



US 20190170372A1

(19) **United States**

(12) **Patent Application Publication**  
Yoshioka et al.

(10) **Pub. No.: US 2019/0170372 A1**

(43) **Pub. Date: Jun. 6, 2019**

(54) **INDOOR HEAT EXCHANGER**

**Publication Classification**

(71) Applicant: **DAIKIN INDUSTRIES, LTD.**, Osaka (JP)

(51) **Int. Cl.**  
*F24F 1/0067* (2006.01)  
*F24F 13/30* (2006.01)  
*F25B 39/00* (2006.01)  
*F28F 1/32* (2006.01)

(72) Inventors: **Shun Yoshioka**, Osaka (JP); **Yoshiyuki Matsumoto**, Osaka (JP); **Satoshi Inoue**, Osaka (JP)

(52) **U.S. Cl.**  
CPC ..... *F24F 1/0067* (2019.02); *F28F 1/32* (2013.01); *F25B 39/00* (2013.01); *F24F 13/30* (2013.01)

(73) Assignee: **DAIKIN INDUSTRIES, LTD.**, Osaka (JP)

(57) **ABSTRACT**

(21) Appl. No.: **16/091,440**

An indoor heat exchanger reduces an increase in air flow resistance and enables easy discharge of condensed water. A first heat transfer fin and a second heat transfer fin each include a windward main portion formed with a notch that receives a first flat tube and a second flat tube, respectively, and a leeward communication portion located on a side opposite to an open end of the notch. In the first heat exchange portion and the second heat exchange portion, the plurality of first flat tubes and the plurality of second flat tubes in the rows are arranged in a width direction, and the first and second heat exchange portions each have a bent shape with an inner peripheral side on a windward side and an outer peripheral side on a leeward side.

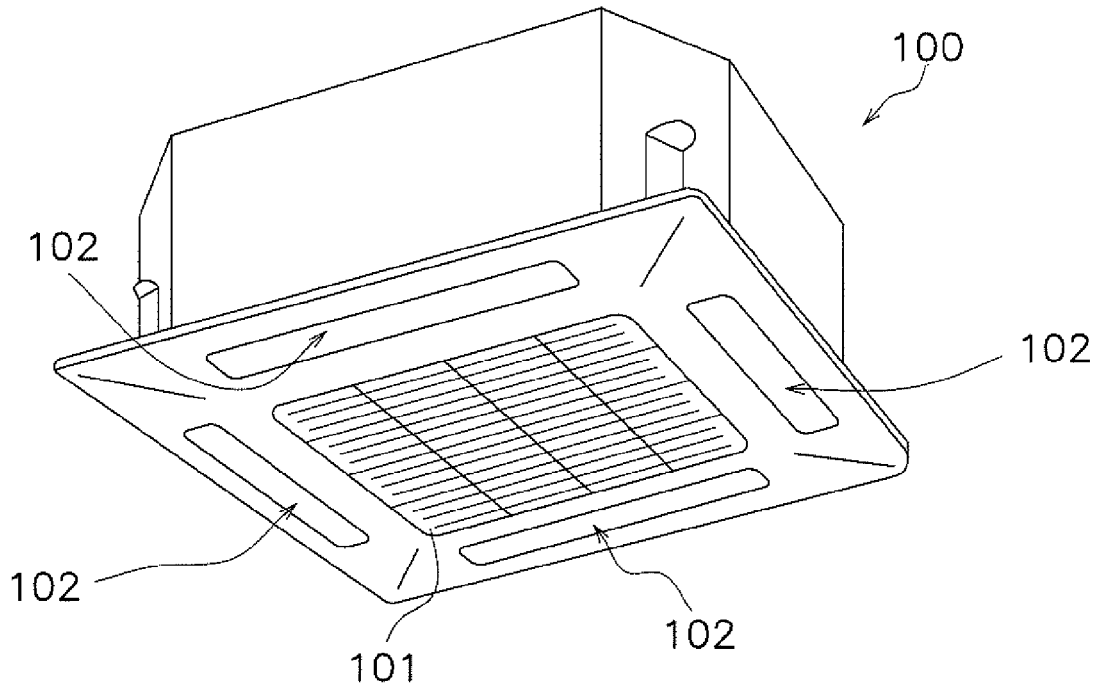
(22) PCT Filed: **Apr. 3, 2017**

(86) PCT No.: **PCT/JP2017/013908**

§ 371 (c)(1),  
(2) Date: **Oct. 4, 2018**

(30) **Foreign Application Priority Data**

Apr. 7, 2016 (JP) ..... 2016-077262



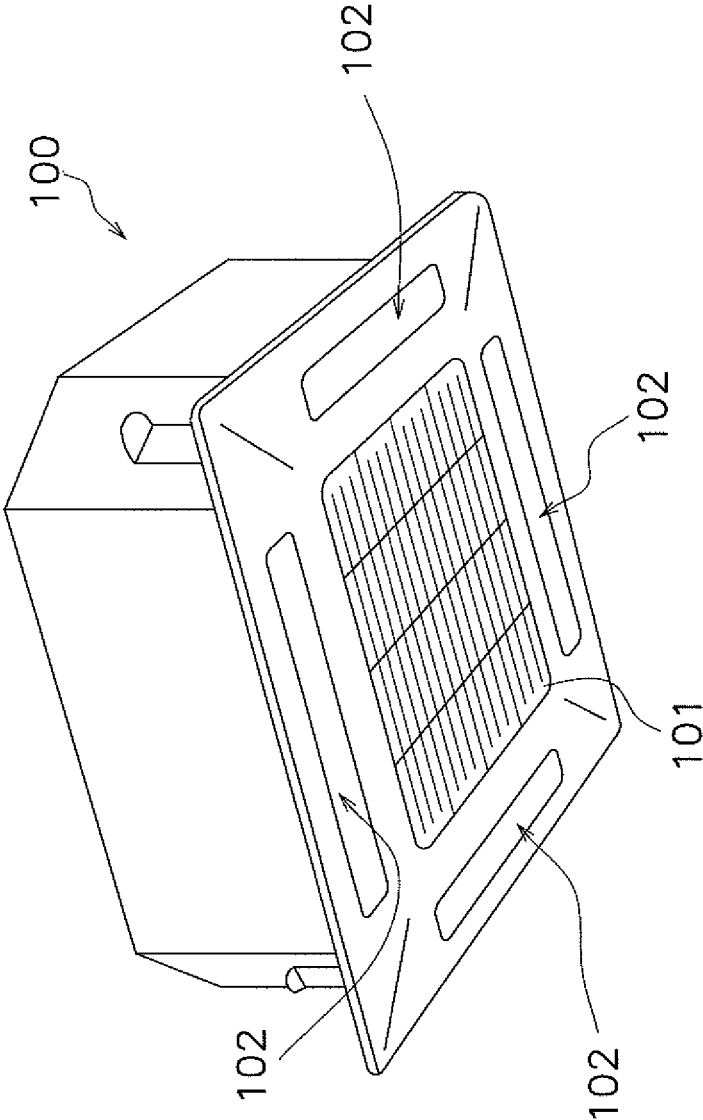


FIG. 1

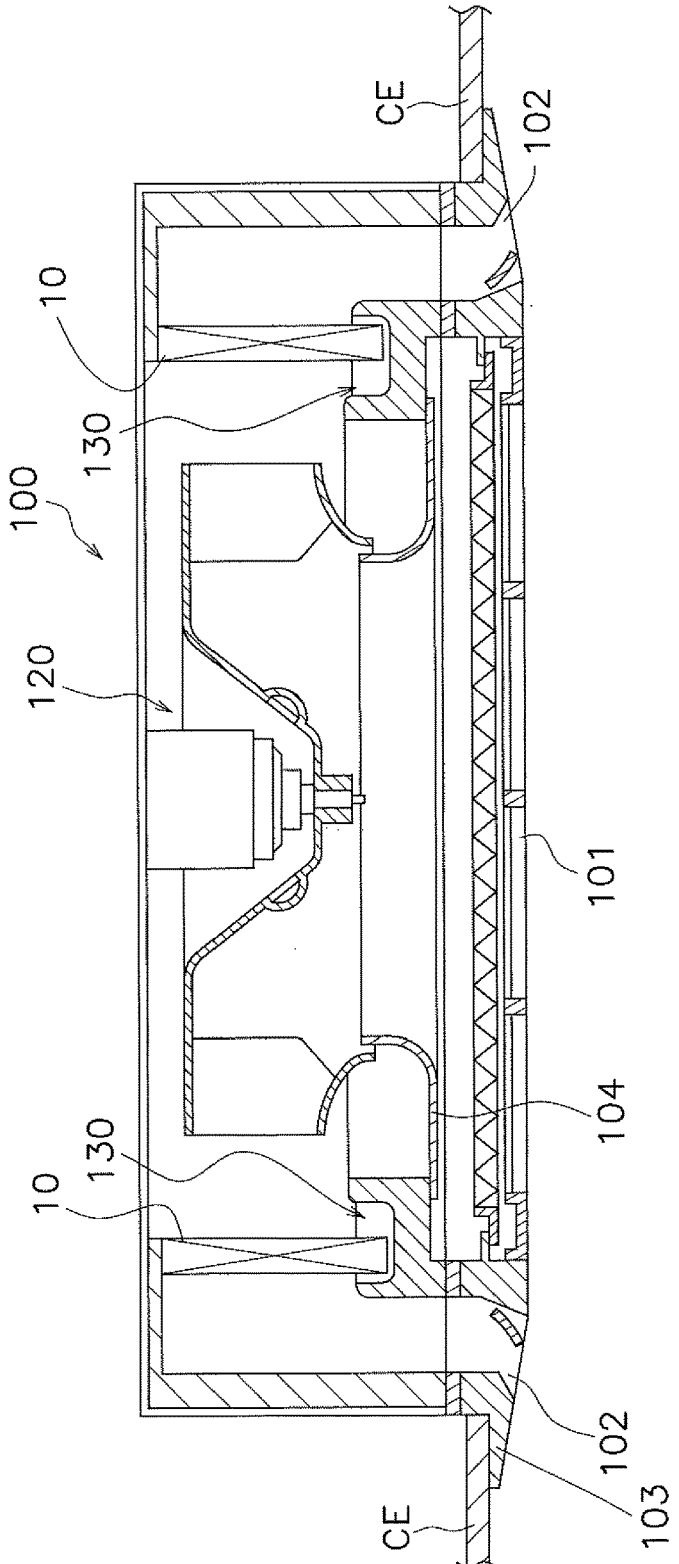


FIG. 2

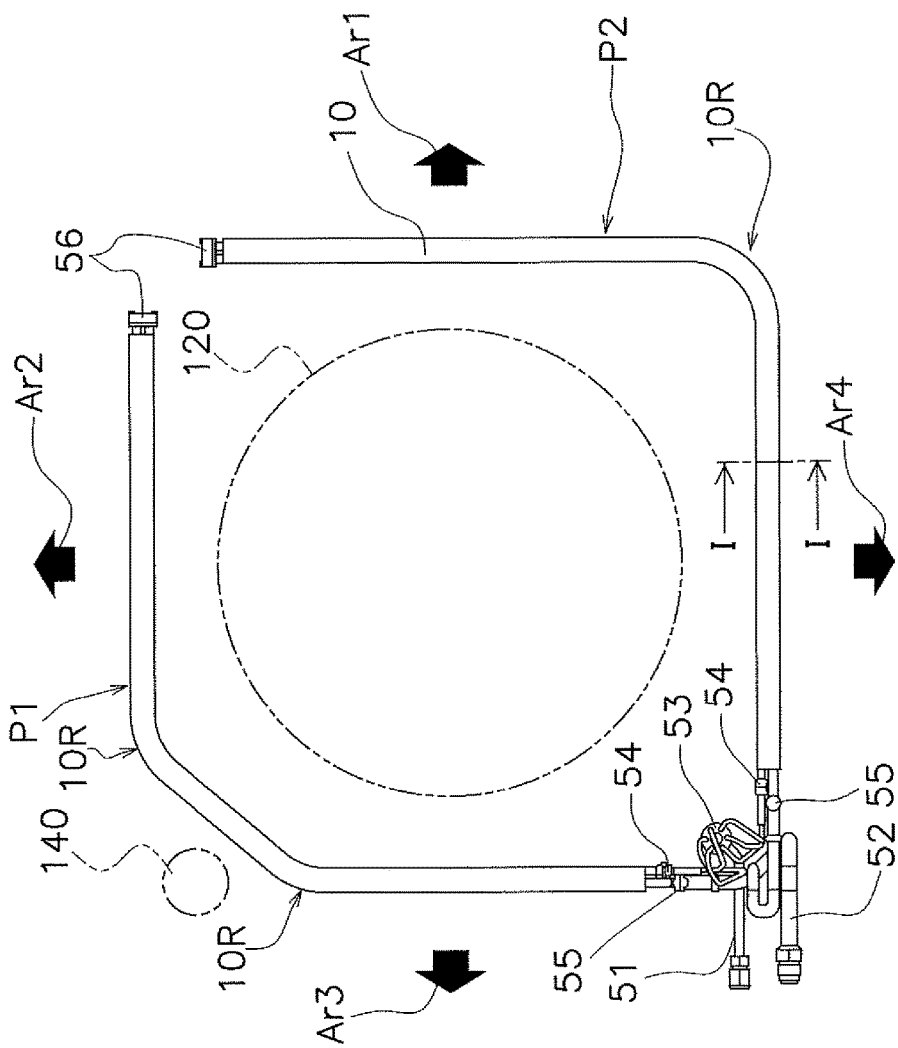


FIG. 3

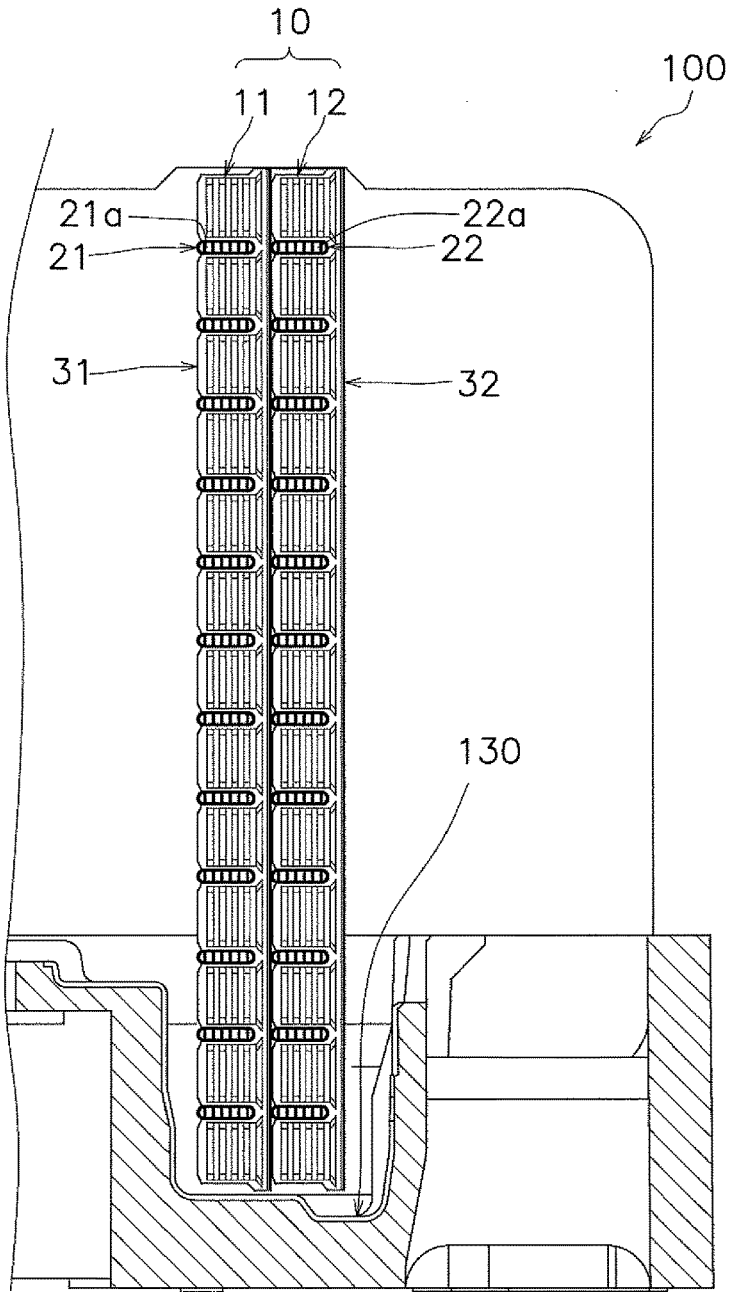


FIG. 4

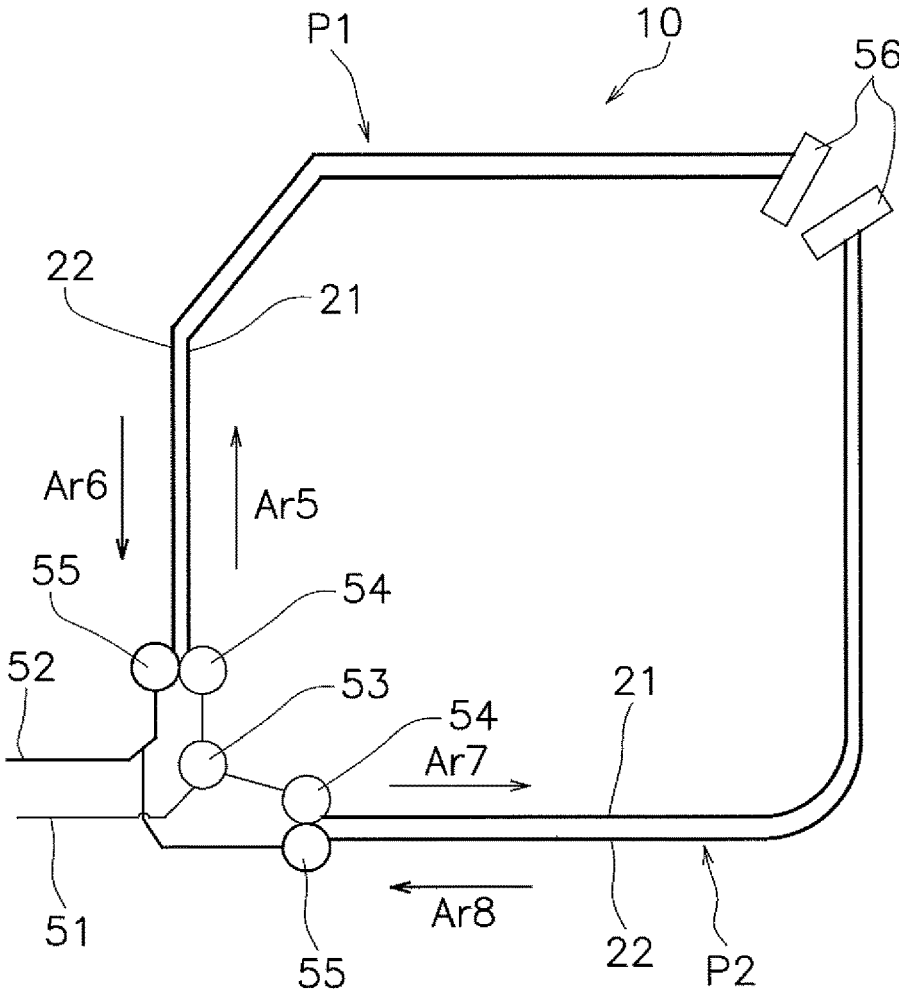


FIG. 5

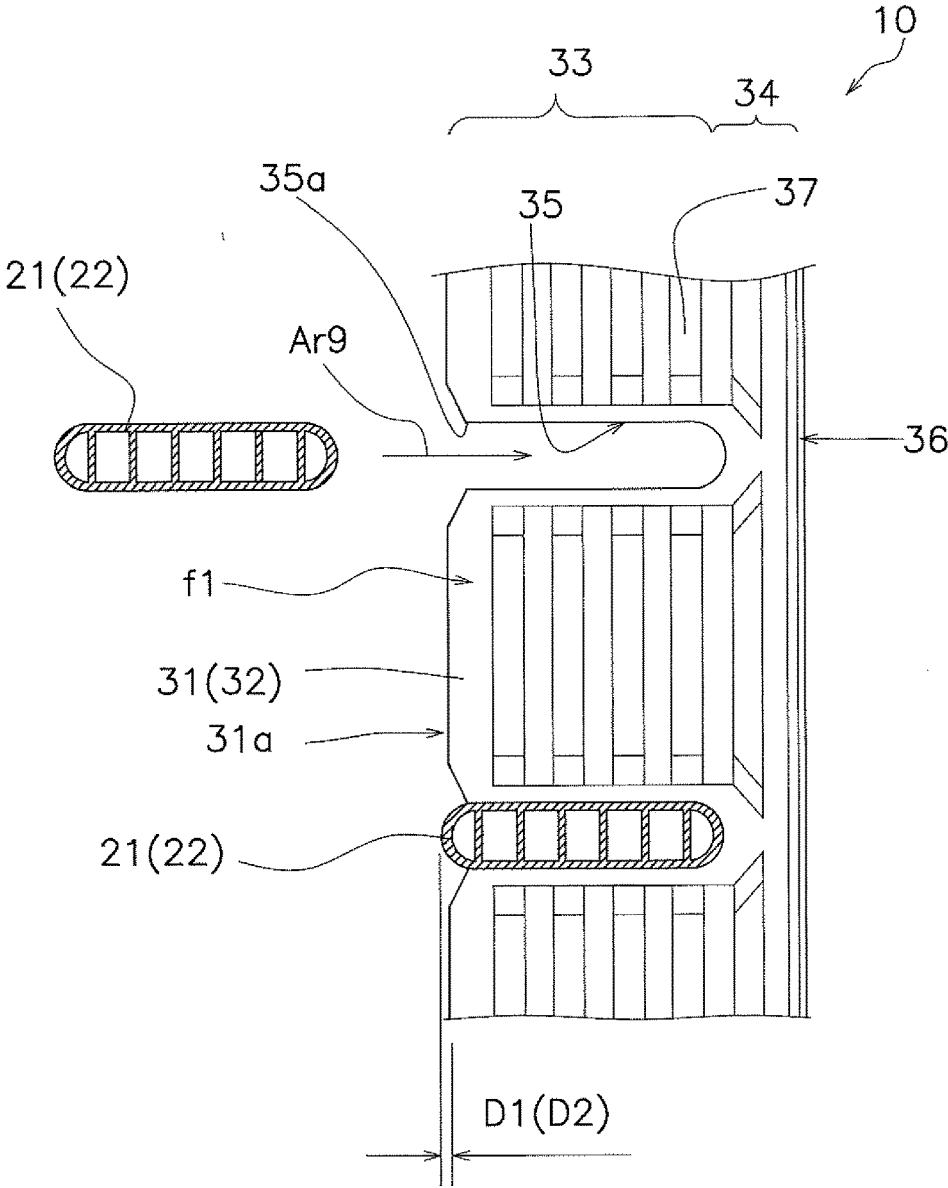


FIG. 6

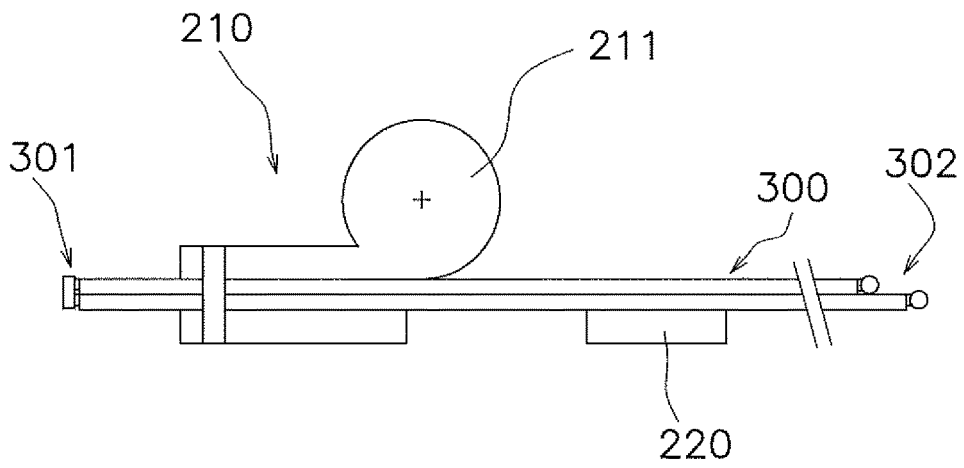


FIG. 7

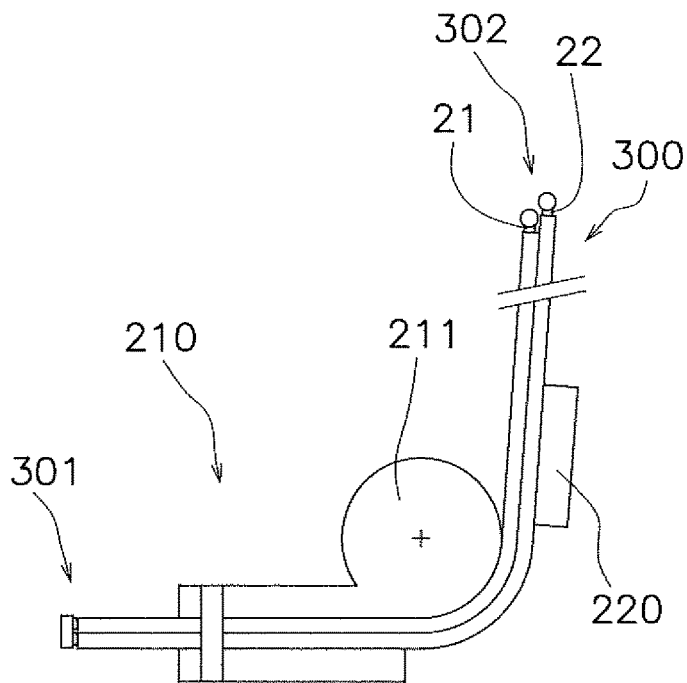


FIG. 8

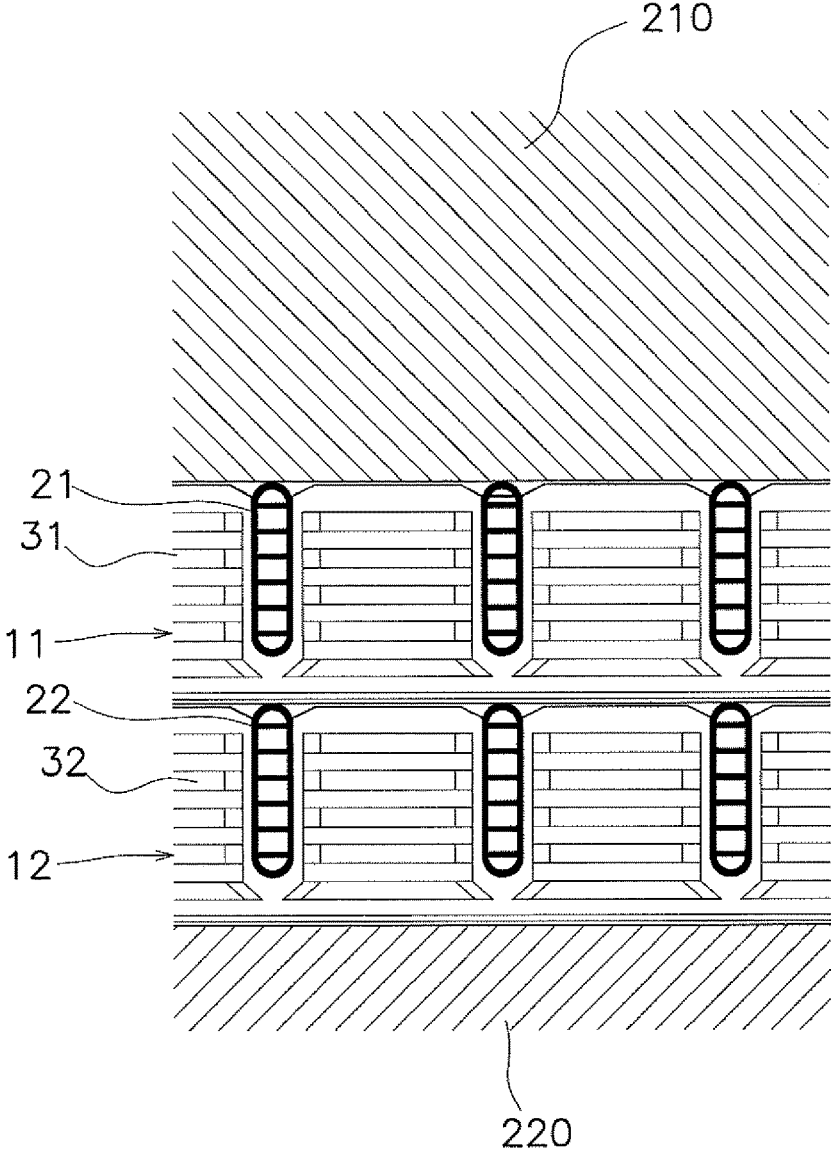


FIG. 9

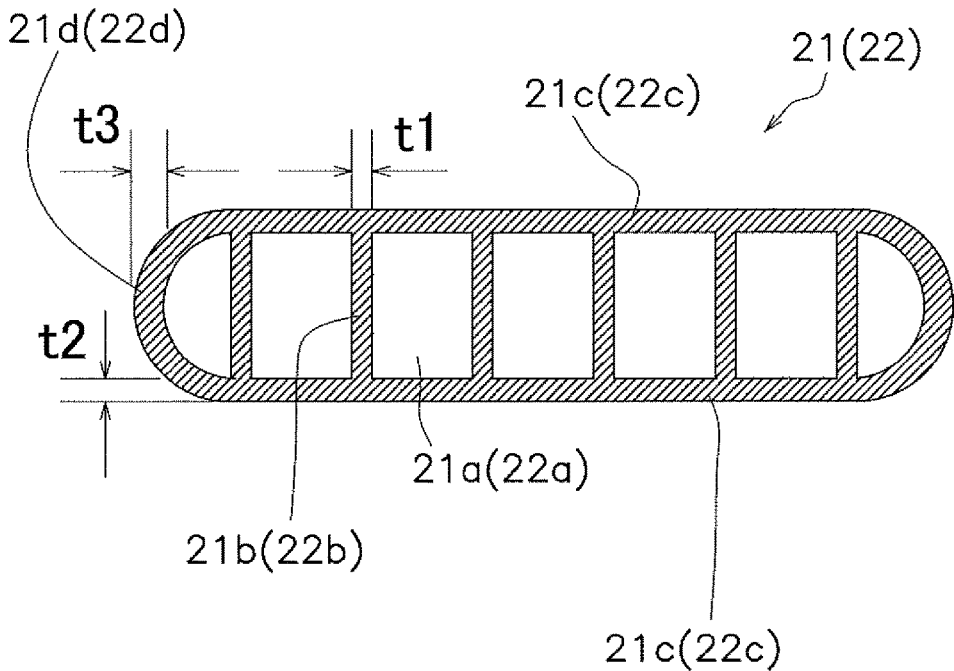


FIG. 10

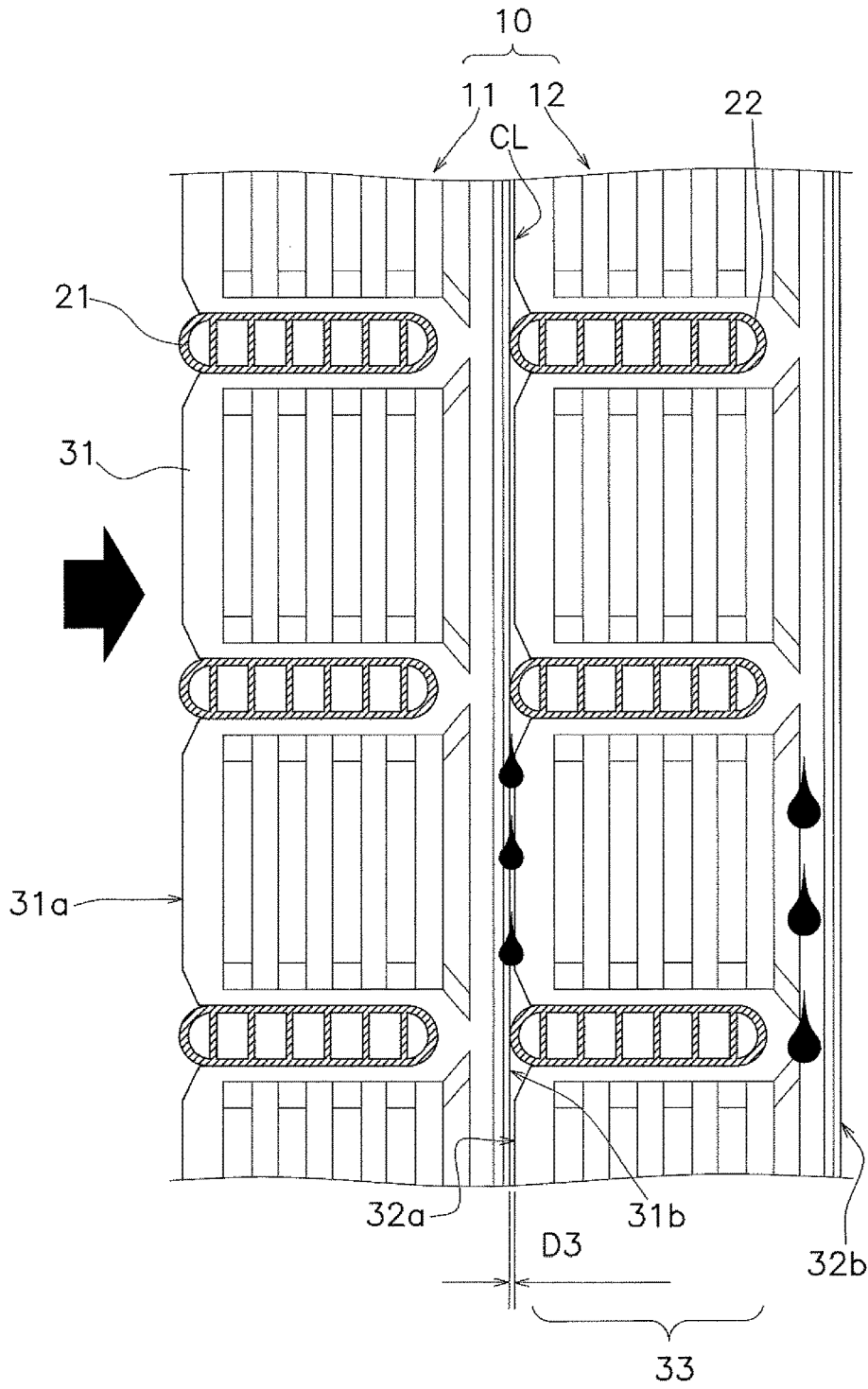


FIG. 11

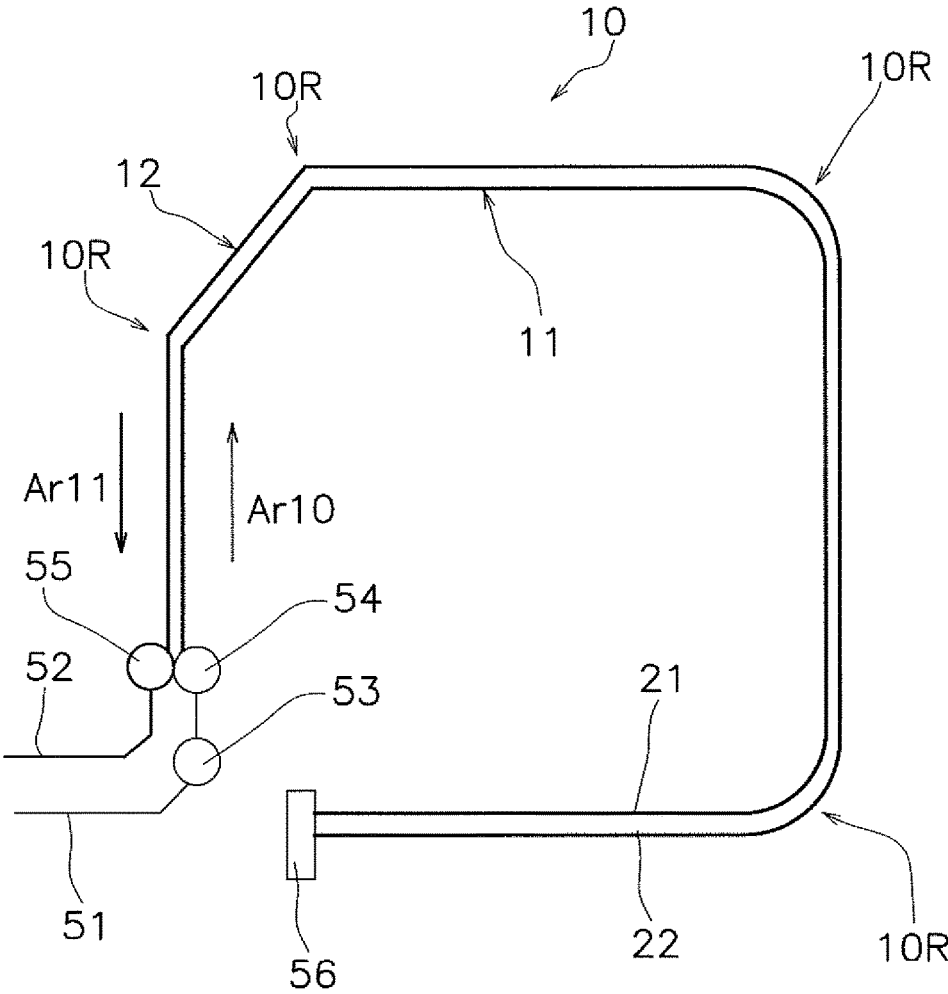


FIG. 12

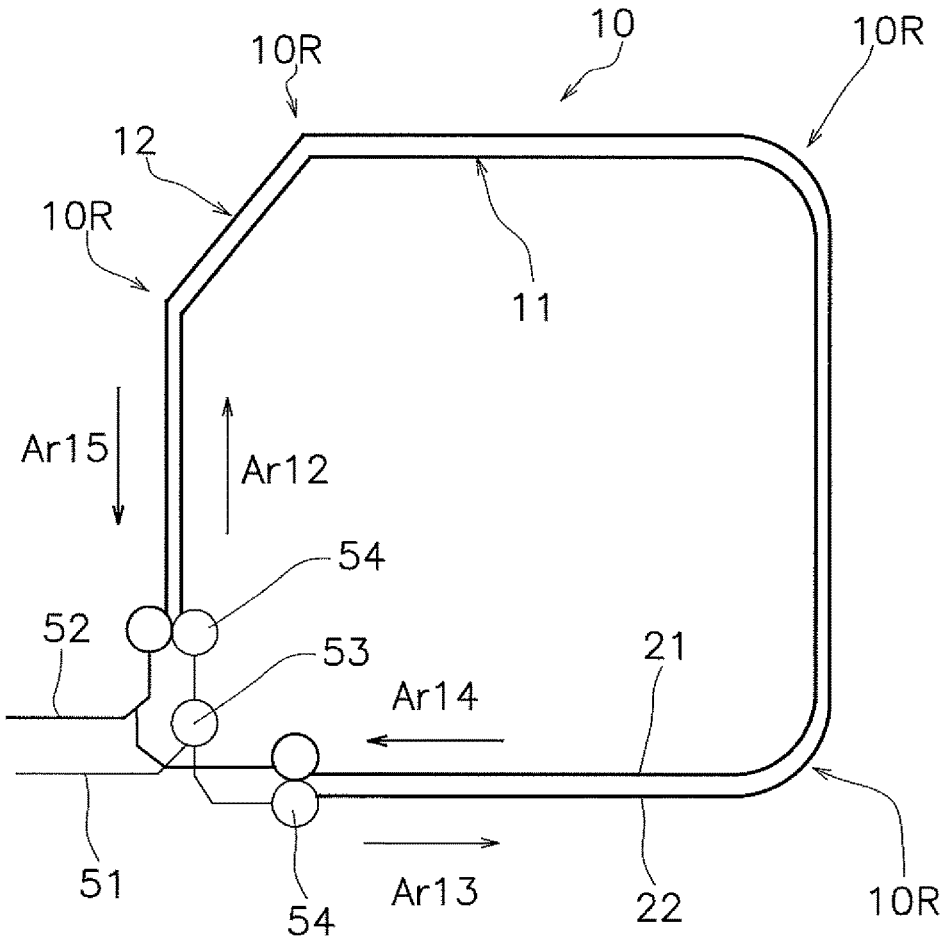


FIG. 13

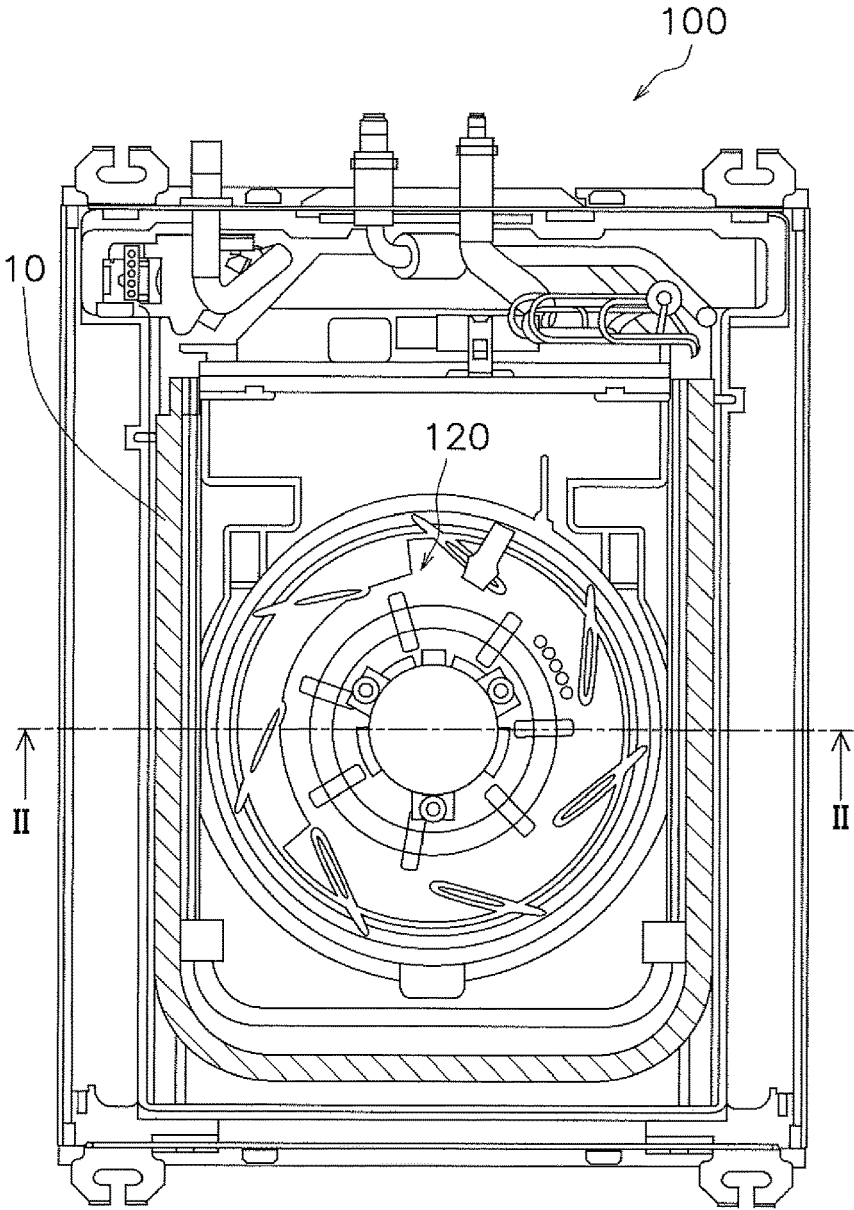


FIG. 14

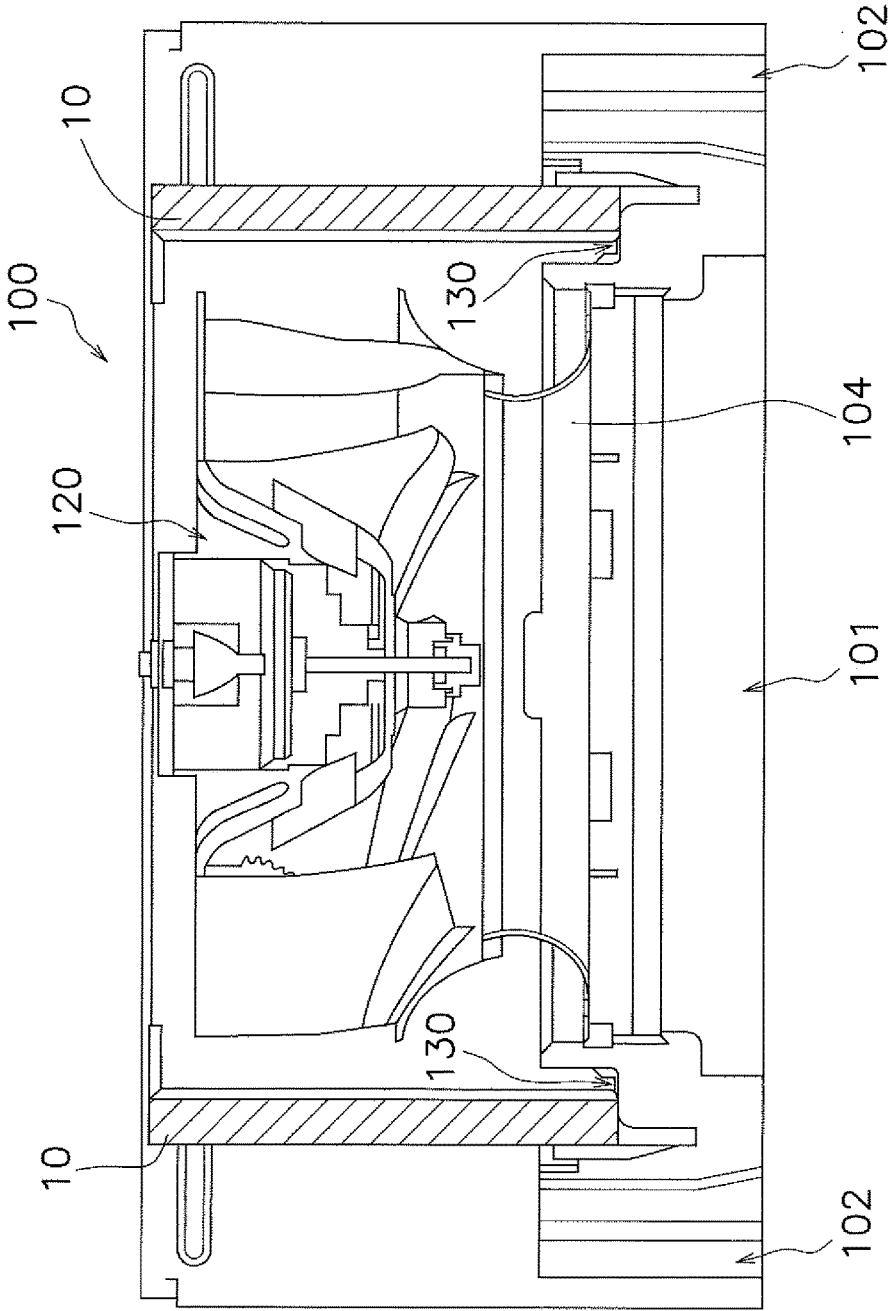


FIG. 15

## INDOOR HEAT EXCHANGER

### BACKGROUND

[0001] The present invention relates to an indoor heat exchanger, more particularly, to an indoor heat exchanger used for exchanging heat between indoor air and refrigerant.

[0002] As a heat exchanger used for exchanging heat with indoor air in an indoor unit of an air conditioner, there is known a cross-finned heat exchanger such as that described in Patent Literature 1 (WO 2008/041656). In this type of cross-finned heat exchanger, a dead water region is likely to occur on a leeward side of cylindrical heat transfer tubes that penetrate fins. Because there is less contribution to heat exchange at this fin portion corresponding to the dead water region, heat transfer tubes must be provided in at least three rows in order to secure necessary heat exchange capacity and increase performance. However, providing three or more rows causes the heat exchanger to increase in size. In addition, because the air that flows between these heat transfer tubes travels through a path made narrow by the heat transfer tubes, the heat transfer tubes cause air flow resistance to increase.

[0003] As an improvement over this type of cross-finned heat exchanger, there is, for example, described in Patent Literature 2 (WO 2013/160957) a heat exchanger that uses flat tubes in place of the tubular heat transfer tubes. In such a heat exchanger that uses flat pipes, air flow resistance is reduced.

[0004] However, a heat exchanger must increase in size through, for example, providing more rows of tubes in order for the heat exchanger to achieve better performance. Providing a plurality of rows of flat tubes in the heat exchanger described above may cause the fins to deform when the flat tubes are bent, and this increases air flow resistance. In addition, flat tubes are longer than cylindrical tubes in the direction in which indoor air flows, and hence it becomes difficult to discharge condensed water that is generated in the indoor heat exchanger.

### SUMMARY

[0005] One or more embodiments of the present invention provide an indoor heat exchanger that reduces an increase in air flow resistance and enables easy discharge of condensed water.

[0006] An indoor heat exchanger according to one or more embodiments of the present invention includes a first heat exchange portion including a plurality of first flat tubes arranged in rows and a plurality of first heat transfer fins that intersect with the plurality of first flat tubes, the first heat transfer portion being configured to exchange heat between indoor air that flows in a width direction of the plurality of first flat tubes and refrigerant that flows through the plurality of first flat tubes; and a second heat exchange portion including a plurality of second flat tubes arranged in rows and a plurality of second heat transfer fins that intersect with the plurality of second flat tubes, the second heat transfer portion being configured to exchange heat between indoor air that flows in a width direction of the plurality of second flat tubes and refrigerant that flows through the plurality of second flat tubes, the plurality of first heat transfer fins and the plurality of second heat transfer fins each including a windward main portion formed with a notch that receives the first flat tube and the second flat tube respectively, and

a leeward communication portion located on a side opposite to an open end of the notch, and, in the first heat exchange portion and the second heat exchange portion, the plurality of first flat tubes and the plurality of second flat tubes in the rows being arranged in a width direction, and the first heat exchange portion and the second heat exchange portion each having a bent shape with an inner peripheral side on a windward side and an outer peripheral side on a leeward side.

[0007] According to the indoor heat exchanger of one or more embodiments of the present invention, because the notches of the first heat transfer fins and the second heat transfer fins are disposed inward and the first flat tubes and the second flat tubes each have an inwardly bent shape, deformation of the main portions of the first heat transfer fins and the main portions of the second heat transfer fins is reduced. Because the communication portions of the first heat transfer fins and the second heat transfer fins are disposed on a leeward side, condensed water guided by the indoor air traveling in the width direction of the first flat tubes and the second flat tubes can be sent in an up-down direction via the communication portion.

[0008] An indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which the first heat exchange portion and the second heat exchange portion each have the bent shape so as to surround an indoor fan with the inner peripheral sides, and are disposed such that indoor air discharged from the indoor fan disposed on the inner peripheral side can be guided along the width direction of the plurality of first flat tubes and the plurality of second flat tubes to pass between the plurality of first heat transfer fins and between the plurality of second heat transfer fins and reach the outer peripheral side on which the communication portion of the second heat transfer fins is located.

[0009] According to the indoor heat exchanger of one or more embodiments of the present invention, the indoor air discharged from the indoor fan surrounded by the inner peripheral sides of the first heat exchange portion and the second heat exchange portion can be discharged in the width direction of the first flat tubes and the second flat tubes, which has low air flow resistance. In addition, condensed water can be sent across the entire indoor heat exchanger from the inner peripheral sides to the outer peripheral sides of the first heat exchange portion and the second heat exchange portion.

[0010] The indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which the plurality of first flat tubes are disposed so as to be positioned windward of windward edges of the plurality of first heat transfer fins by 0 mm or more.

[0011] According to the indoor heat exchanger according to one or more embodiments of the present invention, because the plurality of first flat tubes are positioned windward of the windward edges of the plurality of first heat transfer fins by 0 mm or more, the first flat tubes protrude leeward of the windward edges of the first heat transfer fins by 0 mm or more, and hence first abut against a member or other component when, for example, the first heat exchange portion and the second heat exchange portion are bent. This reduces the occurrence of buckling of the windward edges of the plurality of first heat transfer fins, for example.

**[0012]** The indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which, in the plurality of first flat tubes arranged in rows and the plurality of second flat tubes arranged in rows, a thickness of tube walls at a windward portion located windward is larger than a thickness of tube walls at a side portion located in a row direction of the plurality of first flat tubes and the plurality of second flat tubes.

**[0013]** According to the indoor heat exchanger according to one or more embodiments of the present invention, because the tube walls at the windward portion located windward are thick, a reduction in compressive strength can be suppressed even if the first flat tubes and the second flat tubes are damaged by a jig when the first flat tubes and the second flat tubes are bent using the jig.

**[0014]** The indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which the first heat exchange portion is configured so as not to make contact with the second heat exchange portion due to a clearance that is located between leeward edges of the plurality of first heat transfer fins of the first heat exchange portion and the windward main portions of the plurality of second heat transfer fins of the second heat exchange portion.

**[0015]** According to the indoor heat exchanger according to one or more embodiments of the present invention, because the first heat exchange portion and the second heat exchange portion, which have different temperatures, are configured such as not to make contact with each other, heat transfer can be reduced from one of the first heat exchange portion and the second heat exchange portion to the other.

**[0016]** The indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which the plurality of second flat tubes are arranged so as to be positioned windward of windward edges of the plurality of second heat transfer fins by 0 mm or more.

**[0017]** According to the indoor heat exchanger of one or more embodiments of the present invention, because the plurality of second flat tubes are positioned windward of the windward edges of the plurality of second heat transfer fins by 0 mm or more, the clearance between the first heat exchange portion and the second heat exchange portion can be easily maintained.

**[0018]** The indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which the plurality of second flat tubes are disposed so as to be positioned windward of the windward edges of the plurality of second heat transfer fins by 2 mm or less.

**[0019]** According to the indoor heat exchanger of one or more embodiments of the present invention, because the plurality of second flat tubes are positioned windward of the windward edges of the plurality of second heat transfer fins by 2 mm or less, condensed water is more likely to be drawn by surface tension into a clearance of 2 mm or less formed between the first heat exchange portion and the second heat exchange portion, to flow and drop down.

**[0020]** The indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which the leeward edges of the plurality of first heat transfer fins in the first heat exchange portion extend in a straight line along the clearance in a vertical direction.

**[0021]** According to the indoor heat exchanger of one or more embodiments of the present invention, because the leeward edges of the plurality of first heat transfer fins extend in a straight line along the clearance in a vertical direction, condensed water is more likely to be guided along the leeward edges.

**[0022]** The indoor heat exchanger according to one or more embodiments of the present invention is an indoor heat exchanger in which the first heat exchange portion and the second heat exchange portion each have an L-shape, a C-shape, or a rectangular shape when viewed from the row direction of the plurality of first flat tubes and the plurality of second flat tubes.

**[0023]** According to the indoor heat exchanger of one or more embodiments of the present invention, because the first heat exchange portion and the second heat exchange portion each have an L-shape, a C-shape, or a rectangular shape, windward space can be surrounded by either one or two pairs of the first heat exchange portion and the second heat exchange portion.

**[0024]** In the indoor heat exchanger according to one or more embodiments of the present invention, an increase in air flow resistance is reduced and the leeward communication portion improves drainability of water when condensation occurs.

**[0025]** In the indoor heat exchanger according to one or more embodiments of the present invention, drainability of condensed water can be improved by efficiently utilizing air flow discharged around by the indoor fan.

**[0026]** In the indoor heat exchanger according to one or more embodiments of the present invention, an increase in air flow resistance caused by deformation of the windward edges of the plurality of first heat transfer fins can be reduced.

**[0027]** In the indoor heat exchanger according to one or more embodiments of the present invention, decrease of compressive strength of the first flat tubes and the second flat tubes at inwardly bent portions is suppressed due to damage from a jig.

**[0028]** In the indoor heat exchanger according to one or more embodiments of the present invention, heat exchange capacity is less likely to decrease due to thermal conduction between the first heat exchange portion and the second heat exchange portion.

**[0029]** In the indoor heat exchanger according to one or more embodiments of the present invention, it becomes easy to prevent the degradation of the performance of the first heat exchange portion and the second heat exchange portion due to thermal conduction between the first heat exchange portion and the second heat exchange portion.

**[0030]** In the indoor heat exchanger according to one or more embodiments of the present invention, drainability of condensed water is improved.

**[0031]** In the indoor heat exchanger according to one or more embodiments of the present invention, problems caused by condensed water, such as condensed water splashing outward, can be reduced.

**[0032]** In the indoor heat exchanger according to one or more embodiments of the present invention, the configuration of the device to which the indoor heat exchanger is applied can be simplified.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. 1 is a perspective view for illustrating the external appearance of an indoor unit according to one or more embodiments.

[0034] FIG. 2 is a cross-sectional view of the indoor unit in FIG. 1.

[0035] FIG. 3 is a schematic plan view of an indoor heat exchanger according to one or more embodiments.

[0036] FIG. 4 is a cross-sectional view for illustrating the structure of the indoor heat exchanger and the vicinity thereof taken along the line I-I in FIG. 3.

[0037] FIG. 5 is a schematic view from above illustrating the indoor heat exchanger functioning as an evaporator according to one or more embodiments.

[0038] FIG. 6 is a partially enlarged cross-sectional view of an exemplary relationship between first and second flat tubes and notches according to one or more embodiments.

[0039] FIG. 7 is a schematic view for illustrating an exemplary process of manufacturing the indoor heat exchanger according to one or more embodiments.

[0040] FIG. 8 is a schematic view for illustrating another exemplary process of manufacturing the indoor heat exchanger according to one or more embodiments.

[0041] FIG. 9 is a cross-sectional view for schematically illustrating the relationship between indoor heat exchanger parts and jigs according to one or more embodiments.

[0042] FIG. 10 is a cross-sectional view for explaining wall thicknesses of the first flat tube and the second flat tube according to one or more embodiments.

[0043] FIG. 11 is a partially enlarged cross-sectional view of a first heat exchange portion and a second heat exchange portion according to one or more embodiments.

[0044] FIG. 12 is a schematic view from above for illustrating an indoor heat exchanger according to a modification example 1A.

[0045] FIG. 13 is a schematic view from above for illustrating another indoor heat exchanger according to the modification example 1A.

[0046] FIG. 14 is a diagram for illustrating an internal structure of an indoor unit according to a modification example 1B when viewed from below.

[0047] FIG. 15 is a cross-sectional view of the indoor unit taken along the line II-II in FIG. 14.

## DETAILED DESCRIPTION

## (1) Outline of Configuration of Air Conditioner

[0048] FIG. 1 illustrates the external appearance of an indoor unit to which an indoor heat exchanger according to one or more embodiments of the present invention is applied. FIG. 2 illustrates the internal structure of the indoor unit in FIG. 1. An indoor unit 100 is a ceiling-mounted indoor unit that is used to heat and cool a room inside, for example, a building such as a high-rise building through performing a vapor-compression refrigeration cycle. As illustrated in FIG. 2, the indoor unit 100 is installed into a ceiling CE of a room inside a building such as a high-rise building. The indoor unit 100 includes an indoor fan 120 and an indoor heat exchanger 10. In the indoor unit 100, the indoor fan 120 operates to suck in indoor air through an intake port 101 provided on a lower center part of the indoor unit 100 and discharge this air from four discharge ports 102 provided in the indoor unit 100. The four discharge ports 102

of the indoor unit 100 extend parallel to the four sides of a decorative plate 103 having a substantially square-shaped lower surface, respectively.

[0049] Inside the indoor unit 100, a bell mouth 104 is mounted directly above the intake port 101. The indoor air sucked in through the intake port 101 is guided to the indoor fan 120 using this bell mouth 104. The indoor air is discharged from the indoor fan 120 in a direction substantially parallel to the ceiling CE. Then, the indoor air passes through the indoor heat exchanger 10 that surrounds the indoor fan 120 in a horizontal direction to be discharged from the indoor fan 120 and then discharged from the four discharge ports 102 located further outside than the indoor heat exchanger 10.

[0050] Condensation may occur in the indoor heat exchanger 10 when, for example, the temperature of the indoor heat exchanger 10 becomes lower than the temperature of the room during a cooling operation. In the indoor unit 100, a drain pan 130 is provided beneath the indoor heat exchanger 10 to receive condensed water generated by condensation in the indoor heat exchanger 10. The condensed water generated in the indoor heat exchanger 10 is pulled by gravity so as to flow down through the indoor heat exchanger 10 and drop from the indoor heat exchanger 10 into the drain pan 130.

## (2) Indoor Heat Exchanger 10

[0051] FIG. 3 illustrates a state in which the indoor heat exchanger 10 is viewed from above. As illustrated in FIG. 3, the indoor heat exchanger 10 surrounds the indoor fan 120. The arrows Ar1, Ar2, Ar3 and Ar4 in FIG. 3 indicate the direction of air flow. The four discharge ports 102 are formed in the directions in which these arrows Ar1 to Ar4 face, respectively. When viewed from above, the indoor heat exchanger 10 has a shape similar to the four sides of a square with a diagonal center at the center of the indoor fan 120. However, a portion corresponding to where a drain pump 140 is located is recessed toward the inner periphery of the indoor heat exchanger 10.

[0052] The indoor heat exchanger 10 is, for example, a device that partly forms a refrigerant circuit (not illustrated) which performs a refrigerant cycle and exchanges heat between refrigerant that flows through the refrigerant circuit and indoor air. A liquid pipe 51 and a gas pipe 52 that extend outward from the indoor heat exchanger 10 are connected to the refrigerant circuit. Liquid refrigerant and gas refrigerant primarily flow through the liquid pipe 51 and the gas pipe 52 that extend outward from the indoor heat exchanger 10, respectively.

## (2-1) First Heat Exchange Portion 11 and Second Heat Exchange Portion 12

[0053] FIG. 4 illustrates in an enlarged manner a partial cross-sectional structure of the indoor unit 100 at a place corresponding to a portion taken along the line I-I in FIG. 3. As illustrated in FIG. 4, the indoor heat exchanger 10 includes a first heat exchange portion 11 on an inner peripheral side and a second heat exchange portion 12 on an outer peripheral side. In other words, the first heat exchange portion 11 is disposed on a windward side and the second heat exchange portion 12 is disposed on a leeward side. The first heat exchange portion 11 includes a plurality of first flat tubes 21 arranged in rows and a plurality of first heat transfer

fins 31 that intersect with the plurality of first flat tubes 21. The first flat tubes 21 and the first heat transfer fins 31 are substantially orthogonal to one another. Only one first heat transfer fin 31 is illustrated in FIG. 4. Other first heat transfer fins 31 that are adjacent to the first heat transfer fin 31 illustrated in FIG. 4 are arranged parallel to the first heat transfer fin 31 in FIG. 4. However, at bent portions 10R of the indoor heat exchanger 10, these adjacent first heat transfer fins 31 are not parallel to one another, and an interval between outer peripheral sides of the adjacent first heat transfer fins 31 is larger than an interval between inner peripheral sides of the adjacent first heat transfer fins 31. A plurality of flow paths 21a are formed as one windward-to-leeward row inside one first flat tube 21, and refrigerant flows through each of these flow paths 21a.

[0054] The second heat exchange portion 12 includes a plurality of second flat tubes 22 arranged in rows and a plurality of second heat transfer fins 32 that intersect with the plurality of second flat tubes 22. The second flat tubes 22 and the second heat transfer fins 32 are substantially orthogonal to one another. Only one second heat transfer fin 32 is illustrated in FIG. 4. Other second heat transfer fins 32 that are adjacent to the second heat transfer fin 32 illustrated in FIG. 4 are arranged parallel to the second heat transfer fin 32 in FIG. 4. However, at the bent portions 10R of the indoor heat exchanger 10, these adjacent second heat transfer fins 32 are not parallel to one another, and an interval between outer peripheral sides of the adjacent second heat transfer fins 32 is larger than an interval between inner peripheral sides of the adjacent second heat transfer fins 32. A plurality of flow paths 22a are formed as one windward-to-leeward row inside one second flat tube 22, and the refrigerant flows through each of these flow paths 22a.

[0055] FIG. 5 schematically illustrates an exemplary direction of flow of the refrigerant that flows through the indoor heat exchanger 10. The indoor heat exchanger 10 includes a flow divider 53 connected to the liquid pipe 51, a liquid header 54 connected to the flow divider 53, a gas header 55 connected to the gas pipe 52, and a return header 56. The indoor heat exchanger 10 illustrated in FIGS. 3 and 5 includes two pairs of the first heat exchange portion 11 and the second heat exchange portion 12. The pair of heat exchange portions disposed near the drain pump 140 is referred to as a “first pair P1 of the first heat exchange portion 11 and the second heat exchange portion 12” or the “first pair P1” and the other pair of heat exchange portions is referred to as a “second pair P2 of the first heat exchange portion 11 and the second heat exchange portion 12” or the “second pair P2.”

[0056] In FIG. 5, the flow of refrigerant when the indoor heat exchanger 10 functions as an evaporator is indicated by the arrows Ar5 to Ar8. In the first pair P1, liquid refrigerant flows in the direction of the arrow Ar5 after traveling from the liquid pipe 51 to the first flat tube 21 via the flow divider 53 and the liquid header 54. Then, the refrigerant that flows through the first flat tube 21 of the first pair P1 is returned by the return header 56 and flows from the first flat tube 21 into the second flat tube 22. The refrigerant then travels in the direction of the arrow Ar6 to the gas pipe 52 via the gas header 55. In the second pair P2, liquid refrigerant flows in the direction of the arrow Ar7 after traveling from the liquid pipe 51 to the first flat tube 21 via the flow divider 53 and the liquid header 54. Then, the refrigerant that flows through the first flat tube 21 of the second pair P2 is returned by the

return header 56 and flows from the first flat tube 21 into the second flat tube 22. The refrigerant then flows in the direction of the arrow Ar8 to the gas pipe 52 via the gas header 55. In the indoor heat exchanger 10 illustrated in FIG. 5, liquid refrigerant changes to gas refrigerant by evaporating while flowing through the first flat tube 21 and the second flat tube 22. The indoor heat exchanger 10 illustrated in FIG. 5 is formed of a combination of the L-shaped first pair P1 of the first heat exchange portion 11 and the second heat exchange portion 12 and the L-shaped second pair P2 of the first heat exchange portion 11 and the second heat exchange portion 12. Note that the first pair P1 has two bent portions 10R and the second pair P2 only has one bent portion 10R. The shapes of all of these bent portions 10R are classified as an L-shape.

[0057] As described above, the first pair P1 and the second pair P2 each have an L-shape such that inner peripheral sides of the first heat exchange portion 11 and the second heat exchange portion 12 surround the indoor fan 120. Both the first pair P1 and the second pair P2 are disposed such that indoor air discharged from the indoor fan 120, which is disposed on the inner peripheral side, can be guided along a width direction of the first flat tubes 21 and the second flat tubes 22 to pass between a plurality of the first heat transfer fins 31 and a plurality of the second heat transfer fins 32 and reach an outer peripheral side on which a communication portion 34 (see FIG. 6) of the second heat transfer fin 32 is located.

#### (2-2) Detailed Configuration of First Heat Transfer Fin 31

[0058] FIG. 6 illustrates in a further enlarged manner a part of the first heat transfer fin 31 and the first flat tube 21 that is fitted into the first heat transfer fin 31 in the first heat exchange portion 11 illustrated in FIG. 4. The second heat exchange portion 12 has the same structure as that of the first heat exchange portion 11 illustrated in the enlarged manner in FIG. 6. Therefore, herein, the first heat exchange portion 11 is described, but a description of components of the second heat exchange portion 12 that are the same as those of the first heat exchange portion 11 is omitted.

[0059] The first heat transfer fin 31 includes a windward main portion 33 formed with a notch 35 that receives the first flat tube 21, and the leeward communication portion 34 located on a side opposite to an open end 35a of the notch 35. The first flat tube 21 is inserted in the direction of the arrow Ar9 in FIG. 6. Similarly, the second heat transfer fin 32 includes the windward main portion 33 formed with the notch 35 that receives the second flat tube 22, and the leeward communication portion 34 located on a side opposite to the open end 35a of the notch 35. A water guide rib 36 that facilitates condensed water discharge is formed in the communication portion 34. This guide rib 36 is a portion that extends from a pressed groove. A protruded structure extends in the up-down direction along the guide rib 36 when the guide rib 36 is viewed from one main surface f1 of the first heat transfer fin 31 (or the second heat transfer fin 32), while a recessed structure extends in the up-down direction along the guide rib 36 when the guide rib 36 is viewed from the other main surface on a side opposite to the one main surface f1. A plurality of raised-lance portions 37 are formed on the one main surface f1 side of the first heat transfer fin 31 (or the second heat transfer fin 32). Each of

the raised-lance portions 37 protrudes in a bridge shape. As seen in FIG. 6, the raised-lance portions 37 are not formed around the notches 35.

### (3) Bending Parts of the Indoor Heat Exchanger 10

#### (3-1) Summary of Bending

[0060] A method of forming the bent portions 10R of the indoor heat exchanger 10 illustrated in FIG. 3 is described with reference to FIGS. 7 to 9. Two jigs are used to form the bent portions 10R. Examples of such jigs are illustrated in FIGS. 7 and 8. In other words, the bent portions 10R of the indoor heat exchanger 10 is formed using a rolling jig 210 and a pressing jig 220. As illustrated in FIG. 7, the rolling jig 210 is brought into contact with a position at which the bent portion 10R is to be formed, and fixed to a part 300 of the indoor heat exchanger 10 on a side of an end 301 of the part 300. Then, the pressing jig 220 is pressed against the part 300 from a side opposite to a rolling part 211 of the rolling jig 210. The pressing jig 220 is pressed against the part 300 at a position that is closer to the other end 302 of the part 300 than the position of the rolling part 211.

[0061] Next, as illustrated in FIG. 8, the pressing jig 220 applies force to the part 300 of the indoor heat exchanger 10 to bend the first flat tube 21 and the second flat tube 22 of the part 300. The curvature radius of the second flat tube 22 is larger than that of the first flat tube 21 at the position where the bent portion 10R is formed. Thus, as illustrated in FIG. 7, an end of the second flat tube 22 is designed to protrude further outward than an end of the first flat tube 21 before the part 300 is bent so that the ends of the first flat tube 21 and the second flat tube 22 are not arranged too far apart from each other at the other end 302 of the part 300 when bending is completed.

[0062] FIG. 9 illustrates a portion of the part 300 in an enlarged manner. In FIG. 9, the rolling jig 210 and the pressing jig 220 are pushed against the part 300. As is evident from FIG. 9, it is mainly the first flat tube 21 that makes contact with the rolling jig 210. Although not illustrated in FIG. 9, upon completion of this step, a plate is interposed between the first heat exchange portion 11 and the second heat exchange portion 12 during bending. In other words, force is transmitted from the second flat tube 22 to the first heat transfer fin 31 via the plate during bending. Similarly, the area in which the pressing jig 220 comes into contact with the second heat transfer fin 32 is large. Pressure applied to the second heat transfer fin 32 by the pressing jig 220 and pressure applied to the first heat transfer fin 31 by the plate are both smaller than pressure applied to the first flat tube 21 by the rolling jig 210. As a result, buckling of a leeward edge 31b of the first heat transfer fin 31 and a leeward edge 32b of the second heat transfer fin 32 (see FIG. 11) is less likely to occur during the bending.

#### (3-2) Positional Relationship Between Flat Tube and Heat Transfer Fin

[0063] As illustrated in FIG. 6, the plurality of first flat tubes 21 are disposed so as to be positioned windward of windward edges 31a of the plurality of first heat transfer fins 31 by 0 mm or more. In other words, a distance D1 illustrated in FIG. 6 between a windward end portion of the first flat tube 21 and the windward edge 31a of the first heat transfer fin 31 is 0 mm or more, and may be set to 0.5 mm

or more in consideration of, for example, manufacturing errors. As described above, the first flat tube 21 may protrude outward in order to reduce the amount of force applied to the first heat transfer fin 31 during the bending.

[0064] In addition, during bending, force is applied to the first flat tube 21 by the rolling jig 210 and to the second flat tube 22 by the plate interposed between the first flat tube 21 and the second flat tube 22. The wall thicknesses of the first flat tube 21 and the second flat tube 22 are set in consideration of the force. More specifically, as illustrated in FIG. 10, a thickness t3 of tube walls 21d, 22d at windward portions located on the windward side of the first flat tube 21 and the second flat tube 22 is larger than a thickness t2 of the tube walls 21c, 22c at side portions located in the row direction of the first flat tubes 21 and the second flat tubes 22. The thickness t3 of the tube walls 21d, 22d at the windward portion located on the windward side is larger than a thickness t1 of inner walls 21b, 22b that divide flow paths of the multi-hole first flat tubes 21 and second flat tubes 22.

[0065] FIG. 11 illustrates in an enlarged manner a part of the first heat exchange portion 11 and the second heat exchange portion 12. The first heat exchange portion 11 is configured such as not to make contact with the second heat exchange portion 12 through a clearance CL that is located between the leeward edge 31b of the first heat transfer fin 31 and the windward main portion 33 of the second heat transfer fin 32 of the second heat exchange portion 12. More specifically, the leeward edges 31b of the plurality of first heat transfer fins 31 of the first heat exchange portion 11 extend in a straight line along the clearance CL in a vertical direction. A distance of 2 mm or less may be allocated for the distance D3 between the leeward edge 31b of the first heat transfer fin 31 and the windward edge 32a of the second heat transfer fin 32.

[0066] As illustrated in FIG. 6, the plurality of second flat tubes 22 are disposed so as to be positioned windward of the windward edges 32a of the plurality of second heat transfer fins 32 by 0 mm or more. In other words, the distance D2 illustrated in FIG. 6 between a windward end portion of the second flat tube 22 and the windward edge 32a of the second heat transfer fin 32 is 0 mm or more, and may be set to 2 mm or less such that condensed water is more easily drawn by surface tension to flow and drop downward. This distance of 2 mm is set in consideration of the size of water droplets. If this distance is set 2 mm or more, water droplets are not as easily drawn down by surface tension (capillary action). In addition, in order to reduce the force applied to the second heat transfer fin 32 during bending, the second flat tube 22 may protrude outward (the second flat tube 22 may protrude outward by more than 0 mm from the windward edge 32a of the second heat transfer fin 32 and is positioned windward).

#### (4) Modification Example

##### (4-1) Modification Example 1A

[0067] In the above-described embodiments, the indoor heat exchanger 10 is described by taking an example in which the indoor heat exchanger 10 is configured to enclose the entire periphery of windward space in which the indoor fan 120 is disposed when viewed from the row direction of the first flat tubes 21 and the second flat tubes 22 through the combination of the L-shaped first pair P1 and the L-shaped second pair. However, the shape of the indoor heat exchanger 10 for surrounding the windward space in which

the indoor fan **120** is disposed may be, for example, rectangular when viewed from the row direction of the first flat tubes **21** and the second flat tubes **22**, such as that illustrated in FIG. **12** or **13**.

[0068] In FIG. **12**, the arrows Ar**11**, Ar**12** indicate the flow of refrigerant when a rectangular indoor heat exchanger **10** functions as an evaporator. Liquid refrigerant flows in the direction of the arrow Ar**11** after traveling from the liquid pipe **51** to the first flat tube **21** via the flow divider **53** and the liquid header **54**. Then, the refrigerant that flows through the first flat tube **21** is returned by the return header **56** and flows from the first flat tube **21** into the second flat tube **22**. The refrigerant then travels in the direction of the arrow Ar**12** to the gas pipe **52** via the gas header **55**.

[0069] In FIG. **13**, the arrows Ar**12**, Ar**14** indicate the flow of refrigerant in the first flat tube **21** of the first heat exchange portion **11** and the arrows Ar**13**, Ar**15** indicate the flow of refrigerant in the second flat tube **22** of the second heat exchange portion **12** when the rectangular indoor heat exchanger **10** functions as an evaporator. Liquid refrigerant flows in the directions of the arrows Ar**12**, Ar**13** after traveling from the liquid pipe **51** to the first flat tube **21** via the flow divider **53** and the liquid header **54**. Then, the refrigerant that flows through the first flat tube **21** flows in the direction of the arrows Ar**14**, Ar**15** to the gas pipe **52** via the gas header **55**.

#### (4-2) Modification Example 1B

[0070] In the above-described embodiments, the indoor heat exchanger **10** is described as surrounds the entire periphery of the indoor fan **120**, but the indoor heat exchanger **10** may have a configuration that does not surround part of the periphery of the indoor fan. For example, the indoor heat exchanger **10** may have a C-shape such as that illustrated in FIGS. **14** and **15** when viewed from the row direction of the first flat tubes **21** and the second flat tubes **22**.

[0071] FIG. **14** illustrates the internal structure of the indoor unit **100** when viewed from below, and FIG. **15** illustrates a cross-sectional structure of the indoor unit **100** taken along the line II-II in FIG. **14**. The indoor unit **100** includes the indoor fan **120** and the indoor heat exchanger **10**. In FIG. **14**, the C-shaped indoor heat exchanger **10** is the hatched portion. In the indoor unit **100**, the indoor fan **120** operates to suck in indoor air through the intake port **101** provided on a lower center part of the indoor unit **100** and discharge this air from the discharge port **102** of the indoor unit **100**.

[0072] The bell mouth **104** is mounted directly above the intake port **101** in the indoor unit **100**. The indoor air sucked in through the intake port **101** is guided to the indoor fan **120** using this bell mouth **104**. The indoor air is then discharged from the indoor fan **120** in a substantially horizontal direction. The indoor air passes through the C-shaped indoor heat exchanger **10** that surrounds the indoor fan **120** in a horizontal direction to be discharged from the indoor fan **120** and then discharged from the discharge port **102**.

[0073] Condensation may occur in the indoor heat exchanger **10** when, for example, the temperature of the indoor heat exchanger **10** becomes lower than the temperature of the room during a cooling operation. In the indoor unit **100**, the drain pan **130** is provided beneath the indoor heat exchanger **10** to receive condensed water generated in the indoor heat exchanger **10**. The condensed water gener-

ated in the indoor heat exchanger **10** is pulled by gravity so as to flow down through the indoor heat exchanger **10** and drop from the indoor heat exchanger **10** into the drain pan **130**.

#### (4-3) Modification Example 1C

[0074] The refrigerant that flows through the first flat tube **21** and the second flat tube **22** according to the above-described embodiments may be a substance other than refrigerant for vapor compression refrigerant, for example, water.

#### (4-4) Modification Example 1D

[0075] In the indoor heat exchanger **10** according to one or more embodiments, two rows of heat exchange portions, that is, the first heat exchange portion **11** and the second heat exchange portion **12** are provided, but the present invention can also be applied to an indoor heat exchanger having three or more rows of heat exchange portions.

#### (4-5) Modification Example 1E

[0076] The indoor heat exchanger according to the present invention is not limited to being applied to the ceiling-mounted indoor unit **100** and can also be applied to, for example, an indoor unit that hangs from a ceiling.

#### (4-6) Modification Example 1F

[0077] In the above-described embodiments, the first flat tubes **21** and the second flat tubes **22** are arranged at the same height, but the first flat tubes and the second flat tubes in the indoor heat exchanger according to the present invention may be arranged in a staggered fashion.

### (5) Characteristics

#### [0078] (5-1)

[0079] As described above, the notches **35** in the first heat transfer fin **31** and the second heat transfer fin **32** are disposed inward and the first flat tube **21** and the second flat tube **22** each have an inwardly bent shape. This configuration reduces deformation of the main portions **33** of the first heat transfer fin **31** and the second heat transfer fin **32**. As a result, because deformation of the main portions **33** of the first heat transfer fin **31** and the second heat transfer fin **32** is reduced, there is less possibility of increasing air flow resistance caused by such deformation and an increase in air flow resistance is thereby reduced.

[0080] In addition, because the communication portions **34** of the first heat transfer fin **31** and the second heat transfer fin **32** are disposed on a leeward side, condensed water guided by the indoor air traveling in the width direction of the first flat tubes **21** and the second flat tubes **22** can be sent in the up-down direction via the communication portions **34**, particularly guide ribs **36**. In this way, drainability when condensation occurs is improved due to the leeward communication portions **34** of the first flat tube **21** and the second flat tube **22**.

#### (5-2)

[0081] In the above-described embodiments, as illustrated in FIG. **5**, the first pair P**1** and the second pair P**2** of the indoor heat exchanger **10** each have an L-shape so as to surround the indoor fan **120** with the inner peripheral sides thereof. In the modification example 1A, the indoor heat

exchanger 10 illustrated in FIGS. 12 and 13 is rectangular so as to surround the indoor fan 120 with the inner peripheral side thereof. Further, in modification example 1B, the indoor heat exchanger 10 illustrated in FIG. 14 has a C-shape so as to surround the indoor fan 120 with the inner peripheral side thereof. With these configurations, indoor air discharged from the indoor fan 120 arranged on the inner peripheral side is guided along the width direction of the first flat tubes 21 and the second flat tubes 22 to pass between a plurality of the first heat transfer fins 31 and a plurality of the second heat transfer fins 32 and reach the outer peripheral side on which the communication portion 34 of the second heat transfer fin 32 is located. As a result, in the indoor heat exchanger 10, drainability of condensed water is improved by efficiently utilizing air flow discharged around by the indoor fan 120.

(5-3)

[0082] As described with reference to FIG. 6, the first flat tubes 21 are positioned windward of the windward edges 31a of the plurality of first heat transfer fins 31 by 0 mm or more. With this configuration, the first flat tubes 21 protrude leeward of the windward edges 31a of the first heat transfer fins 31 by 0 mm or more, and hence first abut against a member such as the rolling jig 210 when, for example, the first heat exchange portion 11 and the second heat exchange portion 12 are bent. This reduces the possibility of buckling of the windward edges 31a of the plurality of first heat transfer fins 31, for example. As a result, an increase in air flow resistance caused by deformation of the windward edges 31a of the plurality of first heat transfer fins 31 can be reduced.

(5-4)

[0083] When a thickness  $t_3$  of the tube wall 21d, 22d at the windward portion located windward is larger than the thickness  $t_2$  of the tube wall 21c, 22c at the side surface portion as illustrated in FIG. 10, a reduction in compressive strength can be suppressed even if the first flat tube 21 and the second flat tube 22 are damaged by the rolling jig 210 when the first flat tube 21 and the second flat tube 22 are bent by the rolling jig 210. As a result, the compressive strength of the first flat tubes 21 and the second flat tubes 22 at bent portions toward the inner peripheral side of the indoor heat exchanger 10 is less likely to decrease.

(5-5)

[0084] By adopting a configuration such as that illustrated in FIG. 11 in which the first heat exchange portion 11 and the second heat exchange portion 12, which have different temperatures, are configured not to make contact with each other through the clearance CL that is located between the leeward edge 31b of the first heat transfer fin 31 and the windward main portion 33 of the second heat transfer fin 32, heat transfer can be reduced from one of the first heat exchange portion 11 and the second heat exchange portion 12 to the other. As a result, heat exchange capacity of the first heat exchange portion 11 and the second heat exchange portion 12 is less likely to decrease due to thermal conduction between the first heat exchange portion 11 and the second heat exchange portion 12.

(5-6)

[0085] As illustrated in FIG. 11, because the second flat tubes 22 are positioned windward of the windward edges 32a of the plurality of second heat transfer fins 32 by 0 mm or more, the clearance CL can be easily left between the first heat exchange portion 11 and the second heat exchange portion 12. When the clearance CL is left by arranging the

second flat tubes 22 in this way, heat exchange capacity is less likely to decrease due to thermal conduction between the first heat exchange portion 11 and the second heat exchange portion 12.

(5-7)

[0086] As illustrated in FIG. 11, because the second flat tubes 22 are positioned windward of the windward edges of the plurality of second heat transfer fins by 2 mm or less, a clearance CL of 2 mm or less can be reliably formed between the first heat exchange portion 11 and the second heat exchange portion 12. In other words, the distance D3 between the leeward edge 31b of the first heat transfer fin 31 and the windward edge 32a of the second heat transfer fin 32 is 2 mm or less. Condensed water is more likely to be drawn by surface tension into this clearance of 2 mm or less formed between the first heat exchange portion 11 and the second heat exchange portion 12, to flow and drop down. As a result, condensed water in the indoor heat exchanger 10 is drained with better performance.

(5-8)

[0087] As illustrated in FIG. 11, because the leeward edges 31b of the plurality of first heat transfer fins 31 extend in a straight line along the clearance CL in a vertical direction, condensed water is more likely to be guided along these leeward edges 31b. As a result, problems caused by condensed water, such as condensed water splashing outward, can be reduced.

(5-9)

[0088] The windward space can be surrounded by two L-shaped pairs of the first heat exchange portion 11 and the second heat exchange portion 12, namely, the first pair P1 and the second pair P2 as illustrated in FIG. 5, one rectangular pair of the first heat exchange portion 11 and the second heat exchange portion 12 as illustrated in FIGS. 12 and 13, or one C-shaped pair of the first heat exchange portion and the second heat exchange portion as illustrated in FIG. 14. As a result, the configuration of the indoor unit 100 to which the indoor heat exchanger 10 is applied can be simplified.

[0089] Although the disclosure has been described with respect to only a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that various other embodiments may be devised without departing from the scope of the present invention. Accordingly, the scope of the invention should be limited only by the attached claims.

## REFERENCE SIGNS LIST

|        |                                 |
|--------|---------------------------------|
| [0090] | 10 Indoor heat exchanger        |
| [0091] | 11 First heat exchange portion  |
| [0092] | 12 Second heat exchange portion |
| [0093] | 21 First flat tube              |
| [0094] | 21b, 21c, 21d Tube wall         |
| [0095] | 22 Second flat tube             |
| [0096] | 22b, 22c, 22d Tube wall         |
| [0097] | 31 First heat transfer fin      |
| [0098] | 31a Windward edge               |
| [0099] | 31b Leeward edge                |
| [0100] | 32 Second heat transfer fin     |
| [0101] | 32a Windward edge               |
| [0102] | 32b Leeward edge                |
| [0103] | 33 Main portion                 |
| [0104] | 34 Communication portion        |
| [0105] | 35 Notch                        |

CITATION LIST

Patent Literature

[0106] [Patent Literature 1] WO 08/41656

[0107] [Patent Literature 2] WO 13/160957

1. An indoor heat exchanger comprising:

a first heat exchange portion comprising a plurality of first flat tubes arranged in rows and a plurality of first heat transfer fins that intersect with the plurality of first flat tubes, wherein the first heat exchange portion exchanges heat between indoor air that flows in a width direction of the plurality of first flat tubes and refrigerant that flows through the plurality of first flat tubes; and

a second heat exchange portion comprising a plurality of second flat tubes arranged in rows and a plurality of second heat transfer fins that intersect with the plurality of second flat tubes, wherein the second heat exchange portion exchanges heat between indoor air that flows in a width direction of the plurality of second flat tubes and refrigerant that flows through the plurality of second flat tubes,

wherein the plurality of first heat transfer fins and the plurality of second heat transfer fins each comprise a windward main portion formed with a notch that receives the first flat tube and the second flat tube, respectively, and a leeward communication portion located on a side opposite to an open end of the notch, wherein in the first heat exchange portion and the second heat exchange portion, the plurality of first flat tubes and the plurality of second flat tubes in the rows are arranged in the width direction, and the first heat exchange portion and the second heat exchange portion each have a bent shape with an inner peripheral side on a windward side and an outer peripheral side on a leeward side,

wherein the first heat exchange portion does not make contact with the second heat exchange portion,

wherein a clearance of 2 mm or less is located between leeward edges of the plurality of first heat transfer fins of the first heat exchange portion and the windward

main portions of the second heat transfer fins of the second heat exchange portion, and

wherein the second flat tubes are positioned windward of windward edges of the plurality of second heat transfer fins by from 0 mm to 2 mm.

2. The indoor heat exchanger according to claim 1, wherein the first heat exchange portion and the second heat exchange portion each have the bent shape so as to surround an indoor fan with the inner peripheral sides, and are disposed such that indoor air discharged from the indoor fan disposed on the inner peripheral side is guided along the width direction of the plurality of first flat tubes and the plurality of second flat tubes to pass between the plurality of first heat transfer fins and between the plurality of second heat transfer fins and reach the outer peripheral side on which the communication portion of the second heat transfer fin is located.

3. The indoor heat exchanger according to claim 1, wherein the plurality of first flat tubes are positioned windward of windward edges of the plurality of first heat transfer fins by 0 mm or more.

4. The indoor heat exchanger according to claim 3, wherein, in the plurality of first flat tubes arranged in rows and the plurality of second flat tubes arranged in rows, a thickness of tube walls at a windward portion located windward is larger than a thickness of tube walls at a side portion located in a row direction of the plurality of first flat tubes and the plurality of second flat tubes.

5.-7. (canceled)

8. The indoor heat exchanger according to claim 1, wherein

the leeward edges of the plurality of first heat transfer fins in the first heat exchange portion extend in a straight line along the clearance in a vertical direction.

9. The indoor heat exchanger according to claim 1, wherein

the first heat exchange portion and the second heat exchange portion each have an L-shape, a C-shape, or a rectangular shape when viewed from the row direction of the plurality of first flat tubes and the plurality of second flat tubes.

\* \* \* \* \*