages 11 A.

<Detailed Description of Branching Passages and Through-Passage>

[0091] The branching passages and the through-passage in the laminated header of the heat exchanger according to Embodiment 2 will be described in detail below.

[0092] Fig. 8 is a perspective view of a relevant part of the distribution passage, illustrating a state where the laminated header of the heat exchanger according to Embodiment 2 is disassembled. Fig. 9 is a diagram illustrating an overlapped state of the passages of a branching passage in the heat exchanger according to Embodiment 2.

[0093] As shown in Fig. 8, in the branching passage 12b_21, the equivalent diameter of the passage 24_2B facing the part between the ends of the passage 23_1A and also facing the passage 24_1 A is smaller than the equivalent diameter of each of the passages 24_2A facing the ends of the passage 23_1 A.

[0094] In other words, as shown in Fig. 9, assuming that an intersection portion 31 where the passage 23_1A intersects the passage 24_1A is defined as a branching portion 41 of the branching passage 12b, the passage 24_1A is defined as an inflow passage 42 of the branching passage 12b, the passage 24_2B is defined as a first outflow passage 43 of the branching passage 12b, connecting portions 33 and 35, connecting the intersection portion 31 and an upper end 32 or a lower end 34 of the passage 23_1 A, and the passage 24_2A are defined as a second outflow passage 44 of the branching passage 12b, the equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44. The refrigerant flowing into the branching portion 41 from the inflow passage 42 flows easily into the first outflow passage 43 but is unlikely to flow into the second outflow passage 44. In other words, in a passage connecting the inflow passage 42 and the second outflow passage 44, the branching portion 41 corresponds to "a curve at which flow separation of the refrigerant is to occur".

[0095] Specifically, in the first outflow passage 43 of the branching passage 12b_21, the refrigerant inflows from the inflow passage 42 without being bent at the branching portion 41 and flows into the subsequent branching passage 12b_23 without traveling through the bent portion 36 of the passage 23_1 A and the upper end 32 or the lower end 34 of the passage 23_1 A. Therefore, the number of times the refrigerant inflowing from the inflow passage 42 passes through curves at which separation occurs in the flow of the refrigerant before reaching the outlet passages 11 A is small. In contrast, in the second outflow passage 44 of the branching passage 12b_21, the refrigerant inflowing from the inflow passage 42 is bent at the branching portion 41, travels through the bent portion 36 of the passage 23_1A and the upper end 32 or the lower end 34 of the passage 23_1 A, and subsequently flows into the subsequent branching passage 12b_22. Therefore, the number of times the refrigerant inflowing from the inflow passage 42 passes through curves at which separation occurs in the flow of the refrigerant before reaching the outlet passages 11 A is large. Thus, if the equivalent diameter of the first outflow passage 43 and the equivalent diameter of the second outflow passage 44 are equal to each other, a difference occurs between pressure loss in the refrigerant passing through the first outflow passage 43 and pressure loss in the refrigerant passing through the second outflow passage 44, causing the refrigerant distributed to the outlet passages 11 A to become uneven. In contrast, when the equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44, unevenness in the refrigerant distributed to the outlet passages 11 A is suppressed.

[0096] Furthermore, in order to achieve evenness in the flow rate of the refrigerant distributed to the outlet passages 11 A to improve the heat exchanging efficiency of the heat exchanger 1, other passages constituting the distribution passage 12A preferably similarly be set to equivalent diameters with which the pressure loss occurring in the refrigerant becomes even. For example, as shown in Fig. 8, the equivalent diameter of each of the passage 23_2B and the passages 24_3B may be smaller than the equivalent diameter of each of the passages 23_2A and the passages 24_3A, respectively. If there are a plurality of branching passages 12b similar to the branching passage 12b_21, the above-described configuration may be employed in all of the branching passages, or the above-described configuration may be employed in one or more of the branching passages.

<Advantageous Effects of Heat Exchanger>

[0097] The advantageous effects of the heat exchanger according to Embodiment 2 will be described below.

[0098] In the laminated header 2, each branching passage 12b has the first outflow passage 43 having a small number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage 42 passes before reaching the outlet passages 11 A, and also has the second outflow passage 44 having a large number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage 42 passes before reaching the outlet passages 11 A. The equivalent diameter of at least part of the first outflow passage 43 is smaller than the equivalent diameter of at least part of the second outflow passage 44. Therefore, reduction in the evenness of the distribution of the refrigerant is suppressed, while the number of outlet passages 11 A can be changed to a number other than multiples of powers of 2, thereby allowing for an increased degree of freedom in the number of outlet passages 11A in the laminated header 2.

[0099] Furthermore, in the laminated header 2, the distribution passage 12A has the branching passage 12b_21 that causes the inflowing refrigerant to branch off into three paths, that is, causes the inflowing refrigerant to branch off into a large number of branch paths. Therefore, the laminated header 2 can be reduced in thickness, so that the laminated header 2 is reduced in size and cost. Moreover, the number of plate-like members constituting the laminated header 2 can be reduced, thereby reducing, for example, the manufacturing costs.

<Modifications>

[0100] Figs. 10 and 11 are perspective views illustrating a state where the laminated header in modifications of the heat exchanger according to Embodiment 2 is disassembled.

[0101] As shown in Fig. 10, the refrigerant outflowing from the first outflow passage 43 of the branching passage 12b_21 may flow into the through-passage 12c. In other words, the configuration of the heat exchanger according to Embodiment 1 and the configuration of the heat exchanger according to Embodiment 2 may be combined. In that case, the degree of freedom in the number of outlet passages 11 A in the laminated header 2 is further increased.

[0102] Furthermore, as shown in Fig. 11, for example, the refrigerant outflowing from the first outflow passage 43 of the branching passage 12b_21 may flow into the branching passage 12b_22, and the refrigerant outflowing from the second outflow passage 44 of the branching passage 12b_21 may flow into the through-passage 12c. In that case, in order to achieve evenness in the refrigerant distributed to the outlet passages 11 A, the equivalent diameter of at least part of the first outflow passage 43 may possibly be set to be larger than the equivalent diameter of at least part of the second outflow passage 44. In that case, the first outflow passage 43 corresponds to a "second outflow passage" according to the present invention, and the second outflow passage 44 corresponds to a "first outflow passage" according to the present invention.

[0103] Although Embodiment 1 and Embodiment 2 have been described above, the present invention is not to be limited to Embodiment 1 and Embodiment 2. For example, Embodiment 1 and Embodiment 2 may be entirely or partially combined, or may be combined with the modifications.

Reference Signs List

[0104] 1 heat exchanger 2 laminated header 2A refrigerant inflow section 2B refrigerant outflow section 3 header 3A refrigerant inflow section 3B refrigerant outflow section 4 heat-transfer tube 5 support member 6 fin 11 first plate-like body 11 A outlet passage 12 second plate-like body 12A distribution passage 12a inlet passage 12b, 12b_11 to 12b_14, 12b_21 to 12b_23 branching passage 12c through-passage 21 first plate-like member 21A passage 22 second plate-like member 22A passage 23, 23_1 to 23_3 third plate-like member 23_1A to 23_3A, 23_2B, 23_3B passage 24, 24_1 to 24_5 cladding member 24_1A to 24_5A, 24_2B to 24 4B passage 31 intersection portion 32 upper end 33 connecting portion 34 lower end 35 connecting portion 36 bent portion 41 branching portion 42 inflow passage 43 first outflow passage 44 second outflow passage 91 air-conditioning apparatus 92 compressor 93 four-way valve 94 outdoor heat exchanger 95 expansion device 96 indoor heat exchanger 97 outdoor fan 98 indoor fan 99 controller

Claims

1. A laminated header comprising:

a first plate-like body including a plurality of outlet passages; and
a second plate-like body attached to the first plate-like body and including at least part of a distribution passage configured to distribute and deliver refrigerant inflowing from an inlet passage to the plurality of outlet passages,
wherein the distribution passage includes a branching passage having a branching portion, an inflow passage communicating with the branching portion, and a plurality of outflow passages communicating with the branching portion,
wherein the plurality of outflow passages include a first outflow passage and a second outflow passage,
wherein a number of curves, at which flow separation of the refrigerant is to occur, in a flow path through which the refrigerant inflowing from the inflow passage passes via the first outflow passage before reaching the outlet passages is smaller than a number of curves in a flow path through which the refrigerant inflowing from the inflow passage passes via the second outflow passage before reaching the outlet passages, and
wherein an equivalent diameter of at least part of the first outflow passage is smaller than an equivalent diameter of at least part of the second outflow passage.

2. The laminated header of claim 1,
wherein the distribution passage includes an other branching passage in addition to the branching passage, and wherein the refrigerant outflowing from at least one of the first outflow passage and the second outflow passage is further branched off at the other branching passage.

3. The laminated header of claim 1 or 2,
wherein at least one of the first outflow passage and the second outflow passage has an end communicating with the branching portion, the end facing an end of the inflow passage communicating with the branching portion.

4. A laminated header comprising:

a first plate-like body including a plurality of outlet passages; and
a second plate-like body attached to the first plate-like body and including at least part of a distribution passage configured to distribute and deliver refrigerant inflowing from an inlet passage to the plurality of outlet passages,
wherein the distribution passage includes a branching passage having a branching portion, an inflow passage communicating with the branching portion, and a plurality of outflow passages communicating with the branching portion,
and
wherein one outflow passage of the plurality of outflow passages has an end communicating with the branching portion, and the inflow passage has an end communicating with the branching portion, the end of the one outflow passage and the end of the inflow passage facing each other.

5. The laminated header of any one of claims 1 to 4,
wherein the plurality of outflow passages each have ends not communicating with the branching portion, the ends being positioned at different heights in a direction of gravitational force.

6. The laminated header of any one of claims 1 to 5, wherein a flow pattern of the refrigerant before and after passing through at least part of the plurality of outflow passages is identical.

7. The laminated header of claim 6, wherein a flow pattern of the refrigerant before and after passing through at least part of the plurality of outflow passages is an annular flow pattern, and wherein a flow state of the refrigerant has a relationship indicated by an expression below:

$$2\times10^4 < Gg/\lambda < 2\times10^5$$

$$1 < \lambda\times\phi\times Gl/Gg < 100$$

$$\lambda = \{(\rho g/\rho a)\times(\rho l/\rho w)\}^{1/2}$$

$$\phi = (\sigma w/\sigma l)^{1/4}\times \{(\mu l/\mu w)\times(\rho w/\rho l)^2\}^{1/3}$$

where Gg [kg/(m^2·h)] denotes a mass velocity of a gaseous phase of the refrigerant, Gl [kg/(m^2·h)] denotes a mass velocity of a liquid phase of the refrigerant, ρg [kg/m^3] denotes a density of the gaseous phase of the refrigerant, ρl [kg/m^3] denotes a density of the liquid phase of the refrigerant, ρa [kg/m^3] denotes a density of air, ρw [kg/m^3] denotes a density of water, σl [N/m] denotes surface tension of the liquid phase of the refrigerant, σw [N/m] denotes surface tension of water, μl [μPa·s] denotes a viscosity coefficient of the liquid phase of the refrigerant, and μw [μPa·s] denotes a viscosity coefficient of water.

8. The laminated header of claim 6, wherein a flow pattern of the refrigerant before and after passing through at least part of the plurality of outflow passages is an annular spray flow pattern, and wherein a flow state of the refrigerant has a relationship indicated by an expression below:

$$2\times10^5 < Gg/\lambda$$

$$1 < \lambda\times\phi\times Gl/Gg < 100$$

$$\lambda = \{(\rho g/\rho a)\times(\rho l/\rho w)\}^{1/2}$$

$$\phi = (\sigma w/\sigma l)^{1/4}\times \{(\mu l/\mu w)\times(\rho w/\rho l)^2\}^{1/3}$$

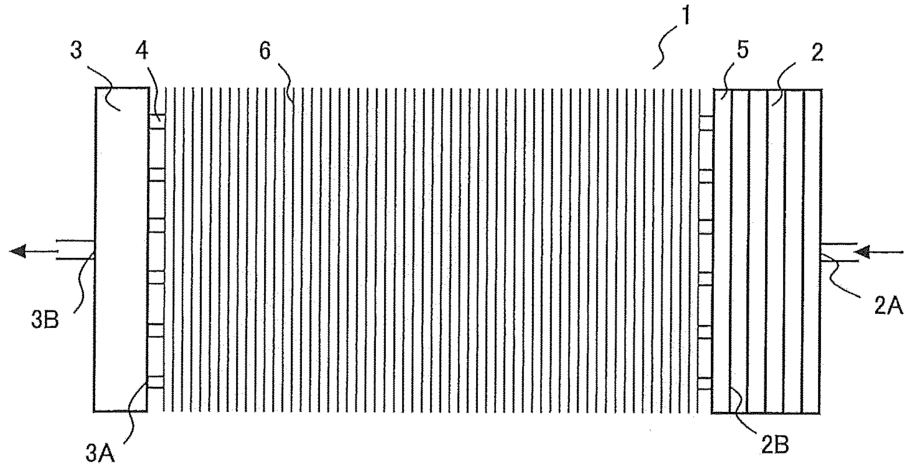
where Gg [kg/(m^2·h)] denotes a mass velocity of a gaseous phase of the refrigerant, Gl [kg/(m^2·h)] denotes a mass velocity of a liquid phase of the refrigerant, ρg [kg/m^3] denotes a density of the gaseous phase of the refrigerant, ρl [kg/m^3] denotes a density of the liquid phase of the refrigerant, ρa [kg/m^3] denotes a density of air, ρw [kg/m^3] denotes a density of water, σl [N/m] denotes surface tension of the liquid phase of the refrigerant, σw [N/m] denotes surface tension of water, μl [μPa·s] denotes a viscosity coefficient of the liquid phase of the refrigerant, and μw [μPa·s] denotes a viscosity coefficient of water.

9. A heat exchanger comprising:

the laminated header of any one of claims 1 to 8; and
a plurality of heat-transfer tubes respectively connected to the plurality of outlet passages.

10. An air-conditioning apparatus comprising
the heat exchanger of claim 9,
wherein the distribution passage delivers the refrigerant to the plurality of outlet passages when the heat exchanger serves as an evaporator.

FIG. 1


1
3
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6
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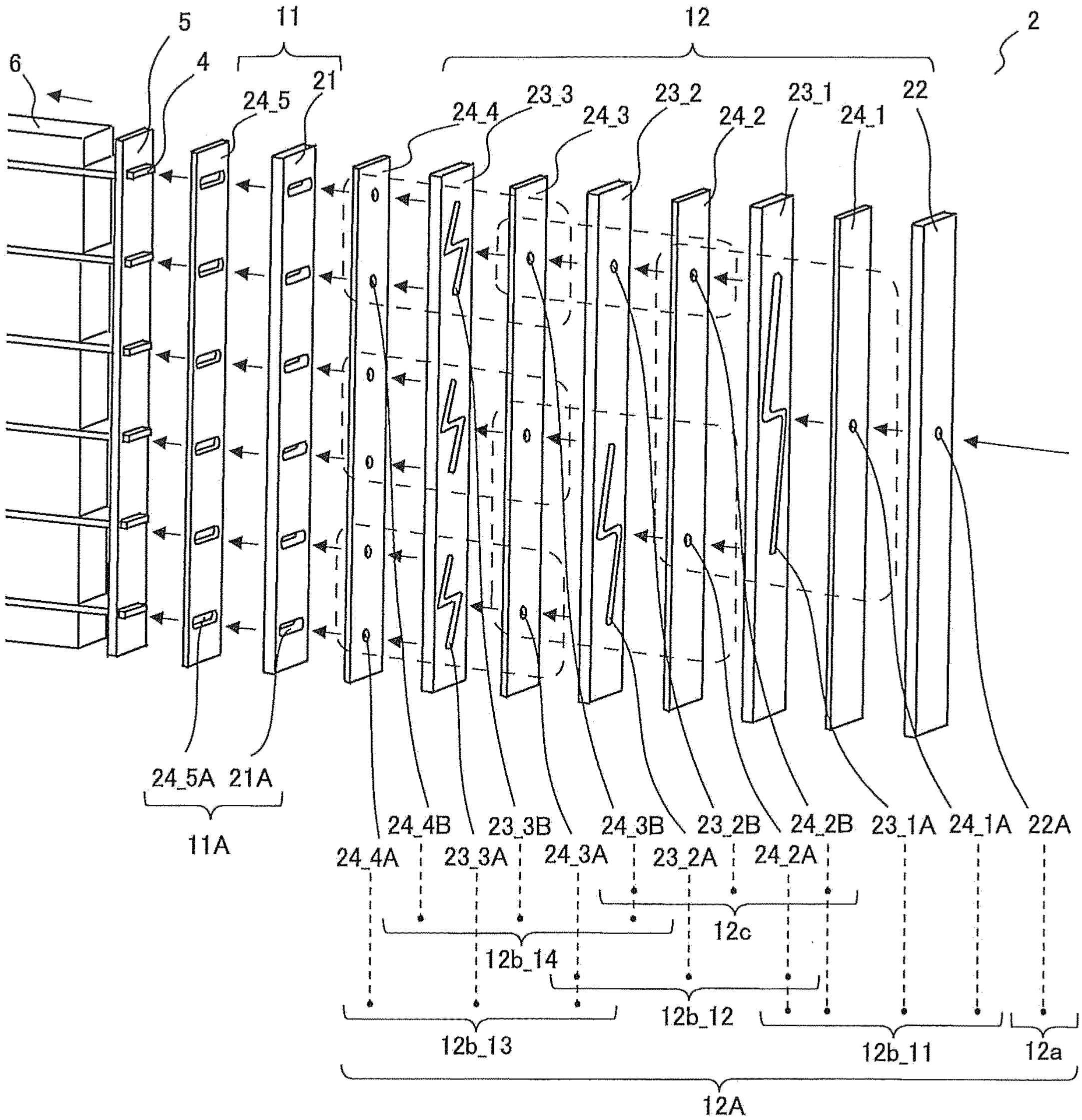
2B

FIG. 2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23_2B
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23_1A
24_1A
22A
24_4A
23_3A
24_3A
23_2A
24_2A
12c
12b_14
12b_12
12b_13
12b_11
12a
12A

FIG. 3

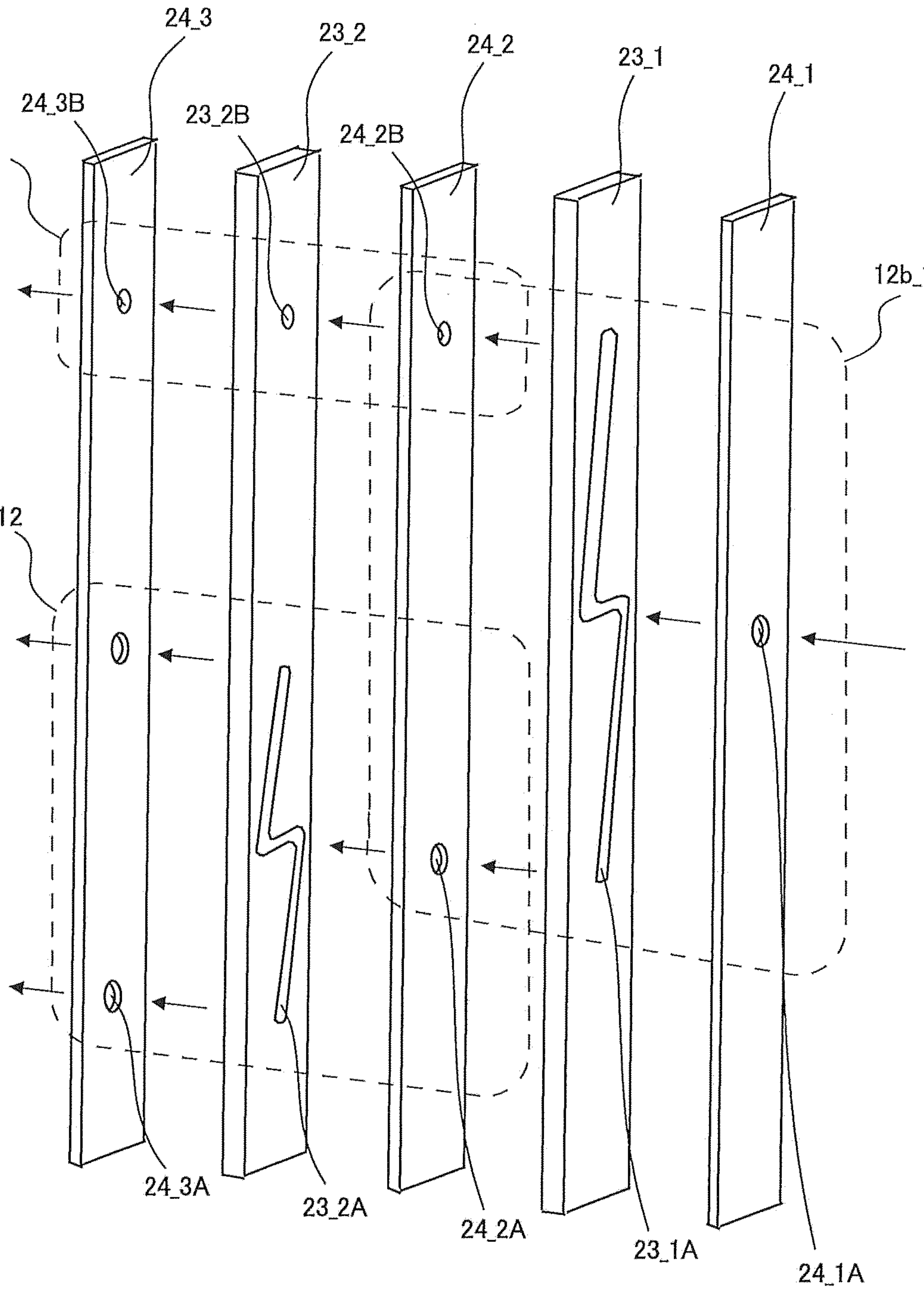

24_3
23_2
24_2
23_1
24_1
24_3B
23_2B
24_2B
12c
12b_11
12b_12
24_3A
23_2A
24_2A
23_1A
24_1A

FIG. 4

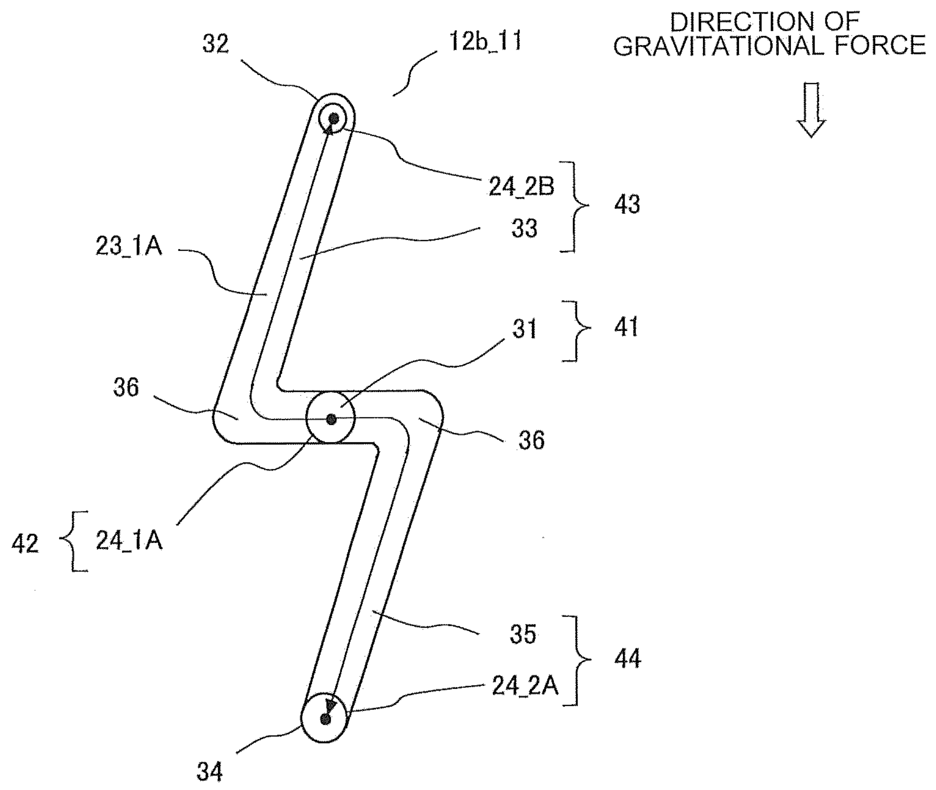

32
12b_11
DIRECTION OF GRAVITATIONAL FORCE
24_2B
33
43
23_1A
31
41
36
36
42
24_1A
35
44
24_2A
34

FIG. 5

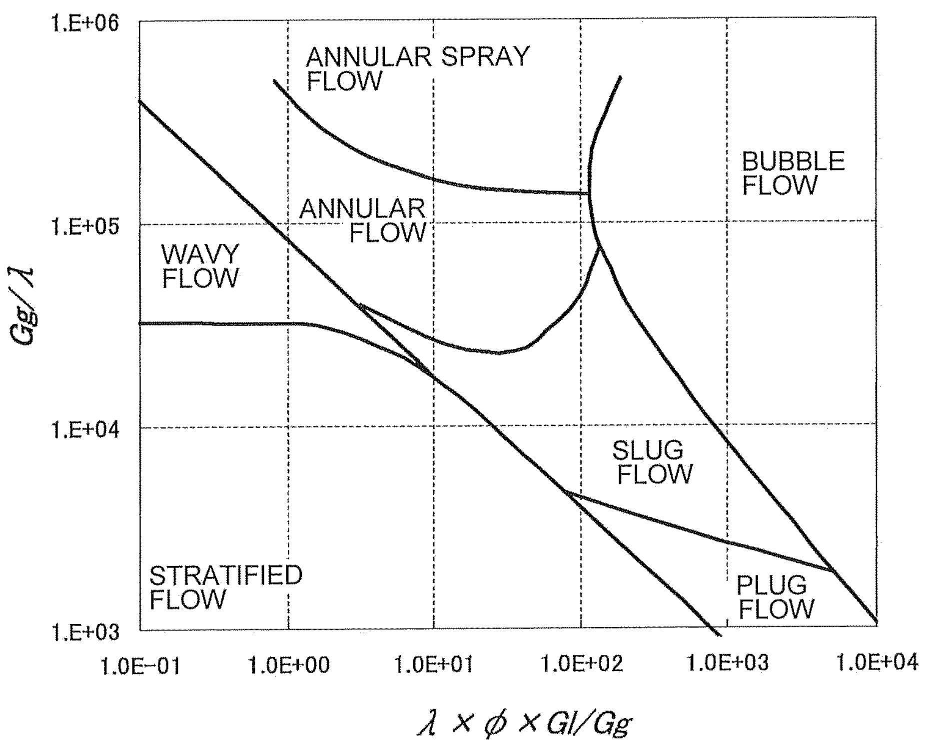
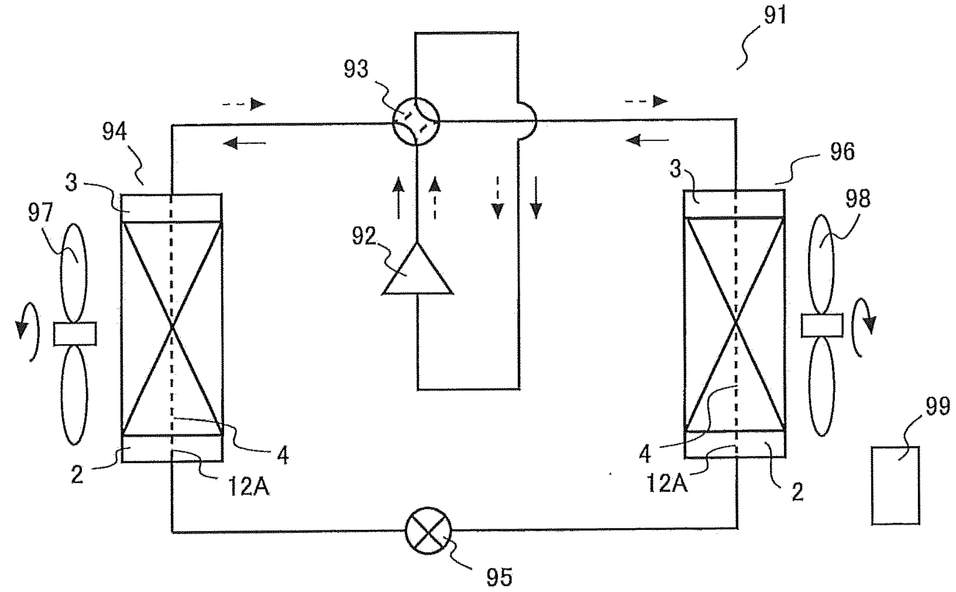
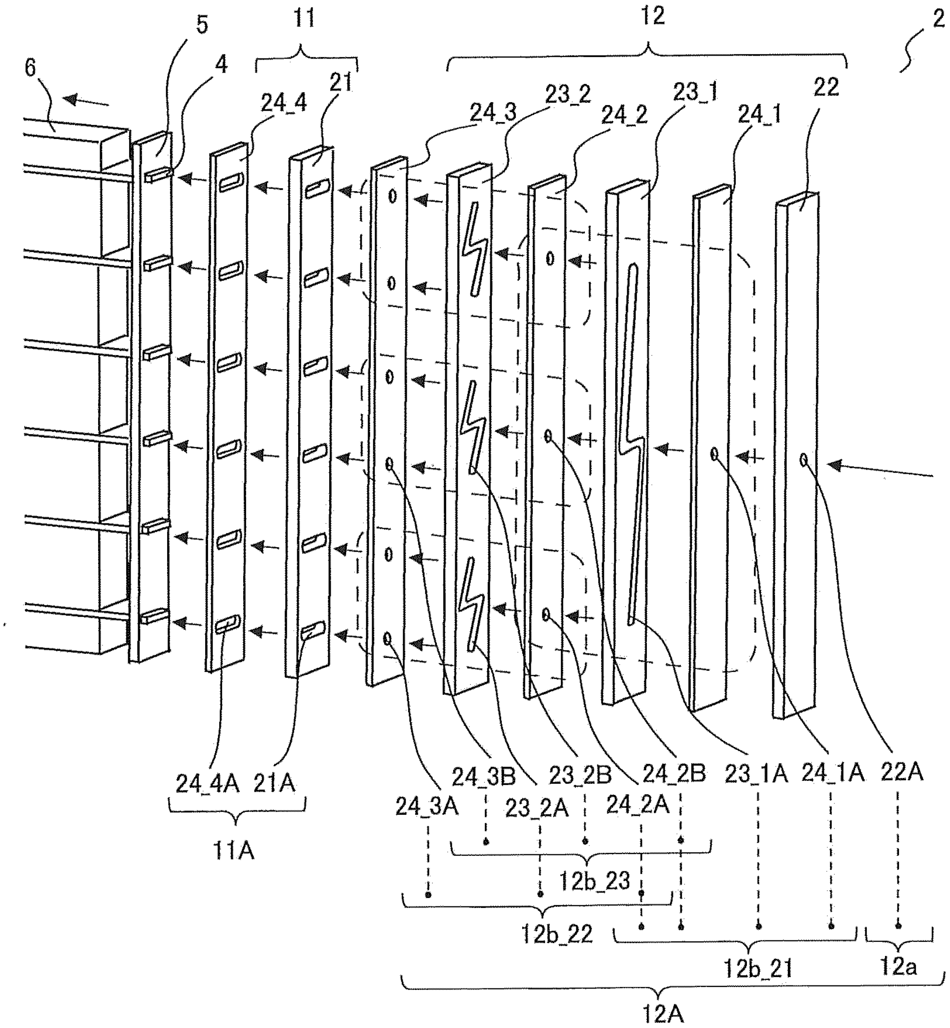

1.E+06
1.E+05
1.E+04
1.E+03
Gg/λ
ANNULAR SPRAY FLOW
BUBBLE FLOW
ANNULAR FLOW
WAVY FLOW
SLUG FLOW
STRATIFIED FLOW
PLUG FLOW
1.0E−01
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
λ × φ × Gl/Gg

FIG. 6



91
93
94
96
3
3
97
98
92
99
4
4
2
12A
12A
2
95

FIG. 7



5
11
12
2
6
4
21
24_4
24_3
23_2
24_2
23_1
24_1
22
24_4A
21A
24_3B
23_2B
24_2B
23_1A
24_1A
22A
24_3A
23_2A
24_2A
11A
12b_23
12b_22
12b_21
12a
12A

FIG. 8

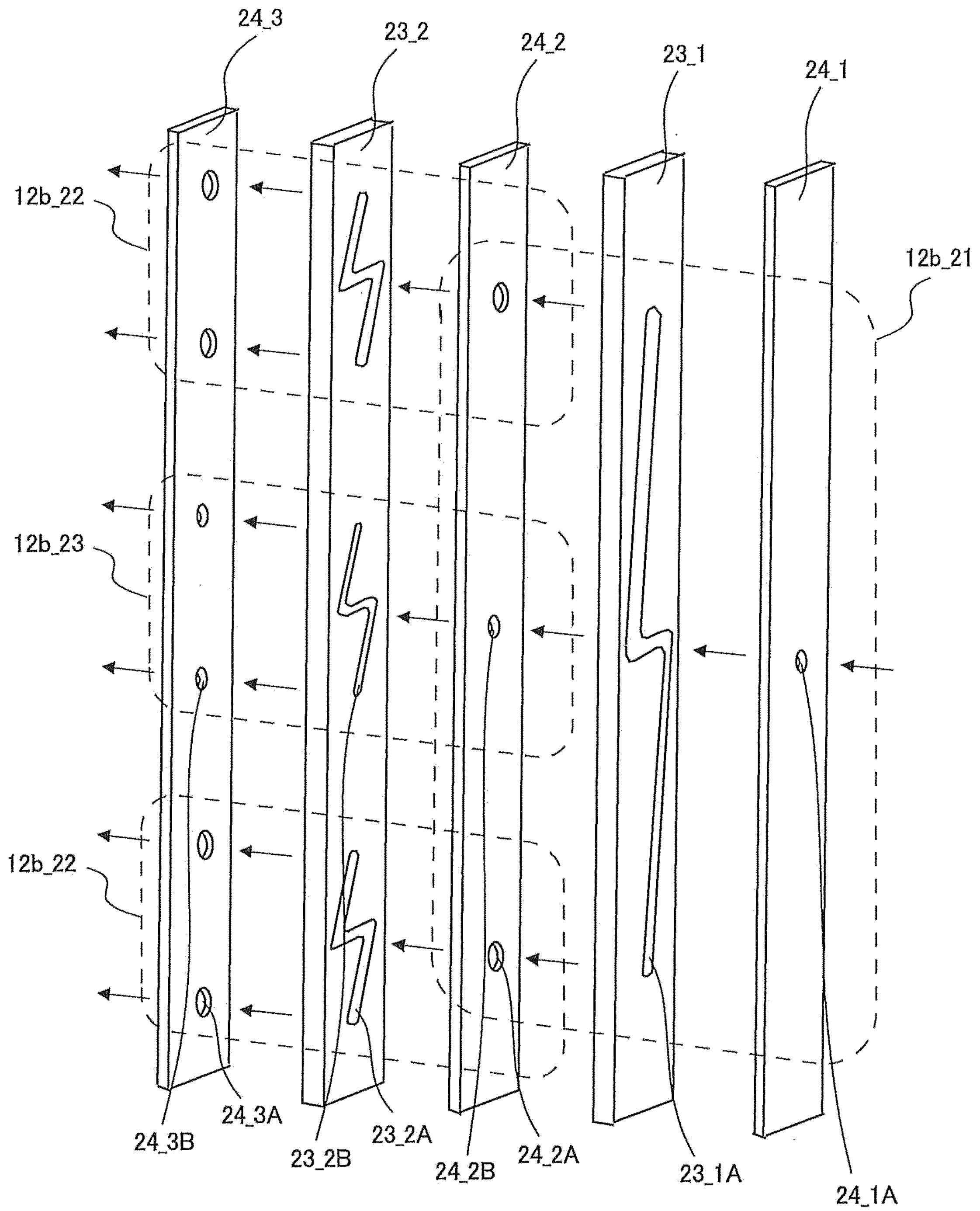

24_3
23_2
24_2
23_1
24_1
12b_22
12b_21
12b_23
12b_22
24_3B
24_3A
23_2B
23_2A
24_2B
24_2A
23_1A
24_1A

FIG. 9

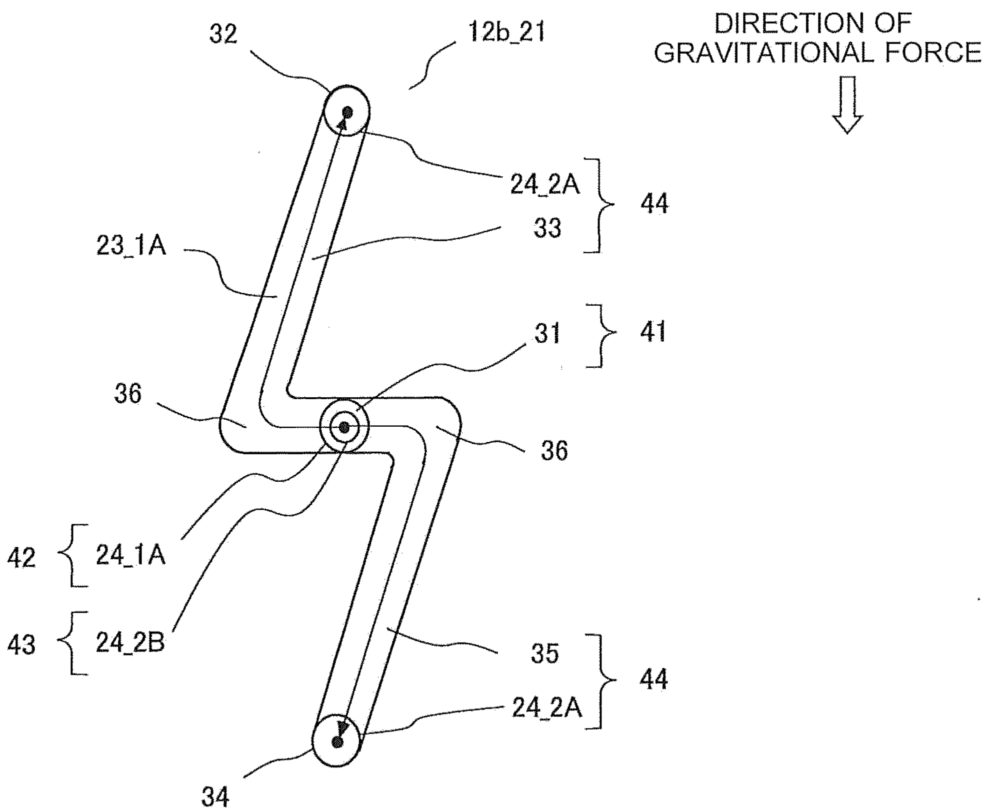

32
12b_21
DIRECTION OF
GRAVITATIONAL FORCE
24_2A
44
33
23_1A
31
41
36
36
42
24_1A
43
24_2B
35
44
24_2A
34

FIG. 10

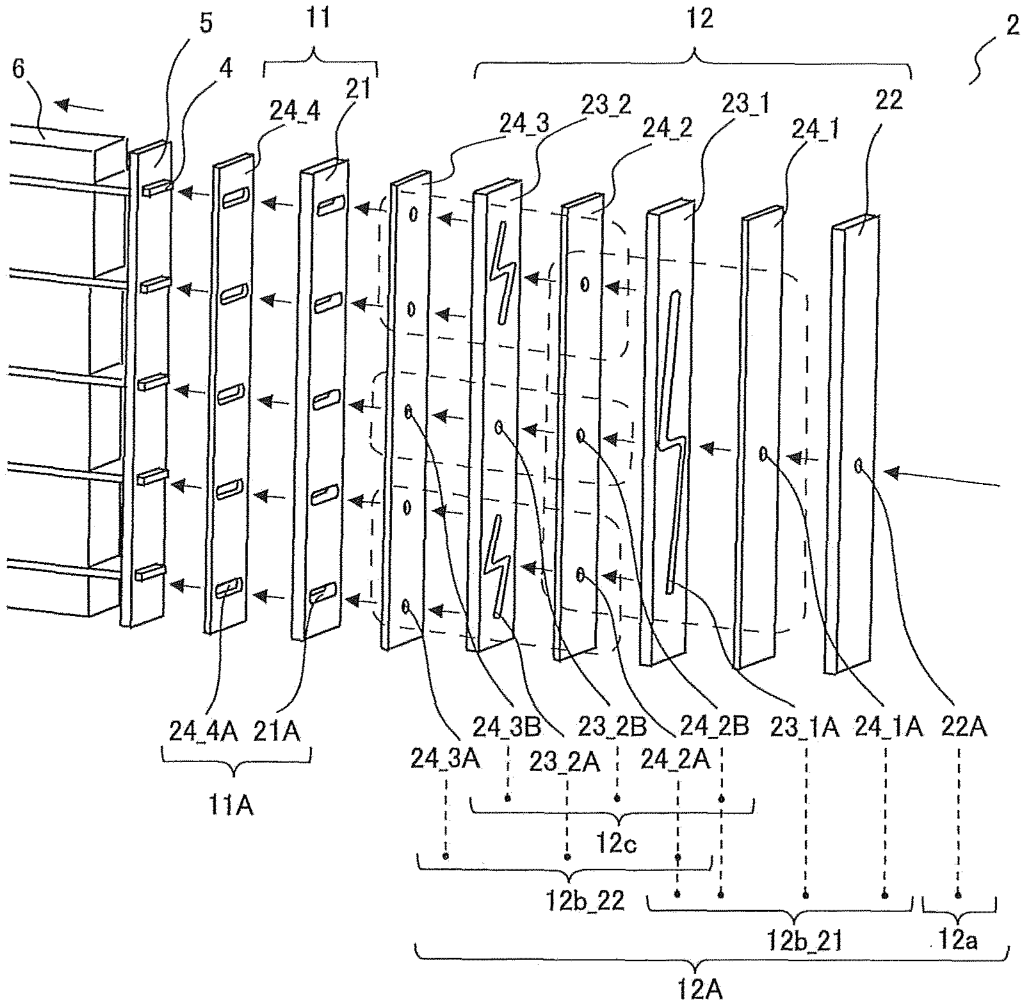
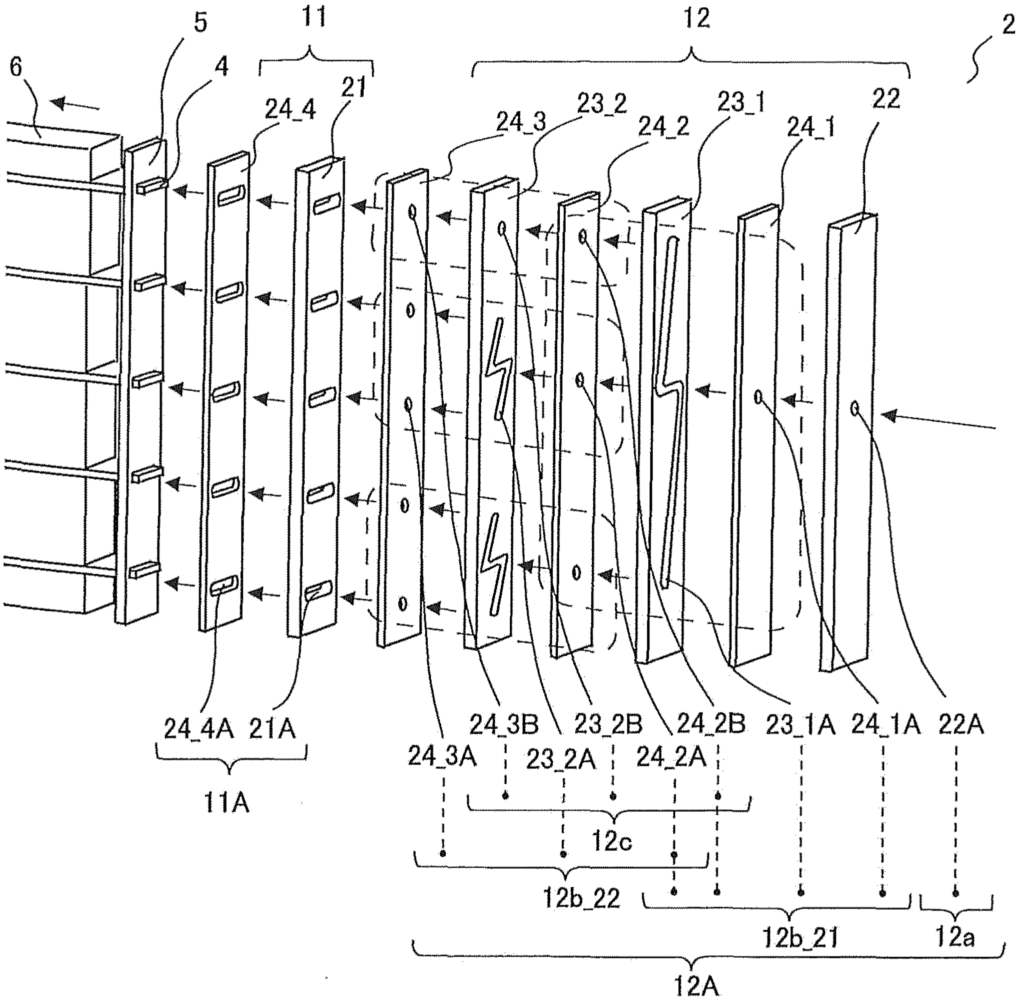

5
11
12
2
6
4
24_4
21
24_3
23_2
24_2
23_1
24_1
22
24_4A
21A
11A
24_3B
23_2B
24_2B
23_1A
24_1A
22A
24_3A
23_2A
24_2A
12c
12b_22
12b_21
12a
12A

FIG. 11



6
5
4
11
21
24_4
12
2
24_3
23_2
24_2
23_1
24_1
22
24_4A
21A
11A
24_3B
23_2B
24_2B
23_1A
24_1A
22A
24_3A
23_2A
24_2A
12c
12b_22
12b_21
12a
12A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/061209

A. CLASSIFICATION OF SUBJECT MATTER
F28F9/02(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)
F28F9/02

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	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 6-11291 A (Nartron Corp.), 21 January 1994 (21.01.1994), entire text; all drawings (particularly, paragraphs [0001] to [0024]; fig. 1 to 9) & US 5242016 A	4,6,9-10 1-3,5,7-8
X Y	JP 9-189463 A (Mitsubishi Electric Corp.), 22 July 1997 (22.07.1997), entire text; all drawings (particularly, paragraphs [0026] to [0035]; fig. 3 to 7) (Family: none)	4,6,9-10 1-3,5,7-8
Y	JP 2004-3810 A (Denso Corp.), 08 January 2004 (08.01.2004), entire text; all drawings (particularly, paragraphs [0081] to [0087]; fig. 13 to 15) & US 2003/0188857 A1 & DE 10314782 A	1-3

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

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Date of the actual completion of the international search 10 July, 2014 (10.07.14)	Date of mailing of the international search report 22 July, 2014 (22.07.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/061209

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	JP 11-118295 A (Hitachi, Ltd.), 30 April 1999 (30.04.1999), entire text; all drawings (particularly, paragraphs [0012] to [0013]; fig. 1 to 4) (Family: none)	5
Y	WO 2013/132679 A1 (Mitsubishi Electric Corp.), 12 September 2013 (12.09.2013), entire text; all drawings (particularly, paragraph [0034]; fig. 11) (Family: none)	7-8

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Patent documents cited in the description

- JP 10267468 A **[0003]**