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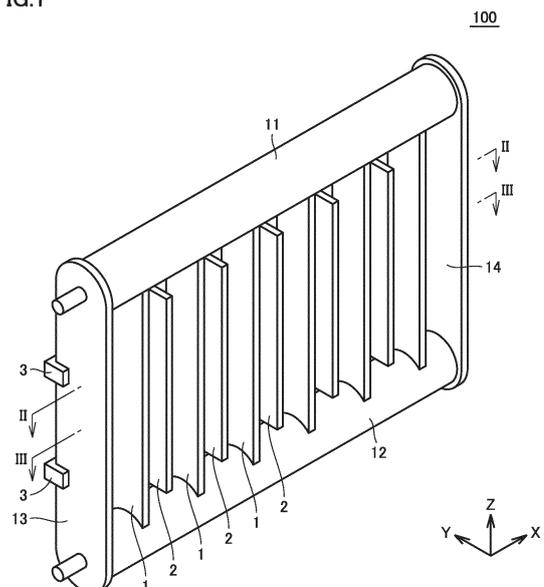
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(54) **HEAT EXCHANGER AND REFRIGERATION CYCLE DEVICE**

(57) A heat exchanger (100) includes: a first header (11) and a second header (12); and a plurality of heat-transfer members (1), each of the plurality of heat-transfer members having a first end in a second direction (Z) connected to the first header and a second end in the second direction connected to the second header. Each of the plurality of heat transfer members is provided to perform heat exchange between a first heat exchange medium flowing through an internal space in the second direction and a second heat exchange medium flowing through an external space of each of the plurality of heat-transfer members in a third direction (Y). The heat exchanger further includes a plurality of heat promotion members (2), each of the plurality of heat promotion members being located in the external space, being arranged in a central region between two heat-transfer members adjacent to each other in a first direction (X) among the plurality of heat-transfer members, and extending in a third direction (Y).

FIG.1



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**Description**

## TECHNICAL FIELD

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

## BACKGROUND ART

**[0002]** Japanese Patent Laying-Open No. 2018-155481 (PTL 1) describes a heat exchanger including a plurality of heat transfer tube units, each of the plurality of heat transfer tube units including a plurality of fins and a plurality of heat transfer tubes. The plurality of heat transfer tube units are arranged apart from each other in an arrangement direction of the heat transfer tube units. In each heat transfer tube unit, the plurality of heat transfer tubes extend in a heat transfer tube extension direction vertical to the arrangement direction of the heat transfer tube units, and the plurality of fins and the plurality of heat transfer tubes are alternately arranged in a heat transfer tube spaced-apart direction vertical to the arrangement direction of the heat transfer tube units and the heat transfer tube extension direction. In each heat transfer tube unit, the plurality of fins include a portion inclined with respect to the heat transfer tube spaced-apart direction. Each heat transfer unit is connected to a first header and a second header.

## CITATION LIST

## PATENT LITERATURE

**[0003]** PTL 1: Japanese Patent Laying-Open No. 2018-155481

## SUMMARY OF INVENTION

## TECHNICAL PROBLEM

**[0004]** In the heat exchanger described in PTL 1, a pitch in the arrangement direction of the heat transfer tube units needs to be set relatively narrow in order to improve the heat transfer performance of the heat transfer tube units.

**[0005]** This is because when the pitch in the arrangement direction of the heat transfer tube units is wide, the air flowing between adjacent heat transfer tube units is likely to flow, in a concentrated manner, through a central region between the adjacent heat transfer tube units in the arrangement direction of the heat transfer tube units.

**[0006]** However, when the pitch in the arrangement direction of the heat transfer tube units is set narrow, a pitch between insertion holes into which the heat transfer tubes are inserted in each of the first header and the second header needs to be set narrow. As the pitch between the insertion holes becomes narrower, the formability of the first header and the second header becomes

worse.

**[0007]** Therefore, the heat exchanger described in PTL 1 has difficulty in improving the heat transfer performance without decreasing the formability of the first header and the second header.

**[0008]** A main object of the present invention is to provide a heat exchanger that can improve the heat transfer performance without decreasing the formability of a first header and a second header, and a refrigeration cycle apparatus including the heat exchanger.

## SOLUTION TO PROBLEM

**[0009]** A heat exchanger according to the present disclosure includes: a first header and a second header extending in a first direction and arranged apart from each other in a second direction perpendicular to the first direction; and a plurality of heat-transfer members arranged apart from each other in the first direction, each of the plurality of heat-transfer members having a first end in the second direction connected to the first header and a second end in the second direction connected to the second header. An internal space, through which a first heat exchange medium flows, of each of the first header, the second header, and the plurality of heat-transfer members is separated from an external space through which a second heat exchange medium flows. The internal space of the first header communicates with the internal space of the second header through the internal space of each of the plurality of heat-transfer members. The heat exchanger further includes: at least one heat-transfer promotion member; and at least one positioning member, the at least one heat-transfer promotion member being located in the external space, being arranged in a central region between two heat-transfer members adjacent to each other in the first direction among the plurality of heat-transfer members, and extending in a third direction, the at least one positioning member being located in the external space, positioning the at least one heat-transfer promotion member with respect to the first header, the second header, and the plurality of heat-transfer members, and being arranged only on a downstream side in the third direction in which the second heat exchange medium flows, relative to the internal space of each of the plurality of heat-transfer members.

## ADVANTAGEOUS EFFECTS OF INVENTION

**[0010]** According to the present invention, there can be provided a heat exchanger that can improve the heat transfer performance without decreasing the formability of a first header and a second header, and a refrigeration cycle apparatus including the heat exchanger.

## BRIEF DESCRIPTION OF DRAWINGS

**[0011]**

Fig. 1 is a perspective view showing a heat exchanger according to a first embodiment.

Fig. 2 is a cross-sectional view when viewed from an arrow II-II in Fig. 1.

Fig. 3 is a cross-sectional view when viewed from an arrow III-III in Fig. 1.

Fig. 4 is a partial front view of the heat exchanger shown in Fig. 1.

Fig. 5 is a partial cross-sectional view showing a first modification of a plurality of heat-transfer members of the heat exchanger according to the first embodiment.

Fig. 6 is a partial cross-sectional view showing a second modification of the plurality of heat-transfer members of the heat exchanger according to the first embodiment.

Fig. 7 is a partial cross-sectional view showing a third modification of the plurality of heat-transfer members of the heat exchanger according to the first embodiment.

Fig. 8 is a perspective view showing a heat exchanger according to a second embodiment.

Fig. 9 is a cross-sectional view when viewed from an arrow IX-IX in Fig. 8.

Fig. 10 is a cross-sectional view when viewed from an arrow X-X in Fig. 8.

Fig. 11 is a partial cross-sectional view when viewed from an arrow XI-XI in Figs. 9 and 10.

Fig. 12 is a partial cross-sectional view showing a heat-transfer promotion member of a heat exchanger according to a third embodiment.

Fig. 13 is a partial cross-sectional view showing a third modification of the heat-transfer promotion member of the heat exchanger according to the third embodiment.

Fig. 14 is a partial cross-sectional view showing a fourth modification of the heat-transfer promotion member of the heat exchanger according to the third embodiment.

Fig. 15 is a partial cross-sectional view showing a fifth modification of the heat-transfer promotion member of the heat exchanger according to the third embodiment.

Fig. 16 is a partial cross-sectional view showing a sixth modification of the heat-transfer promotion member of the heat exchanger according to the third embodiment.

Fig. 17 is a partial cross-sectional view showing a heat exchanger according to a fourth embodiment.

Fig. 18 is a graph showing that a ratio  $\Delta P1/\Delta P2$  between a pressure loss  $\Delta P1$  of air flowing through an air path shown in Fig. 17 and a pressure loss  $\Delta P2$  of air flowing through an air path according to a comparative example changes in accordance with a dimension ratio between each heat-transfer member and each heat-transfer promotion member of the heat exchanger shown in Fig. 17.

Fig. 19 is a graph derived from the graph shown in

Fig. 18 and showing a dimension ratio between each heat-transfer member and each heat-transfer promotion member that allows ratio  $\Delta P1/\Delta P2$  between the pressure losses to be equal to or lower than 100%.

Fig. 20 shows a refrigeration cycle apparatus according to a fifth embodiment.

## DESCRIPTION OF EMBODIMENTS

**[0012]** Embodiments of the present disclosure will be described hereinafter with reference to the drawings. In the following drawings, the same or corresponding portions are denoted by the same reference numerals and description thereof will not be repeated. In addition, for the sake of convenience in description, each figure shows a first direction X, a second direction Z and a third direction Y that are perpendicular to each other.

### 20 First Embodiment

<Configuration of Heat Exchanger 100>

**[0013]** As shown in Figs. 1 to 4, a heat exchanger 100 according to a first embodiment includes a first header 11, a second header 12, a plurality of heat-transfer members 1, a plurality of heat-transfer promotion members 2, a plurality of positioning members 3, a first reinforcing member 13, and a second reinforcing member 14.

**[0014]** Heat exchanger 100 is provided to perform heat exchange between a first heat exchange medium (e.g., refrigerant) flowing in second direction Z and a second heat exchange medium (e.g., air) flowing in third direction Y. Second direction Z is, for example, along a vertical direction. First direction X and third direction Y are, for example, along a horizontal direction. Each of first header 11 and second header 12 is a so-called distribution device. The plurality of heat-transfer members 1 are so-called heat transfer tubes. The plurality of heat-transfer promotion members 2 are not so-called heat transfer tubes.

**[0015]** An internal space, through which the refrigerant can flow, of each of first header 11, second header 12, and the plurality of heat-transfer members 1 is separated from an external space through which the air can flow. The internal spaces of first header 11 and second header 12 communicate with each other through the internal space of each of the plurality of heat-transfer members 1. In other words, the internal spaces of the plurality of heat-transfer members 1 are connected in parallel to each other with respect to the internal spaces of first header 11 and second header 12. For example, the refrigerant flowing from a first inflow/outflow portion 15 into the internal space of first header 11 is distributed into the internal spaces of the plurality of heat-transfer members 1. Heat exchange is performed between the refrigerant flowing through the internal spaces of the plurality of heat-transfer members 1 in the second direction and the air

flowing through the external space of the plurality of heat-transfer members 1 in third direction Y. The refrigerant flowing through the internal spaces of the plurality of heat-transfer members 1 flows out to the internal space of second header 12 and joins, and then, is discharged from a second inflow/outflow portion 16 to the outside of heat exchanger 100.

**[0016]** The external space of each of first header 11, second header 12 and the plurality of heat-transfer members 1, which is surrounded by first header 11, second header 12, first reinforcing member 13, and second reinforcing member 14, is provided such that the air flows in third direction Y. Hereinafter, the upstream side of the air flowing in third direction Y will be simply referred to as "upstream side in third direction Y", and the downstream side of the air flowing in third direction Y will be simply referred to as "downstream side in third direction Y". The above-described external space is open on each of the upstream side and the downstream side in third direction Y.

**[0017]** As shown in Fig. 1, first header 11 and second header 12 extend in first direction X and are arranged apart from each other in second direction Z. First header 11 includes first inflow/outflow portion 15 through which the refrigerant flows in or flows out. Second header 12 includes second inflow/outflow portion 16 through which the refrigerant flows in or flows out.

**[0018]** As shown in Fig. 1, the plurality of heat-transfer members 1 are arranged apart from each other in first direction X. Each of the plurality of heat-transfer members 1 has one end in second direction Z connected to first header 11, and the other end in second direction Z connected to second header 12.

**[0019]** Specifically, first header 11 includes a plurality of insertion holes arranged apart from each other in first direction X. One end of each of the plurality of heat-transfer members 1 in first direction X is inserted into each of the plurality of insertion holes formed in first header 11. Similarly, second header 12 includes a plurality of insertion holes arranged apart from each other in first direction X. The other end of each of the plurality of heat-transfer members 1 in first direction X is inserted into each of the plurality of insertion holes formed in second header 12.

**[0020]** The plurality of heat-transfer promotion members 2 are for suppressing the air flowing between two heat-transfer members 1 adjacent to each other in first direction X from flowing, in a concentrated manner, through a central region between these two heat-transfer members 1 in first direction X. As shown in Figs. 1 to 4, each of the plurality of heat-transfer promotion members 2 is located in the above-described external space, and is arranged in a central region between two heat-transfer members 1 adjacent to each other in first direction X among the plurality of heat-transfer members 1. Each of the plurality of heat-transfer promotion members 2 is, for example, arranged to overlap, in second direction Z, with a center line C1 passing through the center in first direction X between two heat-transfer members 1 adjacent to

each other in first direction X and extending in third direction Y. A center line of each of the plurality of heat-transfer promotion members 2 passing through the center in first direction X and extending in third direction Y is, for example, arranged to overlap with above-described center line C1 in second direction Z. Each of the plurality of heat-transfer promotion members 2 extends in third direction Y. Each of the plurality of heat-transfer promotion members 2 partitions the above-described external space in first direction X.

**[0021]** Each of the plurality of heat-transfer promotion members 2 is spaced apart from each of the plurality of heat-transfer members 1. The plurality of heat-transfer promotion members 2 are not in contact with each of the plurality of heat-transfer members 1. The plurality of heat-transfer promotion members 2 are spaced apart from each of first header 11 and second header 12. The plurality of heat-transfer promotion members 2 are not in contact with each of first header 11 and second header 12. A surface of each of the plurality of heat-transfer promotion members 2 facing in first direction X is, for example, a plane. The surface of each of the plurality of heat-transfer promotion members 2 facing in first direction X is, for example, parallel to a surface of each of the plurality of heat-transfer members 1 facing in first direction X. Each of the plurality of heat-transfer promotion members 2 does not include, for example, a through hole extending from one surface to the other surface facing in first direction X. Each of the plurality of heat-transfer promotion members 2 is not connected to a not-shown fin.

**[0022]** The plurality of positioning members 3 are located in the above-described external space, and position each of the plurality of heat-transfer promotion members 2 with respect to first header 11, second header 12, first reinforcing member 13, second reinforcing member 14, and the plurality of heat-transfer members 1. Each of the plurality of positioning members 3 is connected to each of the plurality of heat-transfer promotion members 2, first reinforcing member 13 and second reinforcing member 14. Each of the plurality of positioning members 3 is spaced apart from the plurality of heat-transfer members 1. Each of the plurality of positioning members 3 is not in contact with the plurality of heat-transfer members 1. Each of the plurality of positioning members 3 is not connected to a not-shown fin.

**[0023]** Each of the plurality of positioning members 3 includes a beam portion 3A spanning between first reinforcing member 13 and second reinforcing member 14 and connected to the plurality of heat-transfer promotion members 2, a connection portion 3B connected to first reinforcing member 13, and a connection portion 3C connected to second reinforcing member 14.

**[0024]** The plurality of positioning members 3 are arranged apart from each other in second direction Z. Each of the plurality of positioning members 3 is, for example, arranged on the first header 11 side or on the second header 12 side relative to the center between first header 11 and second header 12 in second direction Z.

**[0025]** A material of each of the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 is not particularly limited. A thermal conductivity of the material of each of the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 may be lower than a thermal conductivity of a material of the plurality of heat-transfer members 1.

**[0026]** First reinforcing member 13 and second reinforcing member 14 are for reinforcing the strength of a structure of first header 11, second header 12 and the plurality of heat-transfer members 1 assembled as described above. First reinforcing member 13 and second reinforcing member 14 are located in the above-described external space, and are arranged apart from each other in first direction X. First reinforcing member 13 and second reinforcing member 14 are arranged to sandwich the plurality of heat-transfer members 1 and the plurality of heat-transfer promotion members 2 in first direction X. First reinforcing member 13 and second reinforcing member 14 are connected to an outer surface of each of first header 11 and second header 12. First reinforcing member 13 is connected to one end surface of each of first header 11 and second header 12 in first direction X. Second reinforcing member 14 is connected to the other end surface of each of first header 11 and second header 12 in first direction X.

**[0027]** The plurality of heat-transfer members 1 are, for example, configured equivalently to each other. The plurality of heat-transfer promotion members 2 are, for example, configured equivalently to each other. The plurality of positioning members 3 are, for example, configured equivalently to each other. The number of the plurality of heat-transfer members 1, the number of the plurality of heat-transfer promotion members 2, and the number of the plurality of positioning members 3 are not particularly limited. The number of the plurality of heat-transfer promotion members 2 is, for example, smaller by one than the number of the plurality of heat-transfer members 1. The number of the plurality of positioning members 3 is, for example, two.

**[0028]** Next, one example of the positional relationship in third direction Y among the plurality of heat-transfer members 1, the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 in heat exchanger 100 will be described.

**[0029]** As shown in Figs. 2 and 3, each of the plurality of heat-transfer members 1 has a first end 1A located on the upstream side in third direction Y, and a second end 1B located on the downstream side in third direction Y. Each first end 1A is arranged on the downstream side relative to an end of each of first reinforcing member 13 and second reinforcing member 14 located on the upstream side. Each second end 1B is arranged on the upstream side relative to an end of each of first reinforcing member 13 and second reinforcing member 14 located on the downstream side.

**[0030]** As shown in Figs. 2 and 3, each of the plurality of heat-transfer promotion members 2 has a third end 2A

located on the upstream side in third direction Y, and a fourth end 2B located on the downstream side in third direction Y. Each third end 2A is arranged on the downstream side relative to each first end 1A. Each fourth end 2B is arranged on the downstream side relative to each second end 1B.

**[0031]** As shown in Figs. 1 and 2, beam portion 3A of each of the plurality of positioning members 3 is arranged only on the downstream side in third direction Y in the above-described external space, relative to the internal space of each of the plurality of heat-transfer members 1. In other words, beam portion 3A of each of the plurality of positioning members 3 is arranged only on the downstream side in third direction Y, relative to second end 1B of each of the plurality of heat-transfer members 1. For example, connection portions 3B and 3C of each of the plurality of positioning members 3 are also arranged only on the downstream side in third direction Y in the above-described external space, relative to the internal space of each of the plurality of heat-transfer members 1.

**[0032]** One example of the dimensional relationship among the plurality of heat-transfer members 1, the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 in heat exchanger 100 will be described below.

**[0033]** As shown in Figs. 2 and 3, in a cross section perpendicular to the second direction, a width of each of the plurality of heat-transfer members 1 in third direction Y is wider than a width of each of the plurality of heat-transfer members 1 in first direction X. In the cross section perpendicular to the second direction, each of the plurality of heat-transfer members 1 has a longitudinal direction along third direction Y, and a lateral direction along first direction X. Each of the plurality of heat-transfer members 1 is, for example, a flat tube.

**[0034]** As shown in Figs. 2 and 3, each of the plurality of heat-transfer promotion members 2 is arranged at the center between two heat-transfer members 1 adjacent to each other in first direction X. A width of each of the plurality of heat-transfer promotion members 2 in first direction X is narrower than an interval in first direction X between two heat-transfer members 1 adjacent to each other in first direction X. In the cross section perpendicular to second direction Z, a width of each of the plurality of heat-transfer promotion members 2 in third direction Y is wider than the width of each of the plurality of heat-transfer promotion members 2 in first direction X. In the cross section perpendicular to the second direction, each of the plurality of heat-transfer promotion members 2 has a longitudinal direction along third direction Y, and a lateral direction along first direction X.

**[0035]** As shown in Figs. 2 and 3, the interval in first direction X between two heat-transfer members 1 adjacent to each other in first direction X is wider than an interval in first direction X between heat-transfer member 1 and heat-transfer promotion member 2 adjacent to each other in first direction X.

**[0036]** As shown in Figs. 2 and 3, the width of each of

the plurality of heat-transfer promotion members 2 in first direction X is narrower than the width of each of the plurality of heat-transfer members 1 in first direction X. The width of each of the plurality of heat-transfer promotion members 2 in first direction X is, for example, constant regardless of the position in third direction Y. The interval in first direction X between heat-transfer member 1 and heat-transfer promotion member 2 adjacent to each other in first direction X is, for example, less than a half of the interval in first direction X between two heat-transfer members 1 adjacent to each other in first direction X.

**[0037]** A length of each of the plurality of heat-transfer promotion members 2 in second direction Z is shorter than an interval between first header 11 and second header 12 in second direction Z.

**[0038]** As shown in Fig. 1, a width of beam portion 3A of each of the plurality of positioning members 3 in second direction Z is narrower than a width of each of the plurality of heat-transfer promotion members 2 in second direction Z. As shown in Fig. 4, the width of beam portion 3A of each of the plurality of positioning members 3 in second direction Z is wider than the width of each of the plurality of heat-transfer promotion members 2 in first direction X and is narrower than the width of each of the plurality of heat-transfer members 1 in first direction X.

**[0039]** As shown in Figs. 2 and 4, a width of each of the plurality of positioning members 3 in first direction X is, for example, equal to or wider than an interval between first reinforcing member 13 and second reinforcing member 14 in first direction X.

#### <Effect of Heat Exchanger 100>

**[0040]** Next, an effect of heat exchanger 100 will be described based on comparison with comparative examples.

**[0041]** A heat exchanger according to Comparative Example 1 is different from heat exchanger 100 only in that the heat exchanger according to Comparative Example 1 does not include heat-transfer promotion members 2. In the heat exchanger according to Comparative Example 1, an interval in first direction X between two adjacent heat-transfer members 1 is equal to that of heat exchanger 100.

**[0042]** A heat exchanger according to Comparative Example 2 is different from heat exchanger 100 only in that the heat exchanger according to Comparative Example 2 does not include heat-transfer promotion members 2 and an interval in first direction X between two adjacent heat-transfer members is a half of that of heat exchanger 100. In the heat exchanger according to Comparative Example 2, the interval in first direction X between two adjacent heat-transfer members 1 is substantially equal to the interval in first direction X between heat-transfer member 1 and heat-transfer promotion member 2 in heat exchanger 100.

**[0043]** Heat exchanger 100 includes the plurality of heat-transfer promotion members 2, each of the plurality

of heat-transfer promotion members 2 being located in the above-described external space, being arranged in the central region between two heat-transfer members 1 adjacent to each other in first direction X among the plurality of heat-transfer members 1, and extending in third direction Y. Thus, each of heat-transfer promotion members 2 suppresses the air flowing between two heat-transfer members 1 adjacent to each other in first direction X from flowing, in a concentrated manner, through the central region between these two heat-transfer members 1 in first direction X. Therefore, the air flowing between two adjacent heat-transfer members 1 is more likely to flow along surfaces of heat-transfer members 1. As a result, an extratube heat transfer coefficient of heat exchanger 100 is higher than an extratube heat transfer coefficient of the heat exchanger according to Comparative Example 1 in which heat-transfer promotion members 2 are not provided although the interval in first direction X between two adjacent heat-transfer members 1 is equal to that of heat exchanger 100. The extratube heat transfer coefficient of heat exchanger 100 is substantially equal to an extratube heat transfer coefficient of the heat exchanger according to Comparative Example 2.

**[0044]** In the heat exchanger according to Comparative Example 2, an interval in first direction X between the insertion holes into which the heat-transfer members are inserted in each of the first header and the second header needs to be set to be as narrow as the interval in first direction X between the heat-transfer members. As a result, the formability of the first header and the second header in the heat exchanger according to Comparative Example 2 is lower than the formability of the first header and the second header in the heat exchanger according to Comparative Example 1.

**[0045]** In contrast, in heat exchanger 100, an interval in first direction X between the insertion holes into which heat-transfer members 1 are inserted in each of first header 11 and second header 12 may be set to be wider than that of the heat exchanger according to Comparative Example 2, and set to be as wide as that of the heat exchanger according to Comparative Example 1.

**[0046]** As a result, heat exchanger 100 can improve the heat transfer performance without decreasing the formability of first header 11 and second header 12, as compared with the heat exchanger according to Comparative Example 1. Heat exchanger 100 can improve the formability of first header 11 and second header 12 without decreasing the heat transfer performance, as compared with the heat exchanger according to Comparative Example 2.

**[0047]** In addition, a weight of each of the plurality of heat-transfer promotion members 2 can be made lighter than a weight of each of the plurality of heat-transfer members 1. Therefore, heat exchanger 100 can be reduced in weight, as compared with the heat exchanger according to Comparative Example 2. In addition, the manufacturing cost of each of the plurality of heat-trans-

fer promotion members 2 can be reduced, as compared with the manufacturing cost of each of the plurality of heat-transfer members 1. Therefore, the manufacturing cost of heat exchanger 100 can be reduced, as compared with the manufacturing cost of the heat exchanger according to Comparative Example 2.

**[0048]** In heat exchanger 100, each of the plurality of positioning members 3 is arranged only on the downstream side in third direction Y, relative to the internal space of each of the plurality of heat-transfer members 1. With such a configuration, when heat exchanger 100 functions as a condenser under the low temperature environment, such as, for example, when a refrigeration cycle apparatus including heat exchanger 100 performs a defrosting operation, each of positioning members 3 is less likely to obstruct discharge of the frost melting water generated intensively on the upstream side in third direction Y.

**[0049]** In heat exchanger 100, each of the plurality of positioning members 3 is connected to each of first reinforcing member 13 and second reinforcing member 14. Thus, in heat exchanger 100, the position of each of the plurality of heat-transfer promotion members 2 with respect to the plurality of heat-transfer members 1 is less likely to change, and thus, a decrease in extratube heat transfer coefficient and an increase in pressure loss (a decrease in air-passing property) that are caused when the position changes are suppressed.

**[0050]** In addition, when the plurality of positioning members 3 are connected to each of the plurality of heat-transfer members 1 and when the thermal conductivity of the material of each of the plurality of positioning members 3 is relatively low, a thermal resistance of a heat path extending from each heat-transfer member 1 through the plurality of positioning members 3 to the plurality of heat-transfer promotion members 2 is high, which results in a great heat transfer loss (heat loss) in this heat path. In contrast, in heat exchanger 100, each of the plurality of positioning members 3 is spaced apart from the plurality of heat-transfer members 1, and thus, the above-described heat path is not formed and the heat transfer loss is suppressed.

**[0051]** In addition, when heat exchanger 100 functions as an evaporator under the low temperature environment, water vapor in the air flowing between two adjacent heat-transfer members 1 is cooled by each of heat-transfer members 1 to form frost, which adheres to heat-transfer members 1. Since a temperature of the air flowing on the surface of each of heat-transfer members 1 becomes gradually lower from first end 1A toward second end 1B of each of heat-transfer members 1, an amount of the frost that adheres to the surface of each of heat-transfer members 1 exhibits such a distribution that the amount of the frost is the largest on the first end 1A side and becomes gradually smaller toward second end 1B. As a result, if each of the plurality of heat-transfer promotion members 2 is arranged to overlap with first end 1A when viewed from first direction X, an area between heat-trans-

fer member 1 and heat-transfer promotion member 2 is likely to be blocked by the frost. In contrast, in heat exchanger 100, third end 2A of each of the plurality of heat-transfer promotion members 2 is arranged on the downstream side in third direction Y relative to first end 1A of each of the plurality of heat-transfer members 1, and thus, the area between heat-transfer member 1 and heat-transfer promotion member 2 is less likely to be blocked by the frost, as compared with the case in which each of the plurality of heat-transfer promotion members 2 is arranged to overlap with first end 1A when viewed from first direction X.

<Modifications of Heat Exchanger 100>

**[0052]** Modifications described below are allowable as each of the plurality of heat-transfer members 1 of heat exchanger 100.

**[0053]** As shown in Fig. 5, each of the plurality of heat-transfer members 1 may include a heat transfer tube portion 1C, a fin portion 1D and a fin portion 1E. Heat transfer tube portion 1C is provided with the above-described internal space and is configured similarly to the plurality of heat-transfer members 1 of heat exchanger 100. Heat transfer tube portion 1C, fin portion 1D and fin portion 1E are, for example, formed integrally.

**[0054]** In each of the plurality of heat-transfer members 1, fin portion 1D extends from heat transfer tube portion 1C to the upstream side in third direction Y. An end of fin portion 1D located on the upstream side in third direction Y forms first end 1A of heat-transfer member 1. Fin portion 1E extends from heat transfer tube portion 1C to the downstream side in third direction Y. An end of fin portion 1E located on the downstream side in third direction Y forms second end 1B of heat-transfer member 1. A space where the refrigerant flows is not formed in fin portion 1D and fin portion 1E.

**[0055]** As shown in Fig. 6, each of the plurality of heat-transfer members 1 may be formed by a plurality of heat transfer tubes 1G arranged side by side and apart from each other in third direction Y. Each of the plurality of heat transfer tubes 1G is, for example, a circular tube. In this case, above-described first end 1A of each of the plurality of heat-transfer members 1 is an upstream-side end of one heat transfer tube 1G arranged on the most upstream side among the plurality of heat transfer tubes 1G. Above-described second end 1B of each of the plurality of heat-transfer members 1 is a downstream-side end of one heat transfer tube 1G arranged on the most downstream side among the plurality of heat transfer tubes 1G.

**[0056]** As shown in Fig. 7, each of the plurality of heat-transfer members 1 may be formed by the plurality of heat transfer tubes 1G, fin portion 1D, fin portion 1E, and a fin portion 1H. The plurality of heat transfer tubes 1G are arranged side by side and apart from each other in third direction Y. Fin portion 1D extends from heat transfer tube 1G arranged on the most upstream side among

the plurality of heat transfer tubes 1G to the upstream side in third direction Y. Fin portion 1E extends from heat transfer tube 1G arranged on the most downstream side among the plurality of heat transfer tubes 1G to the downstream side in third direction Y. Fin portion 1H connects heat transfer tubes 1G.

#### Second Embodiment

**[0057]** A heat exchanger 101 according to a second embodiment is configured basically similarly to heat exchanger 100 according to the first embodiment and produces an effect similar to the effect produced by heat exchanger 100 according to the first embodiment. However, heat exchanger 101 according to the second embodiment is different from heat exchanger 100 in that each of the plurality of positioning members 3 is connected to each of the plurality of heat-transfer members 1. The difference from heat exchanger 100 will be mainly described below.

**[0058]** As shown in Figs. 8 to 11, each of the plurality of heat-transfer members 1 of heat exchanger 101 is configured similarly to heat-transfer member 1 according to the above-described first modification. Each of the plurality of heat-transfer members 1 includes heat transfer tube portion 1C, fin portion 1D and fin portion 1E. Heat transfer tube portion 1C is provided with the above-described internal space and is configured similarly to the plurality of heat-transfer members 1 of heat exchanger 100. Heat transfer tube portion 1C, fin portion 1D and fin portion 1E are, for example, formed integrally.

**[0059]** In each of the plurality of heat-transfer members 1, fin portion 1D extends from heat transfer tube portion 1C to the upstream side in third direction Y. An end of fin portion 1D located on the upstream side in third direction Y forms first end 1A of heat-transfer member 1. Fin portion 1E extends from heat transfer tube portion 1C to the downstream side in third direction Y. An end of fin portion 1E located on the downstream side in third direction Y forms second end 1B of heat-transfer member 1. A space where the refrigerant flows is not formed in fin portion 1D and fin portion 1E.

**[0060]** Fin portion 1E of each of the plurality of heat-transfer members 1 includes a hole 1F arranged to overlap with each other when viewed from first direction X. Beam portion 3A of each of the plurality of positioning members 3 is inserted through hole 1F of each of the plurality of heat-transfer members 1. Beam portion 3A of each of the plurality of positioning members 3 is connected to fin portion 1E of each of the plurality of heat-transfer members 1.

**[0061]** A material of each of the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 may be any material having a relatively high thermal conductivity, and includes, for example, at least one of aluminum (Al) and copper (Cu).

**[0062]** Third end 2A of each of the plurality of heat-transfer promotion members 2 is arranged on the down-

stream side in third direction Y relative to first end 1A of each of the plurality of heat-transfer members 1. Third end 2A is arranged on the upstream side in third direction Y relative to the plurality of heat transfer tube portions 1C.

**[0063]** Fourth end 2B of each of the plurality of heat-transfer promotion members 2 is arranged on the upstream side in third direction Y relative to second end 1B of each of the plurality of heat-transfer members 1.

**[0064]** Beam portion 3A of each of the plurality of positioning members 3 is arranged on the downstream side in third direction Y relative to the plurality of heat transfer tube portions 1C. Beam portion 3A of each of the plurality of positioning members 3 is arranged on the upstream side in third direction Y relative to second end 1B of each of the plurality of heat-transfer members 1.

**[0065]** Heat exchanger 101 does not include, for example, first reinforcing member 13 and second reinforcing member 14. Heat exchanger 101 may include first reinforcing member 13 and second reinforcing member 14.

**[0066]** In heat exchanger 101, each of the plurality of positioning members 3 is connected to each of the plurality of heat-transfer members 1. Therefore, in heat exchanger 101 as well, the position of each of the plurality of heat-transfer promotion members 2 with respect to the plurality of heat-transfer members 1 is less likely to change, and thus, a decrease in extratube heat transfer coefficient and an increase in pressure loss (a decrease in air-passing property) that are caused when the position changes are suppressed. In addition, in heat exchanger 101, each of the plurality of positioning members 3 can function as a reinforcing member that reinforces the strength of heat exchanger 101.

**[0067]** In heat exchanger 101, a material of each of the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 includes a material having a relatively high thermal conductivity (e.g., at least one of Al and Cu), and thus, a thermal resistance of a heat path extending from each heat-transfer member 1 through the plurality of positioning members 3 to the plurality of heat-transfer promotion members 2 is relatively low, which results in a relatively small heat transfer loss (heat loss) in this heat path. Therefore, in heat exchanger 101, a surface of each of the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 can be effectively used as an extratube heat transfer surface. As a result, in heat exchanger 101, an extratube heat transfer area is larger, and thus, the heat transfer performance is better, as compared with heat exchanger 100 in which a surface of each of the plurality of heat-transfer promotion members 2 and the plurality of positioning members 3 cannot be effectively used as an extratube heat transfer surface.

**[0068]** Each of the plurality of heat-transfer members 1 of heat exchanger 101 may be configured similarly to the third modification of heat-transfer member 1 shown in Fig. 7.

## Third Embodiment

**[0069]** A heat exchanger according to a third embodiment is configured basically similarly to heat exchanger 100 according to the first embodiment and produces an effect similar to the effect produced by heat exchanger 100 according to the first embodiment. However, the heat exchanger according to the third embodiment is different from heat exchanger 100 in that each of the plurality of heat-transfer promotion members 2 includes a protruding portion 21. The difference from heat exchanger 100 will be mainly described below.

**[0070]** As shown in Fig. 12, each of the plurality of heat-transfer promotion members 2 includes a first portion 20A, a second portion 20B, a third portion 20C, protruding portion 21, and a protruding portion 22. In each heat-transfer promotion member 2, first portion 20A is located on the most upstream side in third direction Y. In each heat-transfer promotion member 2, second portion 20B is located on the most downstream side in third direction Y. In each heat-transfer promotion member 2, third portion 20C is located at the center in third direction Y.

**[0071]** Protruding portion 21 is located on the downstream side in third direction Y relative to first portion 20A and protrudes from first portion 20A in first direction X. Protruding portion 21 is located on the upstream side in third direction Y relative to third portion 20C and protrudes from third portion 20C in first direction X.

**[0072]** Protruding portion 21 includes flat plate portions 21A to 21C. An end of flat plate portion 21A located on the upstream side is connected to an end of first portion 20A located on the downstream side. An end of flat plate portion 21B located on the upstream side is connected to an end of third portion 20C located on the upstream side. Flat plate portion 21C connects an end of flat plate portion 21A located on the downstream side and an end of flat plate portion 21B located on the upstream side.

**[0073]** Flat plate portion 21A forms an obtuse angle with respect to first portion 20A. Flat plate portion 21B forms an obtuse angle with respect to third portion 20C. Flat plate portion 21C forms an obtuse angle with respect to each of flat plate portion 21A and flat plate portion 21B. Flat plate portion 21C extends in third direction Y.

**[0074]** Protruding portion 22 is located on the downstream side in third direction Y relative to third portion 20C and protrudes from third portion 20C in first direction X. Protruding portion 22 is located on the upstream side in third direction Y relative to second portion 20B and protrudes from second portion 20B in first direction X. Protruding portion 22 protrudes opposite to protruding portion 21.

**[0075]** Protruding portion 22 includes flat plate portions 22A to 22C. An end of flat plate portion 22A located on the upstream side is connected to an end of third portion 20C located on the downstream side. An end of flat plate portion 22B located on the upstream side is connected to an end of second portion 20B located on the upstream side. Flat plate portion 22C connects an end of flat plate

portion 22A located on the downstream side and an end of flat plate portion 22B located on the upstream side.

**[0076]** Flat plate portion 22A forms an obtuse angle with respect to third portion 20C. Flat plate portion 22B forms an obtuse angle with respect to second portion 20B. Flat plate portion 22C forms an obtuse angle with respect to each of flat plate portion 22A and flat plate portion 22B. Flat plate portion 22C extends in third direction Y.

**[0077]** First portion 20A, second portion 20B, third portion 20C, protruding portion 21, and protruding portion 22 are, for example, formed integrally. First portion 20A, second portion 20B, third portion 20C, protruding portion 21, and protruding portion 22 are, for example, formed by bending one plate-shaped member. In this case, each of protruding portion 21 and protruding portion 22 forms a recessed portion.

**[0078]** First portion 20A, second portion 20B and third portion 20C are arranged at the center between two adjacent heat-transfer members 1 in first direction X. Protruding portion 21 is arranged on the one heat-transfer member 1 side relative to the center between two adjacent heat-transfer members 1 in first direction X. Protruding portion 22 is arranged on the other heat-transfer member 1 side relative to the center between two adjacent heat-transfer members 1 in first direction X.

**[0079]** A distance in first direction X between protruding portion 21 and one heat-transfer member 1 relative to the center between two adjacent heat-transfer members 1 in first direction X is shorter than a distance in first direction X between protruding portion 21 and the other heat-transfer member 1 relative to the center between two adjacent heat-transfer members 1 in first direction X. A distance in first direction X between protruding portion 22 and one heat-transfer member 1 relative to the center between two adjacent heat-transfer members 1 in first direction X is longer than a distance in first direction X between protruding portion 22 and the other heat-transfer member 1 relative to the center between two adjacent heat-transfer members 1 in first direction X.

**[0080]** An amount of protrusion of protruding portion 21 in first direction X with respect to first portion 20A and third portion 20C is, for example, equal to an amount of protrusion of protruding portion 22 in first direction X with respect to second portion 20B and third portion 20C. Heat-transfer promotion member 2 is, for example, arranged to be rotationally symmetric by 180 degrees with respect to the center in third direction Y.

**[0081]** In the heat exchanger according to the third embodiment, each of the plurality of heat-transfer promotion members 2 includes protruding portion 21, and thus, the air flowing between two adjacent heat-transfer members 1 is likely to flow along the surfaces of heat-transfer members 1 and the outdoor heat transfer coefficient is improved, as compared with a heat exchanger in which each of the plurality of heat-transfer promotion members 2 does not include protruding portion 21.

<Modifications of Heat-Transfer Promotion Member 2>

**[0082]** Modifications described below are allowable as each of the plurality of heat-transfer promotion members 2 of the heat exchanger according to the third embodiment.

**[0083]** As shown in Fig. 13, in a cross section vertical to second direction Z, each of protruding portion 21 and protruding portion 22 may have a triangular external shape. In the cross section vertical to second direction Z, each of protruding portion 21 and protruding portion 22 has, for example, an isosceles triangular external shape. In the cross section vertical to second direction Z, an angle formed by two equal sides is, for example, an obtuse angle.

**[0084]** As shown in Fig. 14, each of the plurality of heat-transfer promotion members 2 may include at least one through hole 23 passing through protruding portion 21 in first direction X. Protruding portion 21 may include a plurality of through holes 23. For example, the plurality of through holes 23 passing through each of flat plate portion 21A, flat plate portion 21B and flat plate portion 21C of protruding portion 21 are formed.

**[0085]** With such a configuration, two air paths formed between two adjacent heat-transfer members 1 with heat-transfer promotion member 2 being interposed communicate with each other by through holes 23. Therefore, the air flows, from the other air path, into a region of one air path whose width in first direction X between heat-transfer member 1 and heat-transfer promotion member 2 is reduced by protruding portion 21. As a result, in a heat exchanger including the plurality of heat-transfer promotion members 2 shown in Fig. 14, the extratube heat transfer coefficient is improved, as compared with the heat exchanger including the plurality of heat-transfer promotion members 2 shown in Fig. 12.

**[0086]** Through holes 23 may be provided to pass through at least flat plate portion 21C. In addition, each of the plurality of heat-transfer promotion members 2 may include at least one through hole 23 passing through protruding portion 22 in first direction X. Furthermore, each of the plurality of heat-transfer promotion members 2 may include at least one through hole 23 passing through third portion 20C in first direction X.

**[0087]** Through hole 23 may be formed as a slit including a guide portion that guides an air direction, like a louver formed on a corrugated fin.

**[0088]** As shown in Fig. 15, in a cross section vertical to second direction Z, a plurality of grooves 24 may be formed in an outer perimeter surface of the plurality of heat-transfer promotion members 2 facing in first direction X. Each of the plurality of grooves 24 extends in second direction Z. Each of the plurality of grooves 24 is, for example, continuous to third direction Y. Each of the plurality of grooves 24 is, for example, formed in flat plate portion 21C of protruding portion 21. Each of the plurality of grooves 24 is, for example, a groove formed between two projections that protrude in first direction X

with respect to an outer perimeter surface of flat plate portion 21C facing in first direction X and are adjacent to each other in third direction Y. Each of the plurality of grooves 24 has, for example, two inclined surfaces inclined to form an acute angle with respect to third direction Y. Each of the plurality of grooves 24 has, for example, a V-shaped cross-sectional shape.

**[0089]** Such grooves 24 can function as a discharge path for condensed water or frost melting water.

**[0090]** At least one groove 24 may be formed in the outer perimeter surface of the plurality of heat-transfer promotion members 2 facing in first direction X. Groove 24 may have, for example, a U-shaped cross-sectional shape. Groove 24 may be formed in at least one of first portion 20A, second portion 20B, third portion 20C, flat plate portion 21A, flat plate portion 21B, and flat plate portion 21C.

**[0091]** In heat-transfer promotion members 2 shown in Figs. 12 to 15, an amount of protrusion of protruding portion 21 in first direction X with respect to first portion 20A and third portion 20C may be larger than an amount of protrusion of protruding portion 22 in first direction X with respect to second portion 20B and third portion 20C. Alternatively, the amount of protrusion of protruding portion 21 in first direction X with respect to first portion 20A and third portion 20C may be smaller than the amount of protrusion of protruding portion 22 in first direction X with respect to second portion 20B and third portion 20C.

**[0092]** As shown in Fig. 16, a distance in first direction X between one heat-transfer promotion member 2 and one heat-transfer member 1 adjacent to this heat-transfer promotion member 2 may be set to become gradually shorter from the upstream side toward the downstream side in third direction Y. In other words, a width of one heat-transfer promotion member 2 in first direction X may be set to become gradually wider from the upstream side toward the downstream side in third direction Y. For example, a distance in first direction X between one heat-transfer promotion member 2 and each of two heat-transfer members 1 adjacent to each other in first direction X with this heat-transfer promotion member 2 being interposed may be set to become gradually shorter from the upstream side toward the downstream side in third direction Y. An interval W1 in first direction X between third end 2A of heat-transfer promotion member 2 and each of two heat-transfer members 1 adjacent to each other in first direction X with this heat-transfer promotion member 2 being interposed is longer than an interval W2 in first direction X between fourth end 2B of above-described heat-transfer promotion member 2 and each of above-described two heat-transfer members 1.

**[0093]** Heat-transfer promotion member 2 has, for example, two inclined surfaces 25 and two flat surfaces 26. Each inclined surface 25 is inclined to form an acute angle with respect to third direction Y. An end of one inclined surface 25 located on the downstream side is connected to an end of one flat surface 26 located on the upstream side. One inclined surface 25 and one flat surface 26 and

the other inclined surface 25 and the other flat surface 26 are, for example, line symmetric with respect to a center line of heat-transfer promotion member 2 extending in third direction Y. Each inclined surface 25 is continuous to third end 2A. Each flat surface 26 is continuous to fourth end 2B. Each inclined surface 25 and each flat surface 26 are, for example, planes. Each inclined surface 25 and each flat surface 26 may be, for example, curved surfaces.

**[0094]** The air flowing between two heat-transfer members 1 adjacent to each other in first direction X is likely to concentrate on a central region between these two heat-transfer members 1 in first direction X, as the air flows toward the downstream side in third direction Y. In a heat exchanger including heat-transfer promotion members 2 shown in Fig. 16, the air is likely to flow along the surfaces of heat-transfer members 1 on the downstream side in third direction Y, and thus, the extratube heat transfer coefficient is improved, as compared with heat exchanger 100 including heat-transfer promotion members 2 shown in Figs. 2 and 3.

**[0095]** Although in heat-transfer promotion members 2 shown in Figs. 12 to 16, the shortest distance between heat-transfer promotion member 2 and one of two heat-transfer members 1 adjacent to each other with this heat-transfer promotion member 2 being interposed is equal to the shortest distance between heat-transfer promotion member 2 and the other of the two heat-transfer members 1 adjacent to each other with this heat-transfer promotion member 2 being interposed, the present disclosure is not limited thereto. In heat-transfer promotion members 2 shown in Figs. 12 to 16, the former shortest distance may be different from the latter shortest distance.

**[0096]** In the heat exchanger according to the third embodiment and the above-described modifications thereof, heat-transfer member 1 may be configured similarly to any one of the modifications shown in Figs. 5 to 7. In addition, grooves 24 shown in Fig. 15 may be formed in heat-transfer promotion members 2 of the heat exchanger according to the first or second embodiment.

#### Fourth Embodiment

**[0097]** A heat exchanger according to a fourth embodiment is configured basically similarly to heat exchanger 100 according to the first embodiment and produces an effect similar to the effect produced by heat exchanger 100 according to the first embodiment. However, the heat exchanger according to the fourth embodiment is different from heat exchanger 100 in that the below-described relational equation is satisfied. The difference from heat exchanger 100 will be mainly described below.

**[0098]** As shown in Fig. 17, a represents a length of each of the plurality of heat-transfer members 1 in third direction Y. L represents a length of each of the plurality of heat-transfer promotion members 2 in third direction Y. b represents a maximum width of each of the plurality of heat-transfer members 1 in first direction X. p represents

a pitch of each of the plurality of heat-transfer members 1 in first direction X. Pitch p refers to a distance in first direction X between a center line C2 passing through the center of one of two adjacent heat-transfer members 1 in first direction X and extending in third direction Y and a center line C2 passing through the center of the other of the two adjacent heat-transfer members 1 in first direction X and extending in third direction Y. tP represents an average width of the plurality of heat-transfer promotion members 2 in first direction X. Average width tP is a value obtained by dividing a cross-sectional area of heat-transfer promotion member 2 vertical to second direction Z by above-described length L. Above-described length a, above-described length L, above-described maximum width b, above-described pitch p, and above-described average width tP satisfy the following relational equation in a range of  $0 < tP / (p - b) < 1$ :

[Equation 1]

$$\frac{L}{a} \leq 2.3247 \cdot e^{-5.332 \frac{tP}{p-b}}$$

**[0099]** The above-described relational equation was derived based on a computational fluid dynamics (CFD) method.

**[0100]** First, using a SIMPLEC method, a governing equation that describes an air flow in an air path shown in Fig. 17 is solved as a simultaneous equation of a continuity equation and a Navier-Stokes equation. The graph shown in Fig. 18 is thus derived.

**[0101]** The horizontal axis of the graph shown in Fig. 18 indicates a ratio L/a of length L of heat-transfer promotion member 2 in third direction Y to length a of heat-transfer member 1 in third direction Y.

**[0102]** The vertical axis of the graph shown in Fig. 18 indicates a ratio of a pressure loss  $\Delta P1$  of the air flowing through the air path shown in Fig. 17 to a pressure loss  $\Delta P2$  of the air flowing through an air path according to the comparative example. Pressure loss  $\Delta P2$  refers to a pressure loss of the air flowing through the air path according to the comparative example. The air path according to the comparative example refers to an air path formed in the heat exchanger according to Comparative Example 2 described above. Specifically, the air path according to the comparative example is different from the air path shown in Fig. 17 in that heat-transfer promotion members 2 are not provided and an interval between two adjacent heat-transfer members in first direction X is a half of pitch p in first direction X between two adjacent heat-transfer members 1 shown in Fig. 17.

**[0103]** As shown in Fig. 18, a ratio  $\Delta P1/\Delta P2$  changes in accordance with a ratio  $tP/(p-b)$ . When ratio  $\Delta P1/\Delta P2$  is equal to or lower than 100%, the pressure loss of the air flowing through the air path shown in Fig. 17 is reduced to be equal to or smaller than the pressure loss of the air flowing through the air path according to the above-de-

scribed comparative example.

**[0104]** Next, the graph shown in Fig. 19 is derived from ratio  $L/a$  and ratio  $tP/(p-b)$  that allow ratio  $\Delta P1/\Delta P2$  to be equal to or lower than 100% as shown in Fig. 18. The mathematical equation in Fig. 19 is a relational equation between ratio  $tP/(p-b)$  and ratio  $L/a$  when ratio  $\Delta P1/\Delta P2$  is equal to 100%.

**[0105]** Since the above-described relational equation is satisfied in the range of  $0 < tP/(p-b) < 1$  in the heat exchanger according to the fourth embodiment, the pressure loss is reduced to be equal to or smaller than that in the above-described comparative example and the heat transfer performance is improved as compared with the above-described comparative example. The heat exchanger according to the fourth embodiment may be different from the heat exchanger according to the second or third embodiment only in that the above-described relational equation is satisfied. Average width  $tP$  of each heat-transfer promotion member 2 shown in Figs. 12 to 16 is a value obtained by dividing the cross-sectional area of each heat-transfer promotion member 2 vertical to second direction  $Z$  by above-described length  $L$  thereof. In addition, heat-transfer member 1 of the heat exchanger according to the fourth embodiment may be configured similarly to each of heat-transfer members 1 shown in Figs. 5 to 7.

Fifth Embodiment

<Refrigeration Cycle Apparatus>

**[0106]** A refrigeration cycle apparatus 200 according to a fifth embodiment includes any one of the heat exchangers according to the first to fourth embodiments. As shown in Fig. 20, refrigeration cycle apparatus 200 mainly includes, for example, heat exchanger 100, a compressor 111, a four-way valve 112, a heat exchanger 113, an expansion valve 114, and a blower 115. Blower 115 sends air to heat exchanger 100 in third direction  $Y$ . Four-way valve 112 performs switching between an operation mode in which heat exchanger 100 functions as an evaporator and an operation mode in which heat exchanger 100 functions as a condenser.

**[0107]** First header 11 of heat exchanger 100 is, for example, connected to a discharge port and a suction port of compressor 111 via four-way valve 112. Second header 12 of heat exchanger 100 is, for example, connected to expansion valve 114.

**[0108]** Since refrigeration cycle apparatus 200 includes any one of the heat exchangers according to the first to fourth embodiments, refrigeration cycle apparatus 200 enables energy saving, as compared with a refrigeration cycle apparatus including the heat exchanger according to Comparative Example 1. In addition, since refrigeration cycle apparatus 200 includes any one of the heat exchangers according to the first to fourth embodiments, refrigeration cycle apparatus 200 enables energy saving while enabling a reduction in manufacturing cost

and weight, as compared with a refrigeration cycle apparatus including the heat exchanger according to Comparative Example 2.

**[0109]** It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The technical scope indicated by the present disclosure is defined by the terms of the claims, rather than the description of the embodiments above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

#### REFERENCE SIGNS LIST

**[0110]** 1 heat-transfer member; 1A first end; 1B second end; 1C heat transfer tube portion; 1D, 1E, 1H fin portion; 1F hole; 1G heat transfer tube; 2 heat-transfer promotion member; 2A third end; 2B fourth end; 3 positioning member; 3A beam portion; 3B, 3C connection portion; 11 first header; 12 second header; 13 first reinforcing member; 14 second reinforcing member; 15 first inflow/outflow portion; 16 second inflow/outflow portion; 20A first portion; 20B second portion; 20C third portion; 21, 22 protruding portion; 21A, 21B, 21C, 22A, 22B, 22C flat plate portion; 23 through hole; 24 groove; 25 inclined surface; 26 flat surface; 100, 101, 113 heat exchanger; 111 compressor; 112 four-way valve; 114 expansion valve; 115 blower; 200 refrigeration cycle apparatus.

#### 30 Claims

##### 1. A heat exchanger comprising:

a first header and a second header extending in a first direction and arranged apart from each other in a second direction perpendicular to the first direction; and

a plurality of heat-transfer members arranged apart from each other in the first direction, each of the plurality of heat-transfer members having a first end in the second direction connected to the first header and a second end in the second direction connected to the second header,

an internal space, through which a first heat exchange medium flows, of each of the first header, the second header, and the plurality of heat-transfer members being separated from an external space through which a second heat exchange medium flows,

the internal space of the first header communicating with the internal space of the second header through the internal space of each of the plurality of heat-transfer members,

the heat exchanger further comprising:

at least one heat-transfer promotion member; and

- at least one positioning member,  
the at least one heat-transfer promotion member
- being located in the external space,  
being arranged in a central region between two heat-transfer members adjacent to each other in the first direction among the plurality of heat-transfer members, and  
extending in a third direction perpendicular to the first direction and the second direction,
- the at least one positioning member
- being located in the external space,  
positioning the at least one heat-transfer promotion member with respect to the first header, the second header, and the plurality of heat-transfer members, and  
being arranged only on a downstream side in the third direction in which the second heat exchange medium flows, relative to the internal space of each of the plurality of heat-transfer members.
2. The heat exchanger according to claim 1, wherein the at least one heat-transfer promotion member is spaced apart from each of the plurality of heat-transfer members.
  3. The heat exchanger according to claim 1 or 2, wherein
 

a width of the at least one positioning member in the first direction is wider than an interval between two heat-transfer members adjacent to each other in the first direction among the plurality of heat-transfer members,  
a width of the at least one positioning member in the second direction is narrower than a width of the at least one heat-transfer promotion member in the second direction, and  
the at least one positioning member is connected to the plurality of heat-transfer members.
  4. The heat exchanger according to claim 3, wherein
 

each of the plurality of heat-transfer members includes a heat transfer tube portion provided with the internal space of each of the plurality of heat-transfer members, and a fin portion extending from the heat transfer tube portion to the downstream side,  
the fin portion of each of the plurality of heat-transfer members includes a hole arranged to

overlap with each other when viewed from the first direction, and  
the at least one positioning member is inserted through the hole of each of the plurality of heat-transfer members.

5. The heat exchanger according to claim 3 or 4, wherein
 

a material of the at least one positioning member includes at least one of aluminum (Al) and copper (Cu).
6. The heat exchanger according to claim 1, further comprising
 

a first reinforcing member and a second reinforcing member located in the external space, arranged to sandwich the plurality of heat-transfer members in the first direction, and connected to each of the first header and the second header,  
a width of the at least one positioning member in the first direction is equal to or wider than an interval between the first reinforcing member and the second reinforcing member in the first direction,  
a width of the at least one positioning member in the second direction is narrower than a width of the at least one heat-transfer promotion member in the second direction, and  
the at least one positioning member is connected to each of the first reinforcing member and the second reinforcing member, and is spaced apart from the plurality of heat-transfer members.
7. The heat exchanger according to claim 6, wherein a thermal conductivity of a material of the at least one positioning member is lower than a thermal conductivity of a material of the plurality of heat-transfer members.
8. The heat exchanger according to any one of claims 1 to 7, wherein
 

each of the plurality of heat-transfer members has a first end located on a most upstream side in the third direction in which the second heat exchange medium flows, and a second end located on a most downstream side in the third direction,  
the at least one heat-transfer promotion member has a third end located on a most upstream side in the third direction, and a fourth end located on a most downstream side in the third direction, and  
the third end is arranged on the downstream side in the third direction relative to the first end.

- 9. The heat exchanger according to any one of claims 1 to 8, wherein the at least one heat-transfer promotion member includes a first portion located on an upstream side in the third direction, and a protruding portion located on a downstream side in the third direction relative to the first portion and protruding from the first portion in the first direction. 5
- 10. The heat exchanger according to claim 9, wherein the at least one heat-transfer promotion member includes at least one through hole passing through the protruding portion in the first direction. 10
- 11. The heat exchanger according to any one of claims 1 to 10, wherein
  - in a cross section vertical to the second direction, at least one groove is formed in an outer perimeter surface of the at least one heat-transfer promotion member facing in the first direction, and 20
  - the at least one groove extends in the second direction. 25
- 12. The heat exchanger according to any one of claims 1 to 11, wherein
  - a distance in the first direction between the at least one heat-transfer promotion member and one heat-transfer member adjacent to the at least one heat-transfer promotion member is set to become gradually shorter from an upstream side toward a downstream side in the third direction. 30 35
- 13. The heat exchanger according to any one of claims 1 to 12, wherein
  - a length a of each of the plurality of heat-transfer members in the third direction, a length L of the at least one heat-transfer promotion member in the third direction, a maximum width b of each of the plurality of heat-transfer members in the first direction, a pitch p of each of the plurality of heat-transfer members in the first direction, and an average width tP of the at least one heat-transfer promotion member in the first direction satisfy the following relational equation in a range of  $0 < tP / (p - b) < 1$ : 40 45 50

[Equation 1]

$$\frac{L}{a} \leq 2.3247 \cdot e^{-5.332 \cdot \frac{tP}{p-b}}$$

- 14. A refrigeration cycle apparatus,
  - the first heat exchange medium being refriger-

ant and the second heat exchange medium being air,  
 the refrigeration cycle apparatus comprising:

- a first heat exchange circuit including the heat exchanger as recited in any one of claims 1 to 13, the refrigerant circulating in the first heat exchange circuit; and
- a blower configured to send the air to the heat exchanger in the third direction.

FIG.1

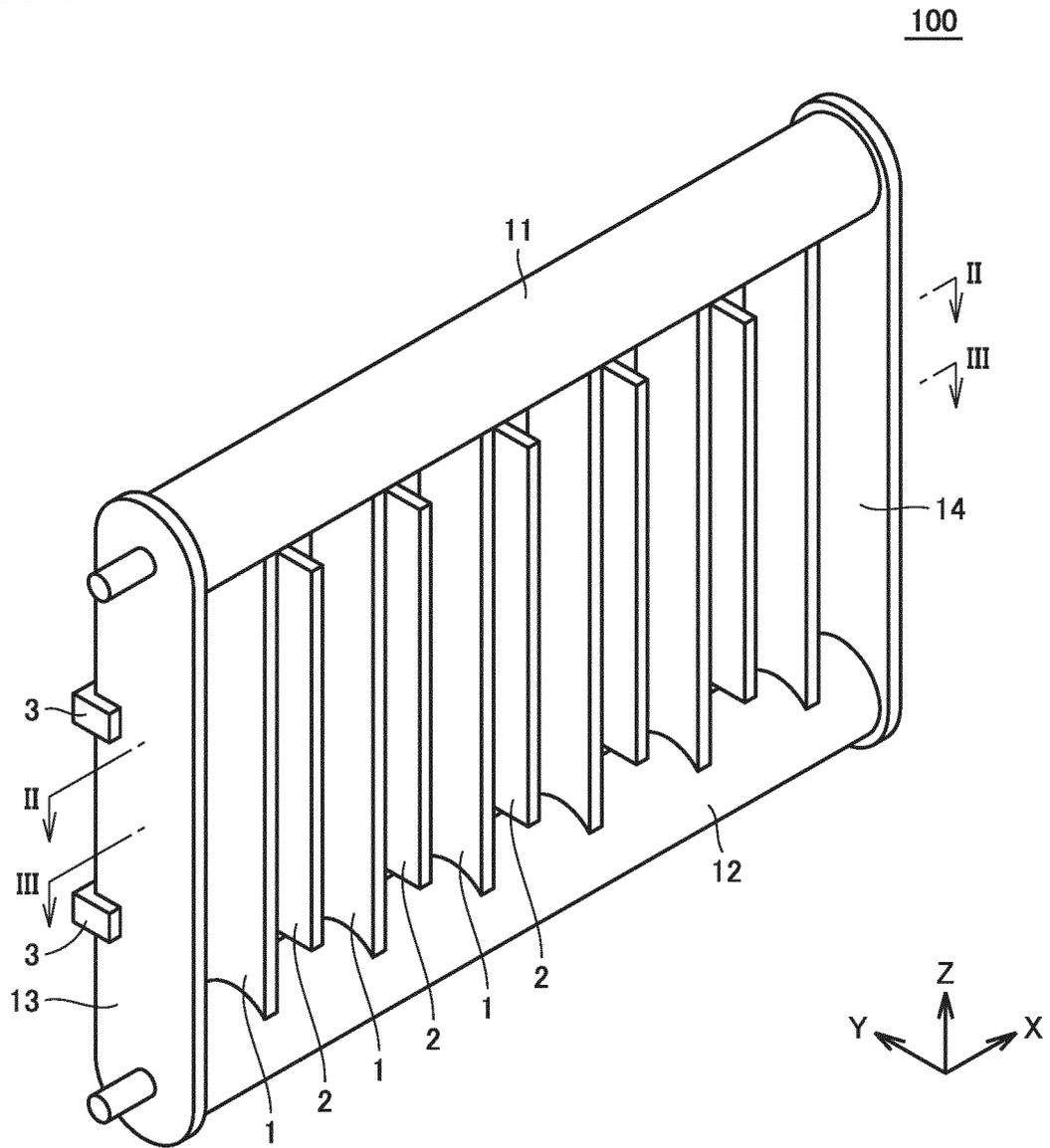


FIG.2

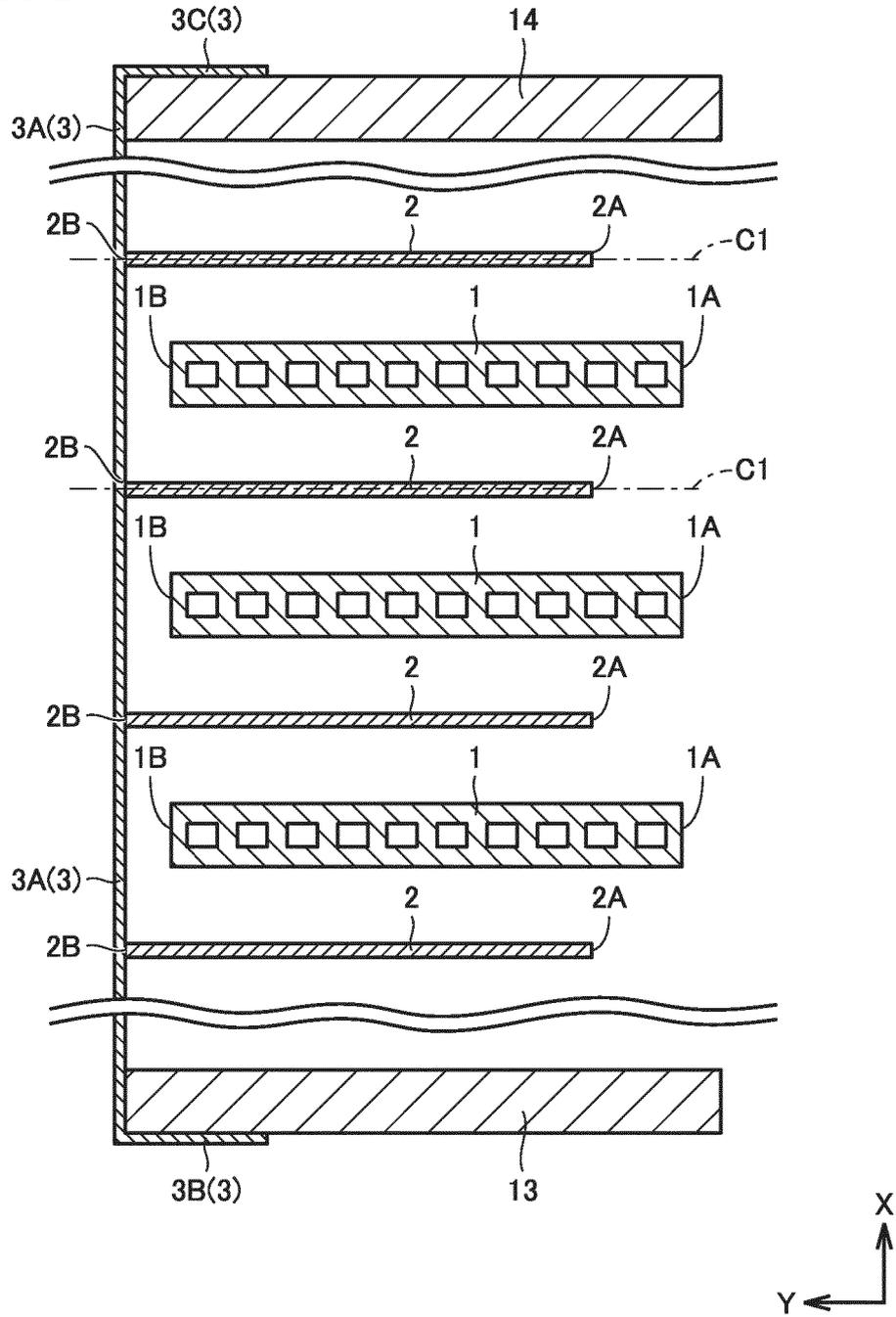
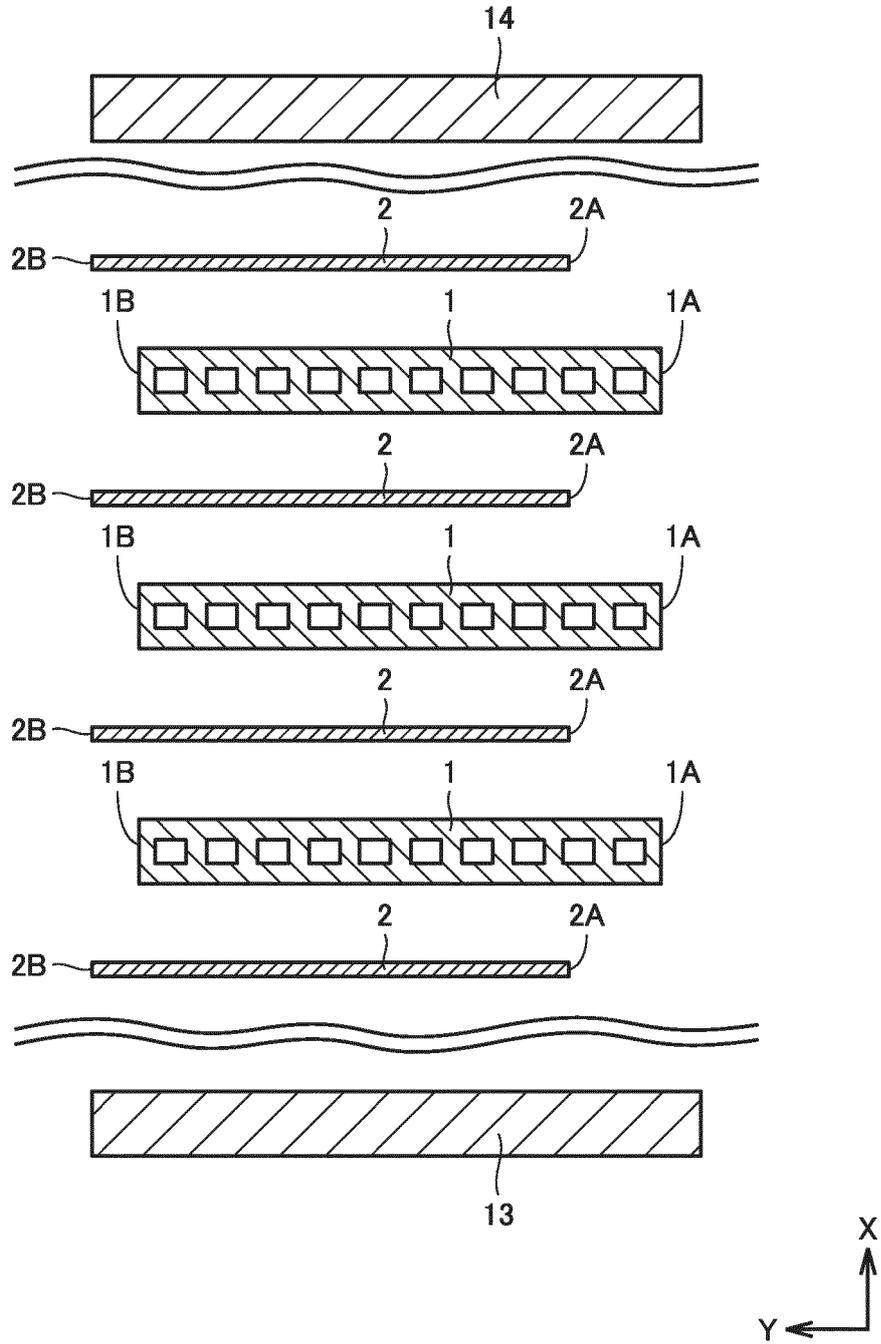


FIG.3



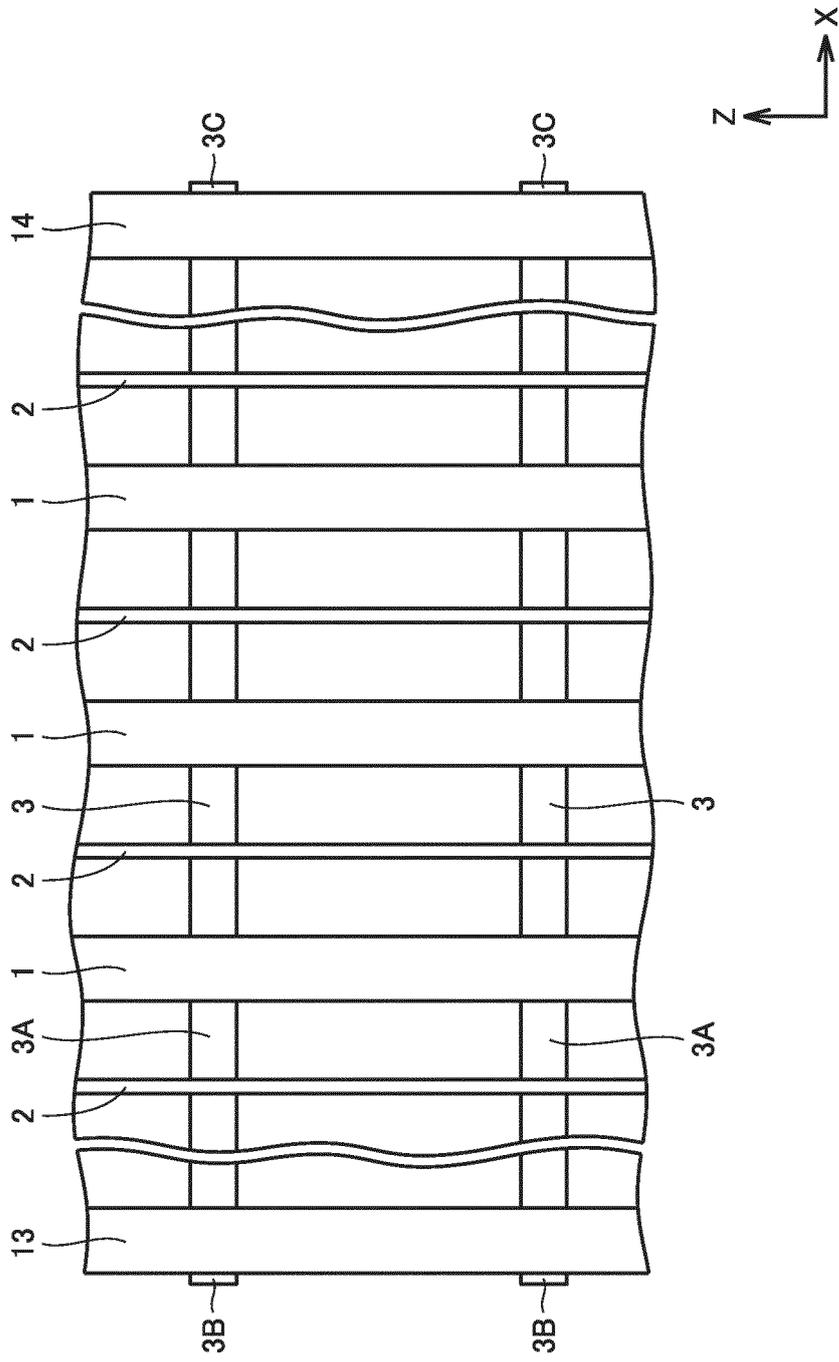


FIG.4

FIG.5

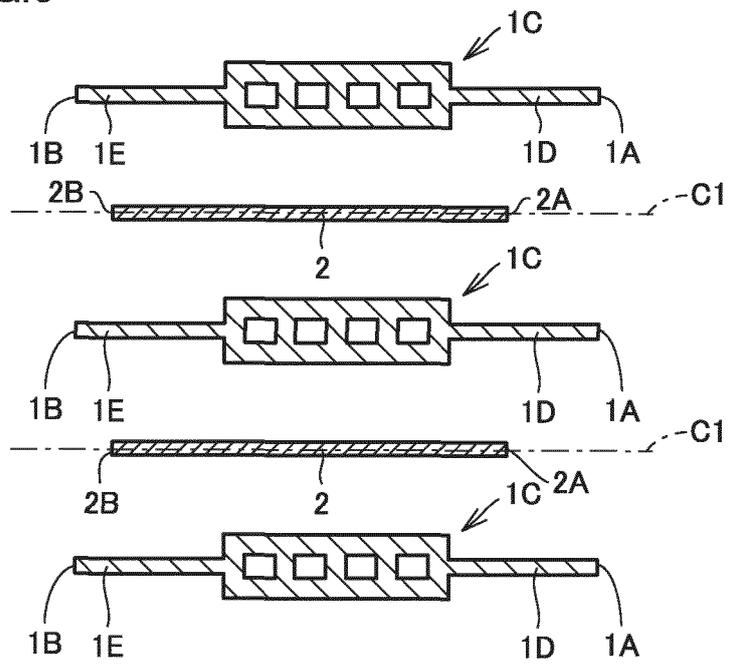


FIG.6

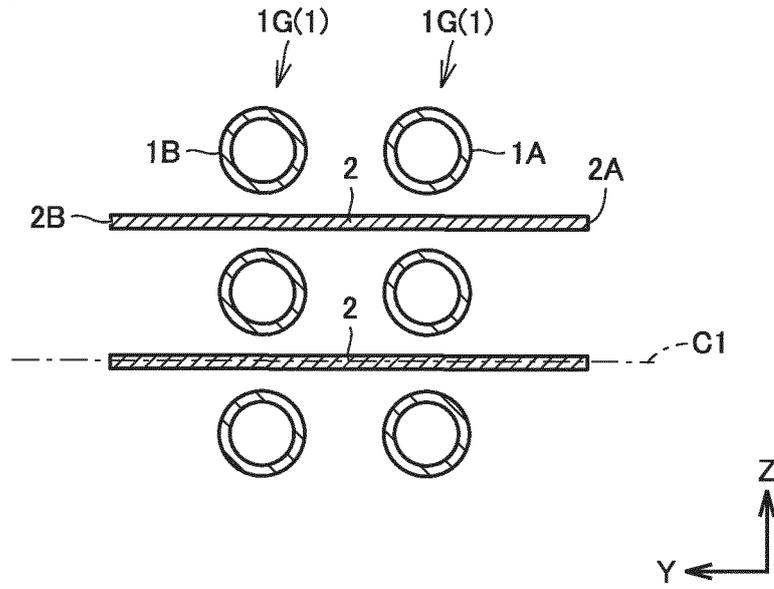


FIG.7

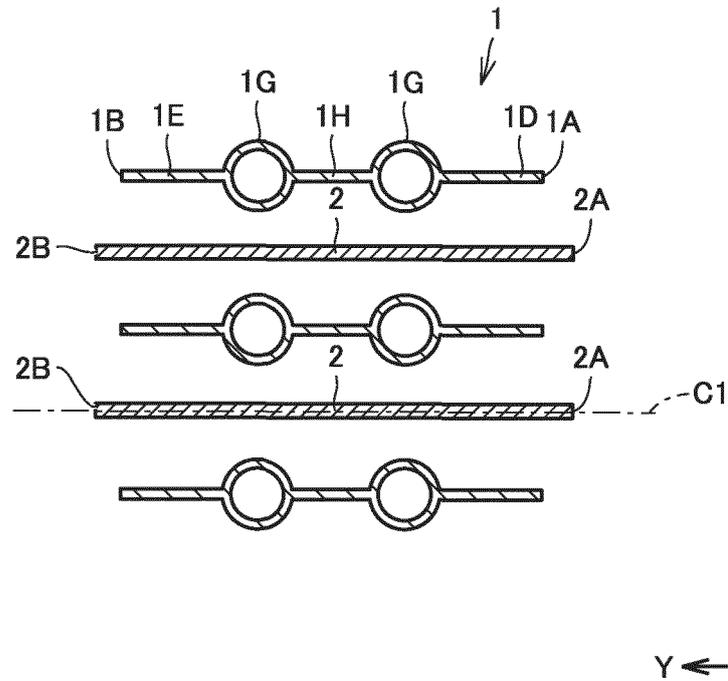


FIG.8

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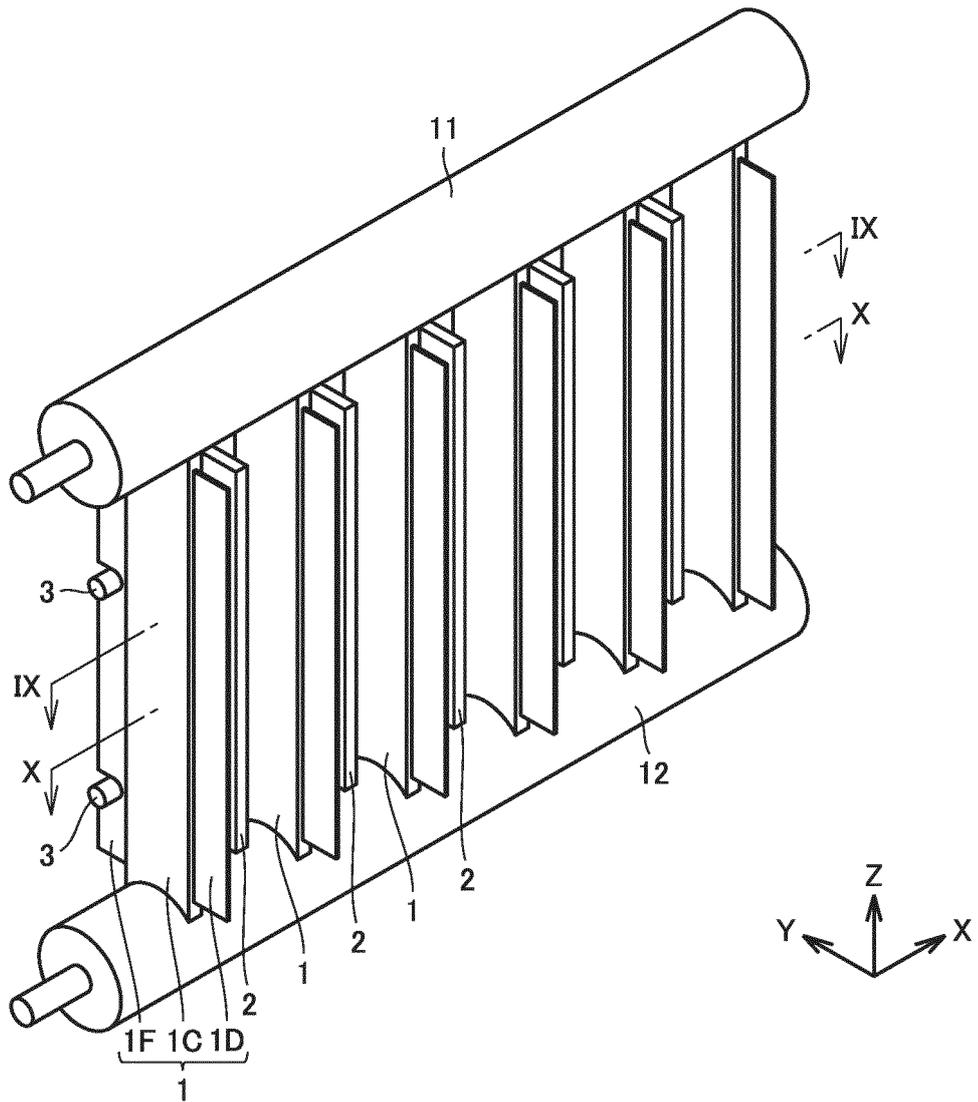


FIG.9

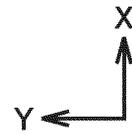
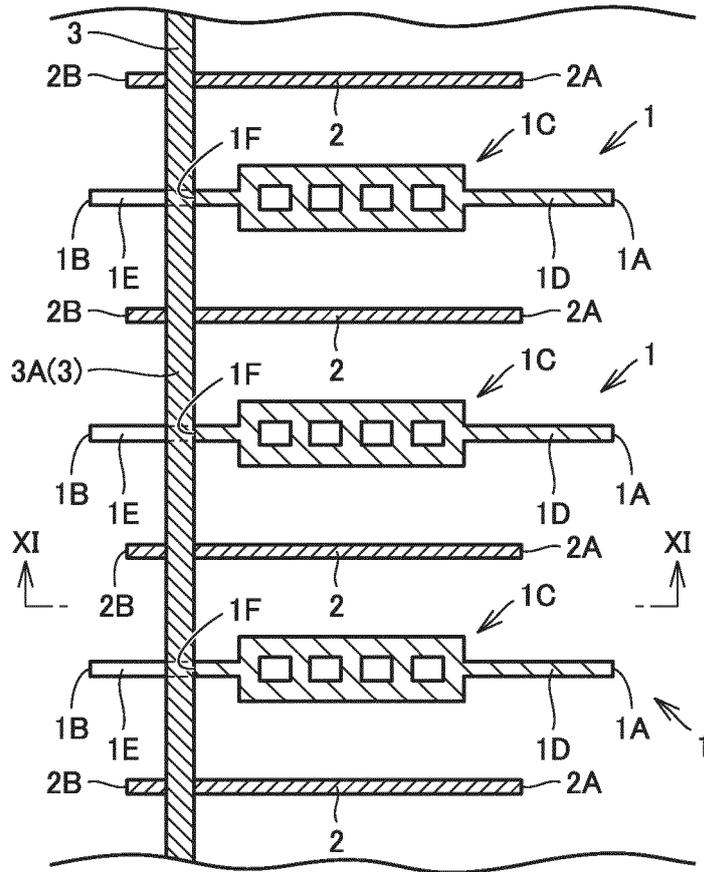


FIG.10

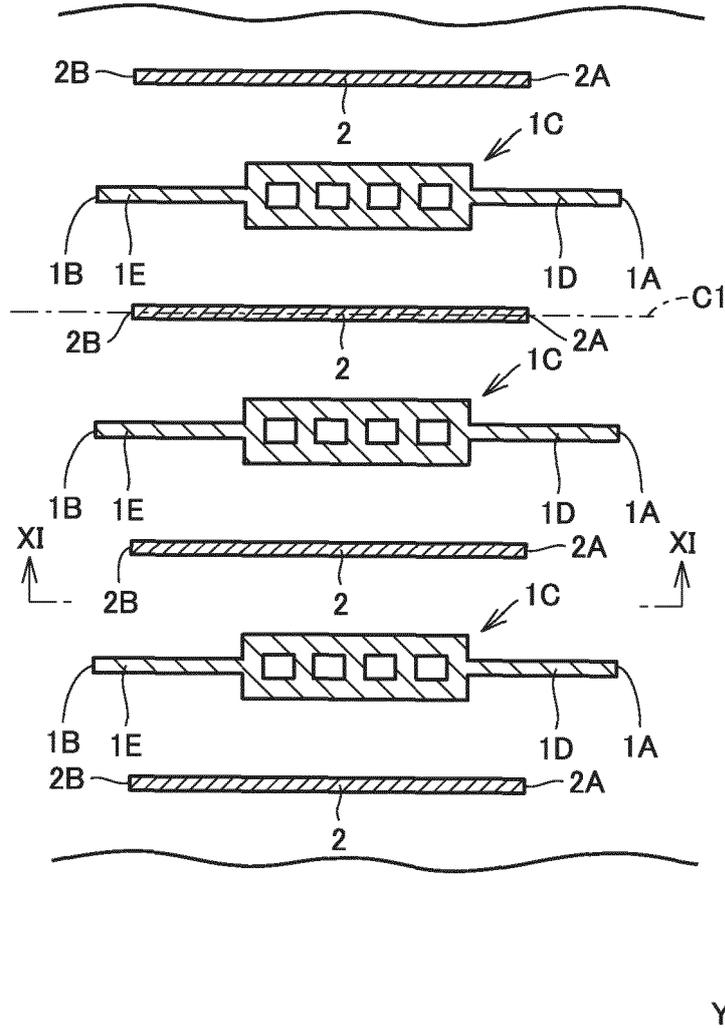


FIG.11

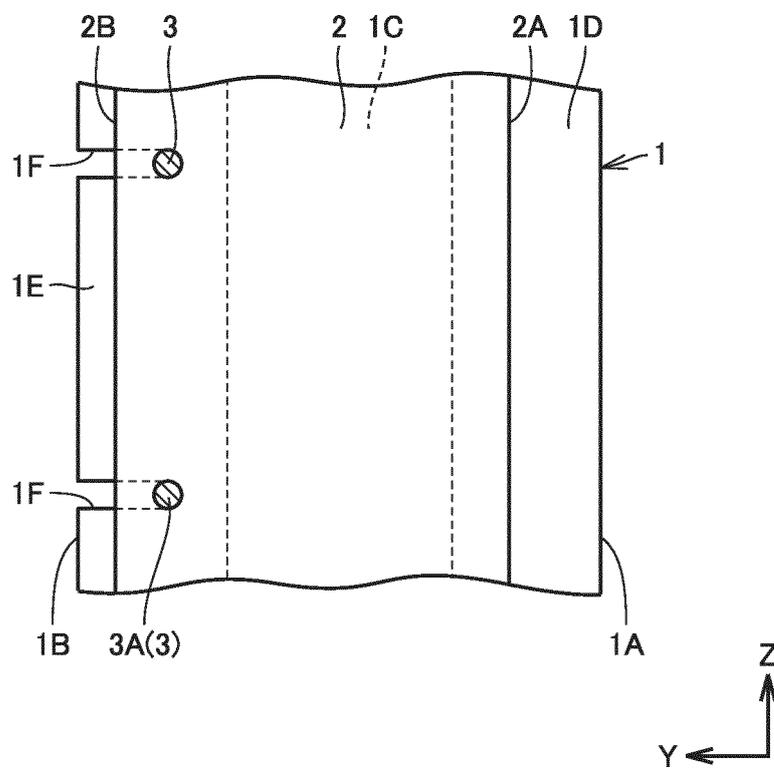


FIG.12

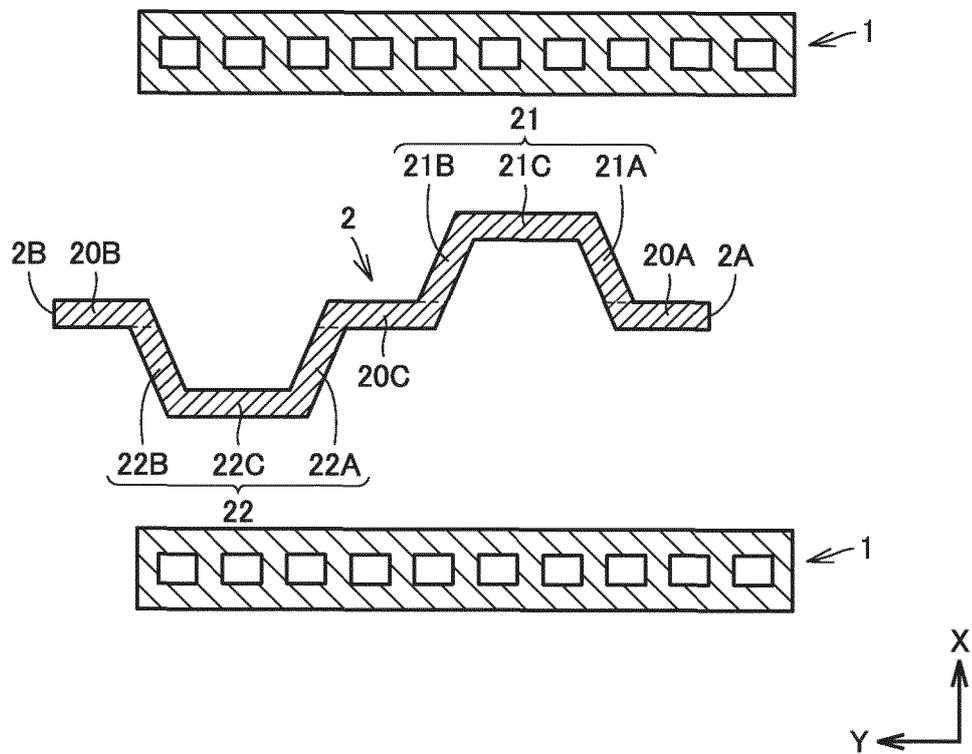


FIG.13

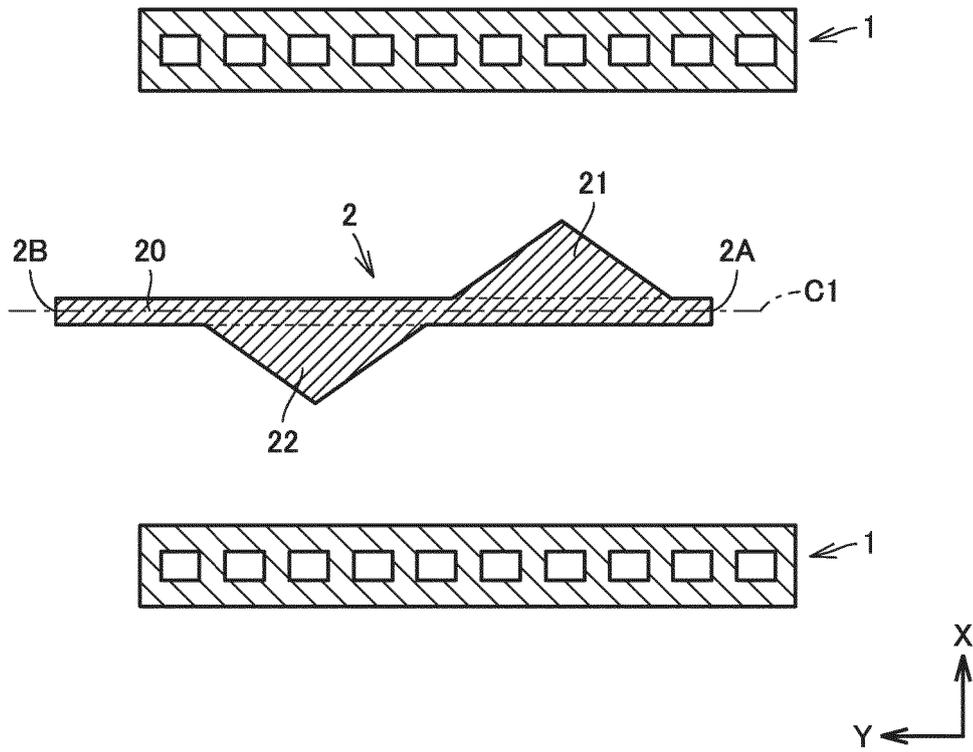


FIG.14

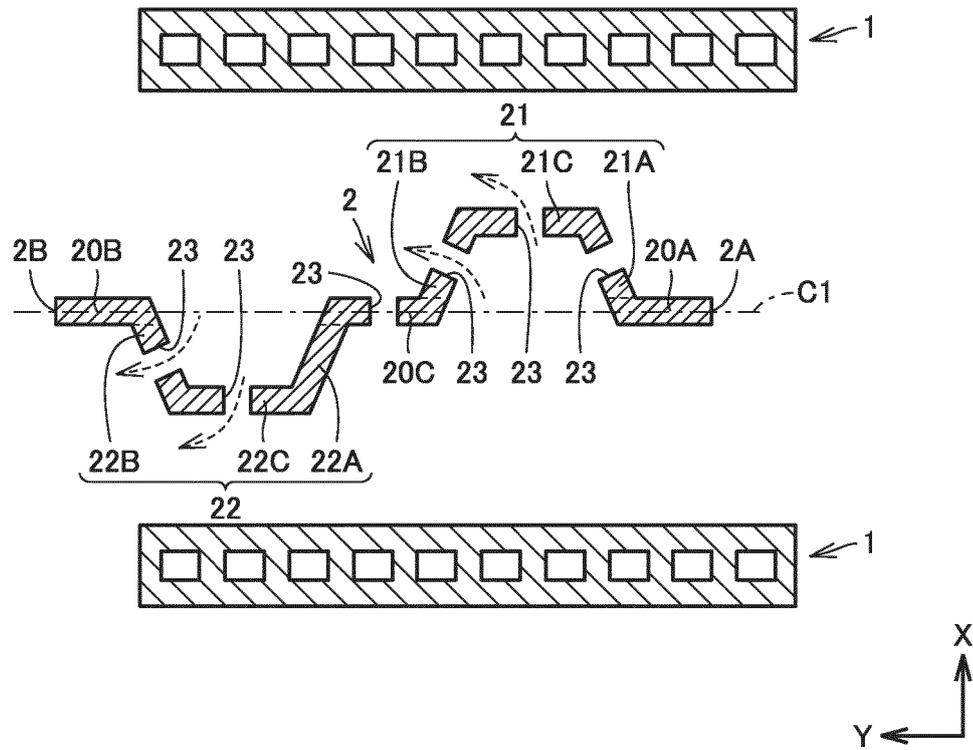


FIG.15

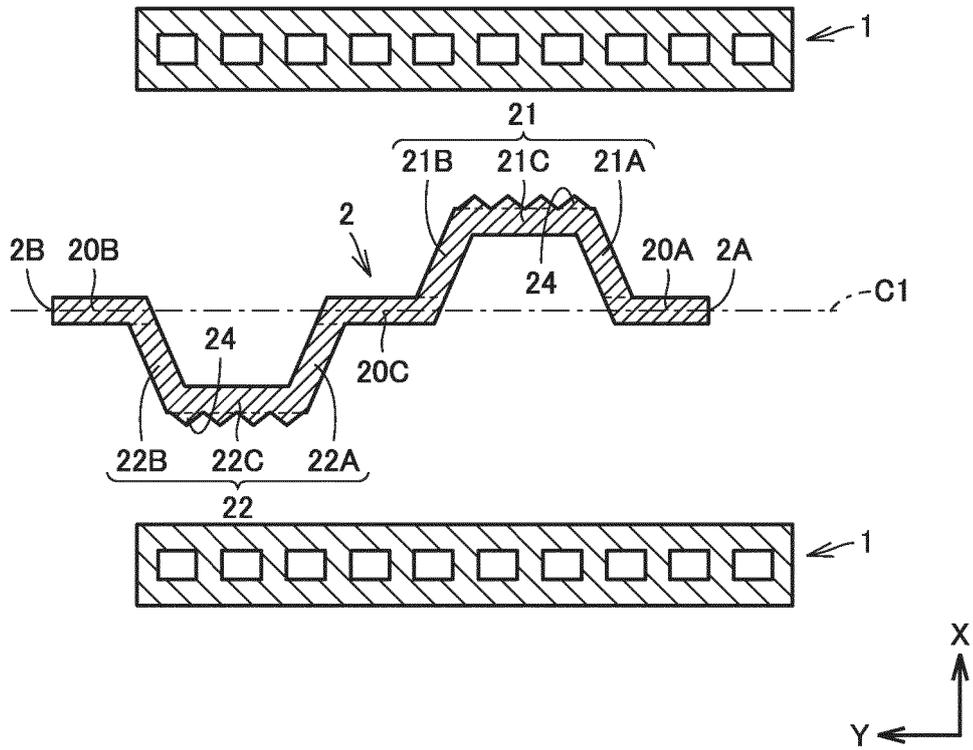


FIG.16

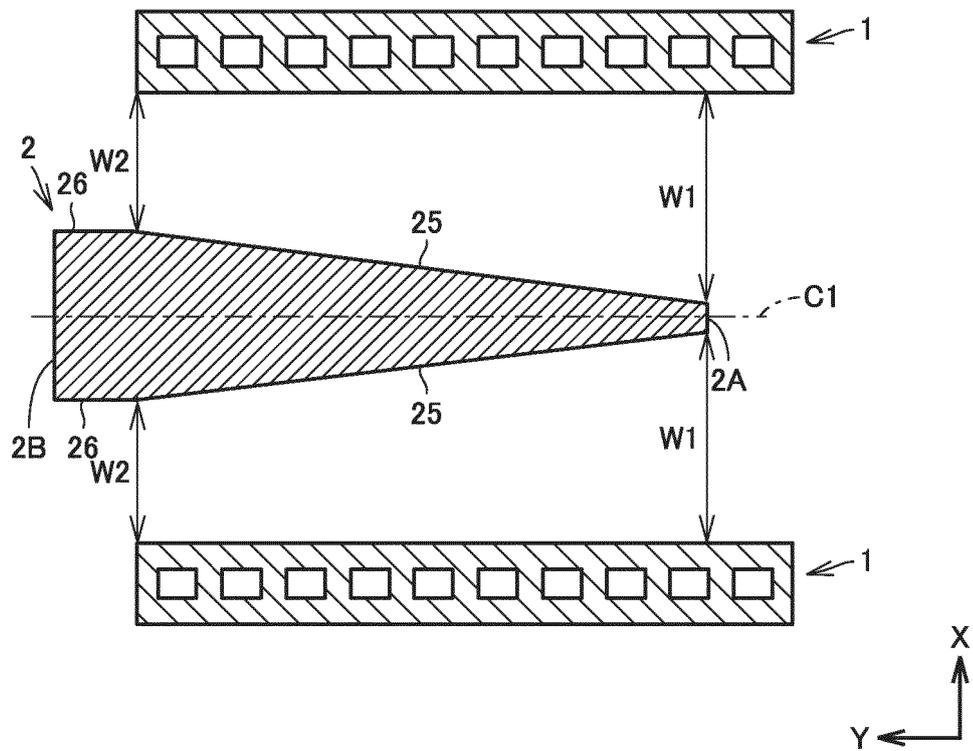


FIG.17

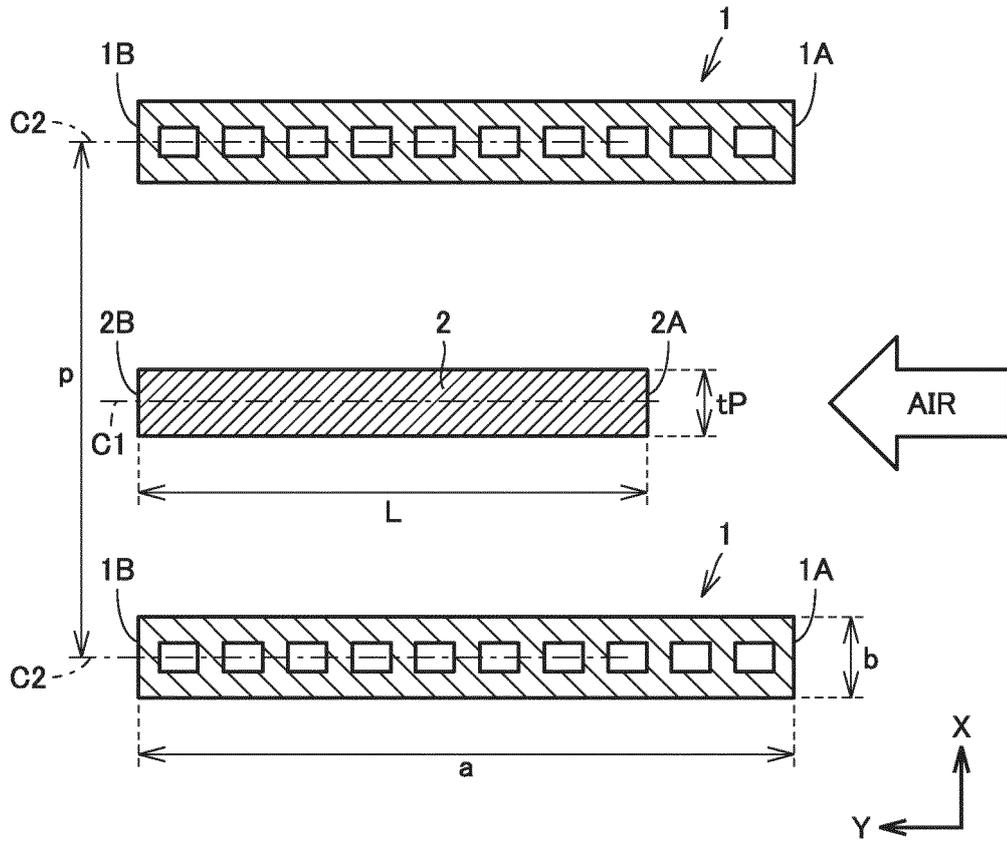


FIG.18

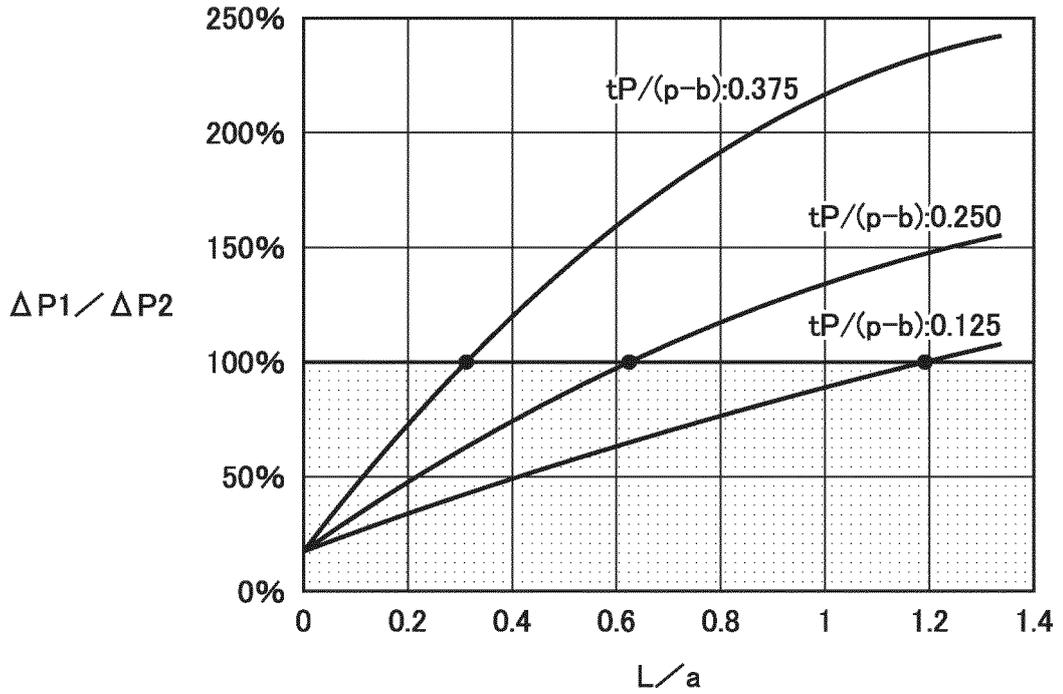


FIG.19

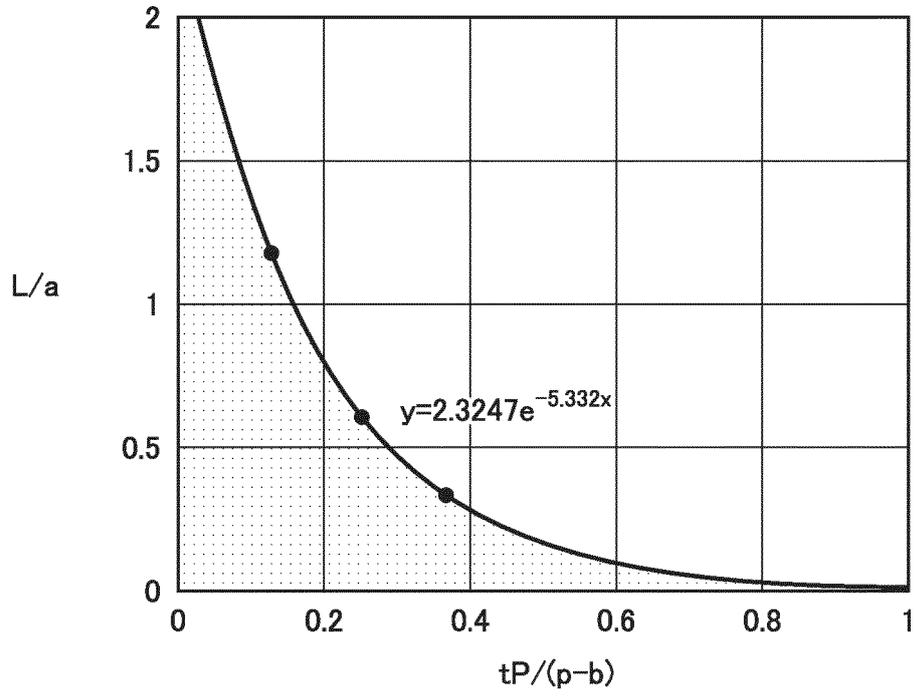
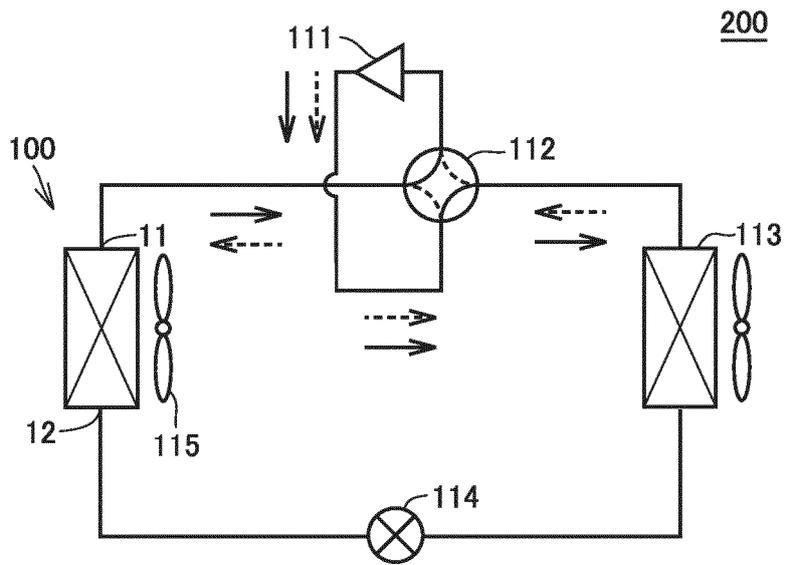


FIG.20



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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/007502

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## A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F28D1/053 (2006.01) i, F28F13/08 (2006.01) i  
 FI: F28F13/08, F28D1/053A

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

15

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
 Int.Cl. F28D1/053, F28F13/08

20

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	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 4678/1986 (Laid-open No. 118990/1987) (DAIKIN IND LTD.) 28 July 1987 (1987-07-28), specification, page 2, line 1 to page 4, line 3, fig. 1-3	1-14
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 23225/1989 (Laid-open No. 115688/1990) (SHOWA ALUMINUM CORPORATION) 17 September 1990 (1990-09-17), specification, page 2, line 3 to page 4, line 8, fig. 1, 2	1-14

Further documents are listed in the continuation of Box C.

See patent family annex.

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

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

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"&" document member of the same patent family

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Date of the actual completion of the international search  
30 March 2021

Date of mailing of the international search report  
13 April 2021

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Name and mailing address of the ISA/  
 Japan Patent Office  
 3-4-3, Kasumigaseki, Chiyoda-ku,  
 Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

International application No. PCT/JP2021/007502
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10

JP 62-118990 U1 28 July 1987 (Family: none)

JP 2-115688 U1 17 September 1990 (Family: none)

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Form PCT/ISA/210 (patent family annex) (January 2015)

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2018155481 A [0002] [0003]