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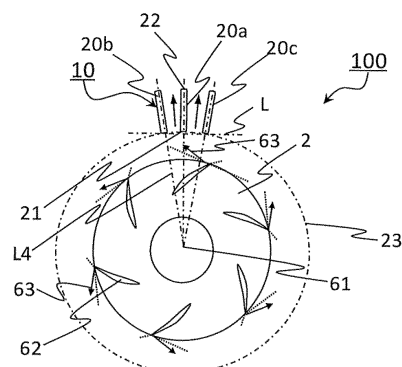
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(54) **HEAT EXCHANGER UNIT, AND REFRIGERATION CYCLE DEVICE**

(57) An object is to provide a heat-exchanger unit and a refrigeration cycle apparatus that make a flow of air passing through portions of a heat exchanger uniform to improve heat exchange performance. The heat-exchanger unit includes an air-sending device configured to send outside air into a casing, and a heat exchanger laterally surrounding a rotation center axis of the air-sending device. The heat exchanger includes a plurality of flat tubes arranged in parallel and surrounding the rotation center axis of the air-sending device, the plurality of flat tubes each having a pipe axis extending in a vertical direction, and a header connecting the plurality of flat tubes. The plurality of flat tubes include a first flat tube, a second flat tube, and a third flat tube, and each of the second flat tube and the third flat tube is placed adjacent to the first flat tube. Where a radial direction through each of the first flat tube, the second flat tube, and the third flat tube has the rotation center axis of the air-sending device as a center of the radial direction, each of the first flat tube, the second flat tube, and the third flat tube has, among two ends of a longitudinal axis of a section perpendicular to the pipe axis, a first end positioned closer to the center of the radial direction than is the other end, and the first ends are arranged on a virtual annular line surrounding the rotation center axis. The first end of the first flat tube is placed further away from the center

of the radial direction than is a virtual straight line connecting the first end of the second flat tube and the first end of the third flat tube.

FIG. 5



Description

Technical Field

[0001] The present disclosure relates to a heat-exchanger unit and a refrigeration cycle apparatus each including a heat exchanger in which flat tubes are arranged such that pipe axes of the flat tubes extend in a vertical direction, and, particularly to an arrangement structure of flat tubes.

Background Art

[0002] An existing heat-exchanger unit in which a heat exchanger including a heat transfer tube and a fin is placed to laterally surround an air-sending device is well-known. Such a heat exchanger is placed such that the heat transfer tube extends in a horizontal direction and the fin perpendicularly intersects with a pipe axis of the heat transfer tube. It is necessary to secure a front surface area of the heat exchanger as large as possible in a limited capacity of a casing. Accordingly, the heat exchanger is configured such that the heat transfer tube is bent a plurality of times in a direction in which the heat exchanger extends to surround an air duct provided with the air-sending device (for example, see Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent No. 4684085

Summary of Invention

Technical Problem

[0004] In a heat-exchanger unit disclosed in Patent Literature 1, as the heat transfer tube of the heat exchanger is placed to have the pipe axis extending in the horizontal direction, a header, a U-shaped bent portion of the heat transfer tube, and a connection pipe are placed at an end in the horizontal direction. Accordingly, the heat exchanger cannot surround the whole surrounding region of the air duct provided with the air-sending device, and cannot improve mounting efficiency in the air duct inside the casing. Thus, a problem with the heat-exchanger unit is that the casing and the heat exchanger have to be upsized to secure necessary heat exchange performance. Another problem with the heat-exchanger unit is that the heat exchange performance is deteriorated as air not subjected to heat exchange passes through the end of the heat exchanger in the horizontal direction. Moreover, another problem with the heat-exchanger unit is that a flow of air passing through the heat exchanger varies among portions of the heat exchanger and the heat ex-

change performance is deteriorated because a distance from the air-sending device to the heat transfer tube is largely varied.

[0005] An object of the present disclosure, which has been made to solve the above-described problems, is to provide a heat-exchanger unit and a refrigeration cycle apparatus that make the flow of the air passing through the portions of the heat exchanger uniform to improve the heat exchange performance.

Solution to Problem

[0006] A heat-exchanger unit according to one embodiment of the present disclosure includes an air-sending device configured to send outside air into a casing, and a heat exchanger laterally surrounding a rotation center axis of the air-sending device. The heat exchanger includes a plurality of flat tubes arranged in parallel and surrounding the rotation center axis of the air-sending device, the plurality of flat tubes each having a pipe axis extending in a vertical direction, and a header connecting the plurality of flat tubes. The plurality of flat tubes include a first flat tube, a second flat tube, and a third flat tube, and each of the second flat tube and the third flat tube are placed adjacent to the first flat tube. Where a radial direction through each of the first flat tube, the second flat tube, and the third flat tube has the rotation center axis of the air-sending device as a center of the radial direction, each of the first flat tube, the second flat tube, and the third flat tube has, among two ends of a longitudinal axis of a section perpendicular to the pipe axis, a first end positioned closer to the center of the radial direction than is the other end, and the first ends are arranged on a virtual annular line surrounding the rotation center axis. The first end of the first flat tube is placed further away from the center of the radial direction than is a virtual straight line connecting the first end of the second flat tube and the first end of the third flat tube.

[0007] A refrigeration cycle apparatus according to another embodiment of the present disclosure includes the above-described heat-exchanger unit.

Advantageous Effects of Invention

[0008] According to an embodiment of the present disclosure, the flat tubes are annularly arranged around the air-sending device, and a difference in distance from the air-sending device to the first end of each of the plurality of flat tubes can be set small by the above-described configuration. Therefore, the flow of the air passing between the flat tubes is made uniform, which improves the heat exchange performance of the heat-exchanger unit and the refrigeration cycle apparatus.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a schematic diagram of a structure in a section perpendicular to a rotation center axis of an air-sending device of a heat-exchanger unit according to Embodiment 1.

[Fig. 2] Fig. 2 is a schematic diagram of a structure in a section parallel to the rotation center axis of the air-sending device of the heat-exchanger unit according to Embodiment 1.

[Fig. 3] Fig. 3 is an explanatory diagram of a refrigeration cycle apparatus to which the heat-exchanger unit according to Embodiment 1 is applied.

[Fig. 4] Fig. 4 is a schematic diagram to explain a structure of a flat tube included in a heat exchanger according to Embodiment 1.

[Fig. 5] Fig. 5 is an explanatory diagram of positional relationship between the air-sending device and a plurality of flat tubes of the heat exchanger of the heat-exchanger unit according to Embodiment 1.

[Fig. 6] Fig. 6 is an explanatory diagram of positional relationship between an air-sending device and a plurality of flat tubes of a heat exchanger of a heat-exchanger unit as a modification of the heat-exchanger unit according to Embodiment 1.

[Fig. 7] Fig. 7 is an explanatory diagram of positional relationship between an air-sending device and a plurality of flat tubes of a heat exchanger of a heat-exchanger unit as a comparative example of the heat-exchanger unit according to Embodiment 1.

[Fig. 8] Fig. 8 is an explanatory diagram of a structure in a section perpendicular to pipe axes of flat tubes of a heat exchanger as a modification of the heat exchanger of the heat-exchanger unit according to Embodiment 1.

[Fig. 9] Fig. 9 is an explanatory diagram of a structure in a section parallel to the pipe axis of the flat tube of the heat exchanger as the modification of the heat exchanger of the heat-exchanger unit according to Embodiment 1.

[Fig. 10] Fig. 10 is an explanatory diagram of positional relationship between an air-sending device and a plurality of flat tubes of a heat exchanger of a heat-exchanger unit according to Embodiment 2.

[Fig. 11] Fig. 11 is an explanatory diagram of positional relationship between an air-sending device and a plurality of flat tubes of a heat exchanger of a heat-exchanger unit according to Embodiment 3.

[Fig. 12] Fig. 12 is a schematic diagram to explain a structure of a flat tube included in the heat exchanger in Fig. 11.

[Fig. 13] Fig. 13 is an explanatory diagram of positional relationship between an air-sending device and a plurality of flat tubes of a heat exchanger of a heat-exchanger unit according to Embodiment 4.

[Fig. 14] Fig. 14 is a schematic diagram to explain a structure of a flat tube included in the heat exchanger in Fig. 13.

[Fig. 15] Fig. 15 is a schematic diagram of a structure in a section perpendicular to a rotation center axis

of the air-sending device of the heat-exchanger unit according to Embodiment 4.

Description of Embodiments

[0010] Embodiments of a heat exchanger and a heat-exchanger unit are described below. Note that forms illustrated in the drawings are illustrative and do not limit the present disclosure. Further, components denoted by the same reference signs in the drawings are the same or equivalent components, which is applied to full text of the specification. Furthermore, in the following drawings, size relationship among the components may be different from actual size relationship.

Embodiment 1

[0011] Fig. 1 is a schematic diagram of a structure in a section perpendicular to a rotation center axis 61 of an air-sending device 2 of a heat-exchanger unit 100 according to Embodiment 1. Fig. 2 is a schematic diagram of a structure in a section parallel to the rotation center axis of the air-sending device 60 of the heat-exchanger unit 100 according to Embodiment 1. Fig. 3 is an explanatory diagram of a refrigeration cycle apparatus 1 to which the heat-exchanger unit 100 according to Embodiment 1 is applied. The heat-exchanger unit 100 illustrated in Fig. 1 is mounted on the refrigeration cycle apparatus 1 such as an air-conditioning apparatus. As illustrated in Fig. 3, the refrigeration cycle apparatus 1 includes a compressor 3, a four-way valve 4, an outdoor heat exchanger 5, an expansion device 6, and an indoor heat exchanger 7, which are connected by a refrigerant pipe 90 to form a refrigerant circuit. For example, in a case where the refrigeration cycle apparatus 1 is an air-conditioning apparatus, refrigerant flows through the refrigerant pipe 90, and heating operation and refrigerating operation can be switched by switching the flows of the refrigerant by the four-way valve 4.

[0012] The outdoor heat exchanger 5 mounted on an outdoor unit 8 and the indoor heat exchanger 7 mounted on an indoor unit 9 are each provided with the air-sending device 2 in the vicinity of the corresponding one of the outdoor heat exchanger 5 and the indoor heat exchanger 7. In the outdoor unit 8, the air-sending device 2 sends outdoor air to the outdoor heat exchanger 5 to cause the outside air and the refrigerant to exchange heat. In the indoor unit 9, the air-sending device 2 introduces indoor air into a casing, sends the indoor air to the indoor heat exchanger 7 to cause the indoor air and the refrigerant to exchange heat, thereby conditioning temperature of the indoor air. Further, the heat-exchanger unit 100 is usable as the outdoor unit 8 and the indoor unit 9 in the refrigeration cycle apparatus 1. In other words, a heat exchanger 10 mounted on the heat-exchanger unit 100 is used as a condenser or an evaporator. A unit on which the heat exchanger 10 is mounted, such as the outdoor unit 8 and the indoor unit 9, is particularly referred to as

the heat-exchanger unit 100.

[0013] In the heat-exchanger unit 100 illustrated in Fig. 1, the air-sending device 2 is placed at a center of a casing 80, and the heat exchanger 10 is placed to surround the rotation center axis 61 of the air-sending device 2. An inside air duct 70 is provided inside the heat exchanger 10, and an outside air duct 71 is provided outside the heat exchanger 10. The outside air duct 71 is provided between an air duct outer wall inside the casing 80 and an outer periphery of the heat exchanger 10. In Embodiment 1, the air-sending device 2 introduces air outside the casing 80 into the casing 80 from an opening port 82. The introduced air passes through the heat exchanger 10 from the inside air duct 70, and is blown out to the outside from an opening port 81 communicating with the outside of the casing 80, through the outside air duct 71. As illustrated in Fig. 2, in the heat-exchanger unit 100 according to Embodiment 1, the heat exchanger 10 is placed to laterally surround the air-sending device 2; however, the heat exchanger 10 is not limited to this form, and the air-sending device 2 and the heat exchanger 10 may be placed at positions displaced from each other in a vertical direction. Further, in Embodiment 1, the air inside the casing 80 flows from the opening port 82 to the opening port 81 through the air-sending device 2, the heat exchanger 10, and the outside air duct 71; however, the air may flow in an opposite direction.

[0014] Fig. 4 is a schematic diagram to explain a structure of a flat tube 20 included in the heat exchanger 10 according to Embodiment 1. The heat exchanger 10 includes a plurality of flat tubes 20, which are arranged to surround the rotation center axis 61 of the air-sending device 2. Of each of the plurality of flat tubes 20, a shape of a section perpendicular to a pipe axis is a flat shape having a longitudinal axis 26 and a short axis 27. A plurality of refrigerant flow paths 24 through which the refrigerant flows are provided inside each of the plurality of flat tubes 20. Further, each of the flat tubes 20 is made of a metal material having thermal conductivity. Examples of the material formed into each of the flat tubes 20 include aluminum, an aluminum alloy, copper, and a copper alloy. Each of the flat tubes 20 is manufactured by extrusion process in which a heated material is extruded from a hole of a die to form a product having the section illustrated in Fig. 3. Alternatively, each of the flat tubes 20 may be manufactured by drawing process in which the material is drawn from the hole of the die to form a product having the section illustrated in Fig. 3. The method of manufacturing each of the flat tubes 20 may appropriately be selected depending on the shape of the section of each of the flat tubes 20.

[0015] As illustrated in Fig. 2, the plurality of flat tubes 20 are arranged such that the pipe axes extend in the vertical direction, namely, in a direction parallel to the rotation center axis 61 of the air-sending device 2. A first header 30 is attached to upper ends of the plurality of flat tubes 20, and a second header 40 is attached to lower ends of the plurality of flat tubes 20. The first header 30

and the second header 40 are connected to the refrigerant pipe 90 illustrated in Fig. 3, and distribute the refrigerant flowing through the refrigeration cycle apparatus 1 into the flat tubes 20. Further, the heat exchanger 10 does not include a fin by which the plurality of flat tubes 20 are connected with each other.

[0016] Fig. 5 is an explanatory diagram of positional relationship between the air-sending device 2 and the plurality of flat tubes 20 of the heat exchanger 10 of the heat-exchanger unit 100 according to Embodiment 1. In Fig. 5, only a part of the plurality of flat tubes 20 is illustrated, and illustration of the other flat tubes 20 is omitted. The plurality of flat tubes 20 are arranged in parallel and surround the rotation center axis 61 of the air-sending device 2. When a radial direction has the rotation center axis 61 of the air-sending device 2 as a center of the radial direction, the longitudinal axis 26 in the section perpendicular to the pipe axis of each of the plurality of flat tubes 20 extends in the radial direction. Out of two ends of the longitudinal axis 26 of each of the plurality of flat tubes 20, an end positioned inward in the radial direction is referred to as a first end 21, and an end positioned outward in the radial direction is referred to as a second end 22. In Embodiment 1, the first ends 21 of the respective flat tubes 20 are arranged on a virtual annular line 23 surrounding the rotation center axis 61 of the air-sending device 2. In Fig. 5, the first ends 21 of the respective flat tubes 20 are positioned on a virtual circle having the rotation center axis 61 as a center.

[0017] The plurality of flat tubes 20 include a first flat tube 20a, a second flat tube 20b, and a third flat tube 20c. Each of the second flat tube 20b and the third flat tube 20c is placed adjacent to the first flat tube 20a. The first flat tube 20a is placed between the second flat tube 20b and the third flat tube 20c. In Embodiment 1, the first ends 21 of the first flat tube 20a, the second flat tube 20b, and the third flat tube 20c are positioned on the virtual line 23. As the virtual line 23 has a circular shape, the first flat tube 20a, the second flat tube 20b, and the third flat tube 20c are equal in distance from the air-sending device 2 to each first end 21. Accordingly, an amount of air flowing between the first flat tube 20a and the second flat tube 20b and an amount of air flowing between the first flat tube 20a and the third flat tube 20c are less different from each other.

[0018] When the radial direction with the rotation center axis 61 of the air-sending device 2 as a center is defined in Fig. 5, the first end 21 of the first flat tube 20a is positioned further outward in the radial direction than is a virtual straight line L connecting the first end 21 of the second flat tube 20b and the first end 21 of the third flat tube 20c. When sets of the first flat tube 20a, the second flat tube 20b, and the third flat tube 20c placed in such positional relationship are arranged on the entire circumference around the rotation center axis 61 of the air-sending device 2, the first ends 21 of the respective flat tubes 20 of the heat exchanger 10 are arranged on the virtual annular line 23 surrounding the rotation center axis.

When an interval between the first ends 21 is made equal among the flat tubes 20 and a distance from the first end 21 of the first flat tube 20a to the virtual straight line L is made equal among all sets of the plurality of flat tubes 20, the first ends 21 of the respective flat tubes 20 are circularly arranged around the rotation center axis 61 as illustrated in Fig. 5. Further, in Embodiment 1, a first virtual line that is an extension of the longitudinal axis 26 in the section perpendicular to the pipe axis of the first flat tube 20a intersects, at a position inward in the radial direction, with each of a second virtual line that is an extension of the longitudinal axis 26 of the second flat tube 20b and a third virtual line that is an extension of the longitudinal axis 26 of the third flat tube 20c.

[0019] Fig. 6 is an explanatory diagram of positional relationship between the air-sending device 2 and the plurality of flat tubes 20 of a heat exchanger 10a of a heat-exchanger unit 100a as a modification of the heat-exchanger unit 100 according to Embodiment 1. In Fig. 6, only a part of the plurality of flat tubes 20 is illustrated, and illustration of the other flat tubes 20 is omitted. Among the plurality of flat tubes 20, a first flat tube placed at a position different from the first flat tube 20a is referred to as a first flat tube 20d. Among the plurality of flat tubes 20, flat tubes 20 each placed adjacent to the first flat tube 20d are referred to as a second flat tube 20e and a third flat tube 20f. In the heat-exchanger unit 100a, the first end 21 of the first flat tube 20a is positioned further outward in the radial direction than is a virtual straight line L1 connecting the first end 21 of the second flat tube 20b and the first end 21 of the third flat tube 20c, as in the heat-exchanger unit 100. Further, the first flat tube 20d that is placed at a position different from the first flat tube 20a, the second flat tube 20b, and the third flat tube 20c is also positioned further outward in the radial direction than is a virtual straight line L2 connecting the first end 21 of the second flat tube 20e and the first end 21 of the third flat tube 20f. However, when a distance from the first end 21 of the first flat tube 20a to the virtual straight line L1 connecting the first end 21 of the second flat tube 20b and the first end 21 of the third flat tube 20c and a distance from the first end 21 of the first flat tube 20d to the virtual straight line L2 connecting the first end 21 of the second flat tube 20e and the first end 21 of the third flat tube 20c are compared, the distance from the first end 21 of the first flat tube 20d to the virtual straight line L2 is set large. At this time, the interval between the first ends 21 is set equal among the plurality of flat tubes 20.

[0020] As illustrated in Fig. 6, when the distance from the first flat tube 20a to the virtual straight line L1 and the distance from the first flat tube 20d to the virtual straight line L2 are set to be different from each other, the first ends 21 of the respective flat tubes 20 are arranged on a virtual annular line 23a surrounding the rotation center axis 61. In the heat-exchanger unit 100a, the first ends 21 of the respective flat tubes 20 are arranged in an elliptical shape having the rotation center axis 61 of the air-sending device 2 as a center. Such a configuration makes

it possible to reduce variation in the amount of air passing among the flat tubes 20 while improving arrangement flexibility of the flat tubes 20 of the heat exchanger 10a.

[0021] Fig. 7 is an explanatory diagram of positional relationship between the air-sending device 2 and a plurality of flat tubes 120 of a heat exchanger 110 of a heat-exchanger unit 1100 as a comparative example of the heat-exchanger units 100 and 100a according to Embodiment 1. In Fig. 7, only a part of the plurality of flat tubes 20 is illustrated, and illustration of the other flat tubes 20 is omitted. The heat exchanger 110 is configured such that the first ends 21 of the respective flat tubes 120 are arranged on a virtual line 123 surrounding the rotation center axis 61 of the air-sending device 2. The virtual line 123 has a rectangular shape, and includes straight line portions 128 and corners 129, which are portions at ends of each of the straight line portions 128 contacting the other straight line portion 128.

[0022] The heat exchanger 110 includes flat tubes 120a, 120b, 120c and 120h that have the respective first ends 121 arranged on one straight line portion 128 and have the respective longitudinal axes 26 arranged parallel to one another. The air-sending device 2 is a centrifugal air-sending device, and blows out the air in a direction of an arrow 63 inclined outward from a tangential direction of an outer periphery of the air-sending device 2 as illustrated in Fig. 7. Accordingly, the air enters among the flat tubes 120a, 120b, 120c, 120f, 120h, and 120i that have the respective first ends 21 arranged on one straight line portion 128, from a direction oblique to the longitudinal axes 26 of the flat tubes 120. At this time, an angle formed by the flow of the air entering between the flat tube 120a and the flat tube 120b with the longitudinal axes 26 of the flat tubes 120a and 120b is referred to as an angle $\theta 1$. Further, an angle formed by the flow of the air entering between the flat tube 120h and the flat tube 120i with the longitudinal axes 26 of the flat tubes 120h and 120i is referred to as an angle $\theta 2$. The angle $\theta 2$ is smaller than the angle $\theta 1$. In other words, the air entering between the flat tube 120h and the flat tube 120i is larger in a bending angle of the flow than the air entering between the flat tube 120a and the flat tube 120b. The flat tubes 120 arranged on one straight line portion 128 is gradually increased in the bending angle of the flow of the air flowing between the flat tubes 120 as approaching the end of the straight line portion 128 in the rotation direction of the air-sending device 2. When the bending angle of the flow of the air flowing between the flat tubes 120 is increased, pressure loss of the flowing air is increased, and a flow rate of the flowing air is reduced.

[0023] Further, the air entering between the flat tube 120a and the flat tube 120b is different from the air entering between the flat tube 120h and the flat tube 120i in distance where the air output from the air-sending device 2 reaches each flat tube 120. A flow speed of the air is reduced between the flat tube 120h and the flat tube 120i, which are relatively far from the air-sending device 2, and the flow rate of the air flowing between the flat

tubes 120 is lower than the flow rate of the air flowing between the flat tube 120a and the flat tube 120b. Accordingly, the flat tubes 120 arranged on one straight line portion 128 is gradually reduced in the flow rate of the air flowing between the flat tubes 120 as approaching the corner 129 of the straight line portion 128.

[0024] As described above, in the heat-exchanger unit 1100, among the plurality of flat tubes 120 of the heat exchanger 110, the flow rate of the air flowing between the flat tubes 120 close to each of the corners 129 of the corresponding virtual lines 123 is reduced. Therefore, the amount of the air flowing between the flat tubes 120 is largely varied, and the heat exchange amount between the air and the refrigerant is also largely varied depending on the portion of the heat exchanger 110. In contrast, in the heat-exchanger unit 100 according to Embodiment 1, the flat tubes 20 of the heat exchanger 10 are placed at an equal distance from the outer periphery of the air-sending device 2 in each of the portions, and the bending angle of the air entering between the flat tubes 20 is equal among the portions. Therefore, the amount of the air flowing between the flat tubes 20 is averaged, and the heat exchange amount between the air and the refrigerant is also averaged among the portions of the heat exchanger 10. Thus, when the heat exchanger 10 and the heat exchanger 110 have the same front surface area, the heat exchanger 10 has a heat exchange capacity larger than the heat exchange capacity of the heat exchanger 110. In other words, the heat exchange efficiency of the heat exchanger 10 is higher than the heat exchange efficiency of the heat exchanger 110 of the heat-exchanger unit 1100 of the comparative example. In addition, the mounting efficiency of the heat exchanger 10 is higher than the mounting efficiency of the heat exchanger 110. Therefore, the casing of the heat-exchanger unit 100 can be made small as compared with the heat-exchanger unit 1100.

[0025] In the heat-exchanger unit 100a, setting of the distance from the first flat tube 20a to the virtual straight line L1 and the distance from the first flat tube 20d to the virtual straight line L2 is appropriately changed in each of the plurality of flat tubes 20, which makes it possible to change the shape of the virtual annular line 23a around the rotation center axis 61. The virtual annular line 23a around the rotation center axis 61 may have a shape in which a distance from the center is fixed, such as a circular shape, or a shape in which a distance from the center is continuously changed, such as an elliptical shape. The first ends 21 of the respective flat tubes 20 can be arranged on the virtual annular line 23a in each of the portions. In the heat-exchanger unit 100a illustrated in Fig. 6, unlike the heat-exchanger unit 100, the first ends 21 of the respective flat tubes 20 included in the heat exchanger 10a are varied in distance from the outer periphery of the air-sending device 2; however, variation in the distance from the outer periphery of the air-sending device 2 is small, the heat exchange efficiency is high and the mounting efficiency is also high as compared

with the heat-exchanger unit 1100 of the comparative example. Further, in the heat-exchanger unit 100a, arrangement of the flat tubes 20 corresponding to the structure of the air duct inside the casing is advantageously possible because flexibility of internal arrangement of the heat exchanger 10a is high.

[0026] Fig. 8 is an explanatory diagram of a structure in a section perpendicular to the pipe axes of the flat tubes 20 of a heat exchanger 10b as a modification of the heat exchanger 10 of the heat-exchanger unit 100 according to Embodiment 1. Fig. 9 is an explanatory diagram of a structure in a section parallel to the pipe axis of the flat tube 20 of the heat exchanger 10b as the modification of the heat exchanger 10 of the heat-exchanger unit 100 according to Embodiment 1. As in the heat exchanger 10 or the heat exchanger 10a, the flat tubes 20 included in the heat exchanger 10b are arranged in parallel and surround the rotation center axis 61 of the air-sending device 2. The heat exchanger 10b includes strength parts 41 arranged adjacent to the respective flat tubes 20. The strength parts 41 are placed between the first header 30 and the second header 40, and are placed on the extensions of the longitudinal axes 26 of the respective flat tubes 20. In Embodiment 1, as the air flowing between the flat tubes 20 flows in a direction directed from the first ends 21 toward the second ends 22, the strength parts 41 are placed close to the second ends 22 of the flat tubes 20. Further, a width of each of the strength parts 41 in a direction parallel to an extending direction of the short axis 27 of each of the flat tubes 20 is less than or equal to a width of the short axis 27 of each of the flat tubes 20. With such a configuration, the strength parts 41 are positioned in a separation region of the air flowing between the flat tubes 20. Therefore, the strength parts 41 can improve strength of the heat exchanger 10b without influencing the flow of the air.

[0027] In particular, in each of the heat exchangers 10, 10a, and 10b of the heat-exchanger units 100 and 100a according to Embodiment 1, the plurality of flat tubes 20 are arranged in parallel and each have the pipe axis extending in the vertical direction, and fins by which the flat tubes 20 are connected with each other are not provided. Accordingly, although strength of each of the heat exchangers 10, 10a, and 10b depends on strength of the flat tubes 20 connected to the first header 30 and the second header 40, providing the strength parts 41 in the above-described manner makes it possible to improve the strength of each of the heat exchangers 10, 10a, and 10b.

Embodiment 2

[0028] A heat-exchanger unit 200 according to Embodiment 2 has a configuration in which an extending direction of the longitudinal axes 26 of the plurality of flat tubes 20 of the heat exchanger 10 is changed from the direction in the heat-exchanger unit 100 according to Embodiment 1. The heat-exchanger unit 200 according to Embodi-

ment 2 is described with a focus on changes from Embodiment 1. Components of the heat-exchanger unit 200 according to Embodiment 2 having the same functions among the drawings are illustrated with the same reference signs in the drawings used for description of Embodiment 1.

[0029] Fig. 10 is an explanatory diagram of positional relationship between the air-sending device 2 and the plurality of flat tubes 20 of a heat exchanger 210 of the heat-exchanger unit 200 according to Embodiment 2. In the heat-exchanger unit 100 according to Embodiment 1, the longitudinal axes 26 of the flat tubes 20 of the heat exchanger 10 extend along the radial direction having the rotation center axis 61 of the air-sending device 2 as a center. In other words, the flat tubes 20 of the heat-exchanger unit 100 according to Embodiment 1 each have the longitudinal axis 26 extending along a virtual straight line L4 connecting the first end 21 of the flat tube 20 and the rotation center axis 61 of the air-sending device 2. In contrast, in the heat-exchanger unit 200 according to Embodiment 2, the extending direction of the longitudinal axis 26 of each of the plurality of flat tubes 20 of the heat exchanger 210 is inclined from the virtual straight line L4. In each of the plurality of flat tubes 20 of the heat exchanger 210, the longitudinal axis 26 is inclined in the rotation direction of the air-sending device 2 from the first end 21, which is a starting point at which the longitudinal axis 26 is inclined.

[0030] The air from the air-sending device 2 is blown out in a direction of an arrow 63 as illustrated in Fig. 10. The air is directed in a direction inclined outward in the radial direction from the tangential direction of the outer periphery of the air-sending device 2. Therefore, the arrow 63 indicating a flowing direction of the air from the air-sending device 2 forms an angle close to a right angle with the virtual straight line L4, which connects the rotation center axis 61 and each of the first ends 21 of the flat tubes 20. In Embodiment 2, however, the longitudinal axis 26 of each of the flat tubes 20 is inclined from the virtual straight line L4, and extends with an angle substantially parallel to the arrow 63, which indicates the flowing direction of the air from the air-sending device 2. Accordingly, the flowing direction of the air from the air-sending device 2 is not largely bent when the air enters between the flat tubes 20, and pressure loss and reduction of the flow speed of the air are small. Consequently, the heat exchanger 210 of the heat-exchanger unit 200 according to Embodiment 2 can improve the heat exchange efficiency and the mounting efficiency, as compared with the heat exchanger 10 of the heat-exchanger unit 100 according to Embodiment 1.

[0031] Note that the arrangement of the flat tubes 20 of the heat exchanger 210 according to Embodiment 2 is applicable to the heat exchanger 10a of the heat-exchanger unit 100a according to Embodiment 1. At this time, the inclination angles of the flat tubes 20 are appropriately changeable depending on positions on the virtual annular line 23a.

Embodiment 3

[0032] A heat-exchanger unit 300 according to Embodiment 3 has a configuration in which first fins 50 are added to the respective flat tubes 20 of the heat exchanger 10 of the heat-exchanger unit 100 according to Embodiment 1. The heat-exchanger unit 300 according to Embodiment 3 is described with a focus on changes from Embodiment 1. Components of the heat-exchanger unit 300 according to Embodiment 3 having the same functions among the drawings are illustrated with the same reference signs in the drawings used for description of Embodiment 1.

[0033] Fig. 11 is an explanatory diagram of positional relationship between the air-sending device 2 and a plurality of flat tubes 320 of a heat exchanger 310 of the heat-exchanger unit 300 according to Embodiment 3. Fig. 12 is a schematic diagram to explain a structure of one flat tube 320 included in the heat exchanger 310 in Fig. 11. As illustrated in Fig. 11, in the heat exchanger 310, the plurality of flat tubes 320 are arranged in a manner similar to the heat exchanger 10 according to Embodiment 1. On the other hand, in Embodiment 3, the first fins 50 extend inward in the radial direction from the respective first ends 21 of the plurality of flat tubes 320. In other words, each of the flat tubes 320 includes the first fin 50 having a plate shape and extending from the first end 21 toward the inside air duct 70.

[0034] As illustrated in Fig. 11, each of the first fins 50 is inclined from the virtual straight line L4 connecting the rotation center axis 61 and the corresponding first end 21, in a direction opposite to the rotation direction of the air-sending device 2, from the first end 21, which is a starting point at which the first fin 50 is inclined. The air blown out from the air-sending device 2 travels in the direction of the arrow 63, and an extending direction of each of the first fins 50 and a flowing direction of the air from the air-sending device 2 form an angle close to parallels. Therefore, the air from the air-sending device 2 is small in a bending angle when entering between the first fin 50 provided to a first flat tube 320a and the first fin 50 provided to a second flat tube 320b. As the flowing direction of the air from the air-sending device 2 is not largely bent when the air enters between the first fins 50, pressure loss and reduction of the flow speed of the air are small. Consequently, the heat exchanger 310 of the heat-exchanger unit 300 according to Embodiment 3 can improve the heat exchange efficiency and the mounting efficiency, as compared with the heat exchanger 10 of the heat-exchanger unit 100 according to Embodiment 1. Further, as the first fins 50 are installed, an area of the heat exchanger 310 contacting with the air is increased as compared with the heat exchanger 10 according to Embodiment 1, which makes it possible to improve the heat exchange efficiency. Note that, in Embodiment 3, the first fins 50 are provided to all of the first flat tube 320a, the second flat tube 320b, and a third flat tube 320c; however, it is unnecessary to provide the first fins

50 to all of the plurality of adjacent flat tubes 320, and the first fins may be provided to only a part of the plurality of flat tubes 320.

Embodiment 4

[0035] A heat-exchanger unit 400 according to Embodiment 4 has a configuration in which a fin is added to each of the plurality of flat tubes 320 of the heat exchanger 310 of the heat-exchanger unit 300 according to Embodiment 3. The heat-exchanger unit 400 according to Embodiment 4 is described with a focus on changes from Embodiment 3. Components of the heat-exchanger unit 400 according to Embodiment 4 having the same functions among the drawings are illustrated with the same reference signs in the drawings used for description of Embodiment 1.

[0036] Fig. 13 is an explanatory diagram of positional relationship between the air-sending device 2 and a plurality of flat tubes 20 of a heat exchanger 410 of the heat-exchanger unit 400 according to Embodiment 4. Fig. 14 is a schematic diagram to explain a structure of one flat tube 20 included in the heat exchanger 410 in Fig. 13. In the heat exchanger 410, second fins 51 extend outward in the radial direction from the respective second ends 22 of the flat tubes 420. In other words, each of the flat tubes 420 includes the second fin 51 having a plate shape and extending from the second end 22 toward the outside air duct 71. As illustrated in Fig. 13, each of the first fins 50 extends along the virtual straight line L4, which connects the rotation center axis 61 and the first end 21. As the second fins 51 are installed, an area of the heat exchanger 410 contacting with the air is increased as compared with the heat exchanger 310 according to Embodiment 3, which makes it possible to improve the heat exchange efficiency.

[0037] Fig. 15 is a schematic diagram of a structure in a section perpendicular to the rotation center axis 61 of the air-sending device 2 of the heat-exchanger unit 400 according to Embodiment 4. The inclination angles of the second fins 51 provided to the respective flat tubes 420 of the heat exchanger 410 according to Embodiment 4 may be appropriately changed depending on positions of the flat tubes 20. In other words, when a shortest path from one second end 22 to the opening port 81 through the outside air duct 71 is defined, the corresponding second fin 51 is inclined toward the shortest path from the second end 22, which is a starting point at which the second fin 51 is inclined. For example, in Fig. 15, the second fin 51 provided to a flat tube 420x that is one of the plurality of flat tubes 420 is inclined leftward from the second end 22 of the flat tube 420x, which is a starting point at which the second fin 51 is inclined. As the shortest path from the second end 22 of the flat tube 420x to the opening port 81, which is an outlet of the outside air duct 71, through the outside air duct 71, a path R1 and a path R2 are considered as illustrated in Fig. 15. In Fig. 15, the path R1 is shorter than the path R2, and the shortest path

from the second end 22 of the flat tube 420x to the opening port 81 is the path R1. Accordingly, each of the second fins 51 is inclined toward the path R1 from the corresponding second end 22, which is a starting point at which the second fin 51 is inclined. More specifically, a front end of each of the second fins 51 is inclined toward the path R1 from a virtual straight line L5 connecting the second end 22 and the rotation center axis 61 of the air-sending device 2.

[0038] As illustrated in Fig. 15, when each of the second fins 51 is inclined toward the shortest path R1 from the corresponding flat tube 420 to the opening port 81 through the outside air duct 71, the flow of the air flowing out between the flat tubes 420 is hardly separated along the second fins 51. This makes it possible to reduce increase in pressure loss caused by addition of the second fins 51.

[0039] The first fins 50 and the second fins 51 in Embodiments 3 and 4 are applicable to the heat-exchanger unit 200 according to Embodiment 2. In this case, the inclination angles of the first fins 50 and the second fins 51 are appropriately changeable to reduce increase in pressure loss of the air flow. Further, in each of the heat-exchanger units 100, 100a, 100b, 200, 300, and 400 according to Embodiments 1 to 4, not only the centrifugal air-sending device but also an axial flow air-sending device or other air-sending device is applicable to the air-sending device 2. At this time, the shapes of the inside air duct 70 and the outside air duct 71 are also appropriately changeable.

Reference Signs List

[0040] 1 refrigeration cycle apparatus 2 air-sending device 3 compressor 4 four-way valve 5 outdoor heat exchanger 6 expansion device 7 indoor heat exchanger 8 outdoor unit 9 indoor unit 10 heat exchanger 10a heat exchanger 10b heat exchanger 20 flat tube 20a first flat tube 20b second flat tube 20c third flat tube 20d first flat tube 20e second flat tube 20f third flat tube 21 first end 22 second end 23 virtual line 23a virtual line 24 refrigerant flow path 26 longitudinal axis 27 short axis 30 first header 40 second header 41 strength part 50 first fin 51 second fin 60 air-sending device 61 rotation center axis 63 arrow 70 inside air duct 71 outside air duct 80 casing 81 opening port 82 opening port 90 refrigerant pipe 100 heat-exchanger unit 100a heat-exchanger unit 100b heat-exchanger unit 110 heat exchanger 120 flat tube 120a flat tube 120b flat tube 120c flat tube 120f flat tube 120h flat tube 120i flat tube 121 first end 123 virtual line 128 straight line portion 129 corner 200 heat-exchanger unit 210 heat exchanger 300 heat-exchanger unit 310 heat exchanger 320 flat tube 320a first flat tube 320b second flat tube 320c third flat tube 400 heat-exchanger unit 410 heat exchanger 420 flat tube 420x flat tube 1100 heat-exchanger unit L virtual straight line L1 virtual straight line L2 virtual straight line L4 virtual straight line L5 virtual straight line R1 (shortest) path R2 path $\theta 1$ angle $\theta 2$ angle

Claims**1.** A heat-exchanger unit, comprising:

an air-sending device configured to send outside air into a casing; and
 a heat exchanger laterally surrounding a rotation center axis of the air-sending device, the heat exchanger including
 a plurality of flat tubes arranged in parallel and surrounding the rotation center axis of the air-sending device, the plurality of flat tubes each having a pipe axis extending in a vertical direction, and
 a header connecting the plurality of flat tubes, the plurality of flat tubes including a first flat tube, a second flat tube, and a third flat tube, each of the second flat tube and the third flat tube being placed adjacent to the first flat tube, where a radial direction through each of the first flat tube, the second flat tube, and the third flat tube has the rotation center axis of the air-sending device as a center of the radial direction, each of the first flat tube, the second flat tube, and the third flat tube having, among two ends of a longitudinal axis of a section perpendicular to the pipe axis, a first end positioned closer to the center of the radial direction than is an other end, the first ends being arranged on a virtual annular line surrounding the rotation center axis, the first end of the first flat tube being placed further away from the center of the radial direction than is a virtual straight line connecting the first end of the second flat tube and the first end of the third flat tube.

2. The heat-exchanger unit of claim 1, wherein a first virtual line that is an extension of the longitudinal axis of the section perpendicular to the pipe axis of the first flat tube intersects with each of a second virtual line that is an extension of the longitudinal axis of the second flat tube and a third virtual line that is an extension of the longitudinal axis of the third flat tube at a position close to the center of the radial direction.

3. The heat-exchanger unit of claim 1 or 2, wherein the first ends of the first flat tube, the second flat tube, and the third flat tube are each arranged at an equal distance from the rotation center axis.

4. The heat-exchanger unit of any one of claims 1 to 3, wherein sets of the first flat tube, the second flat tube, and the third flat tube are arranged on an entire circumference around the air-sending device.

5. The heat-exchanger unit of any one of claims 1 to 4, wherein the plurality of flat tubes consist of the first

flat tube, the second flat tube, and the third flat tube.

6. The heat-exchanger unit of any one of claims 1 to 5, further comprising an inside air duct provided with the air-sending device, the inside air duct being provided inside the heat exchanger in the radial direction, wherein
 at least one of the plurality of flat tubes includes a first fin having a plate shape and extending toward the inside air duct from the first end.

7. The heat-exchanger unit of claim 6, wherein the air-sending device is a centrifugal air-sending device, and
 the first fin is inclined from a virtual straight line connecting the rotation center axis and the first end, in a direction opposite to a rotation direction of the air-sending device, from the first end, which is a starting point at which the first fin is inclined.

8. The heat-exchanger unit of any one of claims 1 to 6, further comprising an outside air duct provided outside the heat exchanger in the radial direction, wherein
 at least one of the plurality of flat tubes includes a second fin having a plate shape and extending toward the outside air duct from a second end positioned outward in the radial direction among the two ends of the longitudinal axis of the section perpendicular to the pipe axis.

9. The heat-exchanger unit of claim 8, wherein the second fin is inclined from the longitudinal axis of the section perpendicular to the pipe axis.

10. The heat-exchanger unit of claim 9, wherein the outside air duct is provided between an air duct outer wall surrounding the heat exchanger and placed away from the center of the radial direction and an outer periphery of the heat exchanger, the air duct outer wall includes an opening port through which the outside air duct communicates with an outside of the outside air duct, and when a shortest path from the second end to the opening port through the outside air duct is defined, the second fin is inclined toward the shortest path from the second end, which is a starting point at which the second fin is inclined.

11. The heat-exchanger unit of any one of claims 1 to 10, wherein
 the air-sending device is a centrifugal air-sending device, and
 in each of the first flat tube, the second flat tube, and the third flat tube, the longitudinal axis of the section perpendicular to the pipe axis is inclined from a straight line connecting the rotation center axis and the first end, in a rotation direction of the air-sending

device, from the first end, which is a starting point at which the longitudinal axis is inclined.

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

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FIG. 1

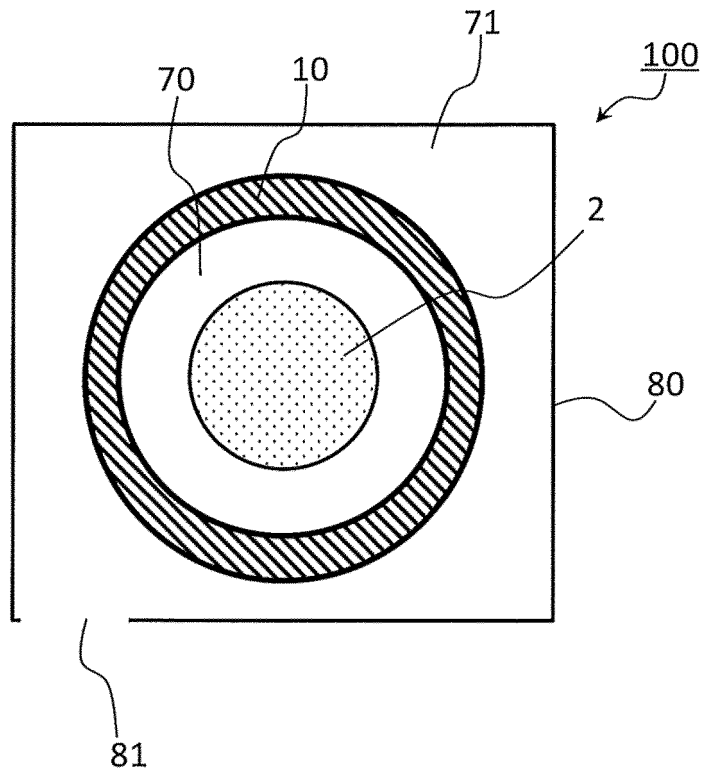


FIG. 2

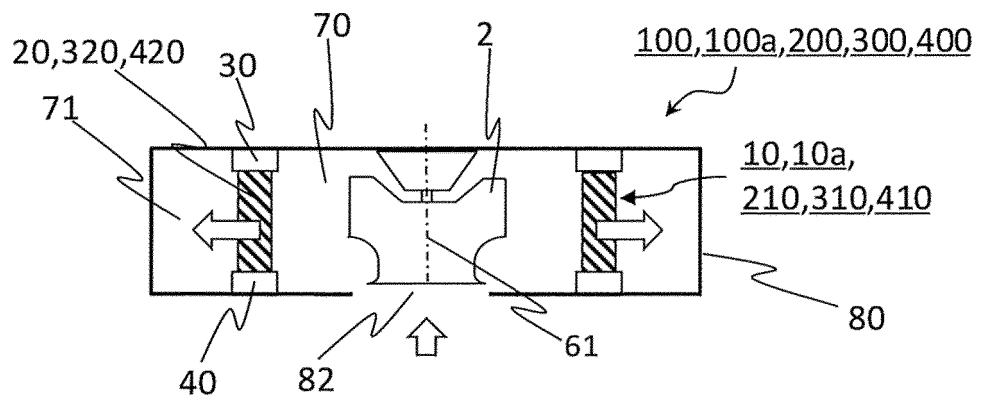


FIG. 3

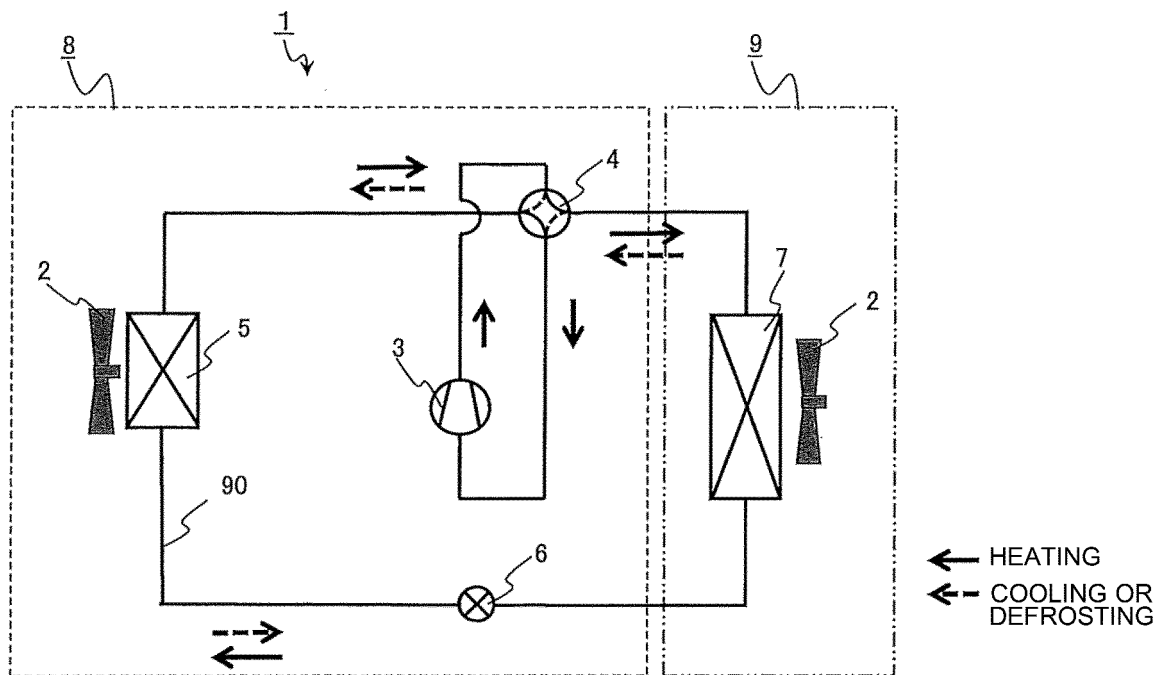


FIG. 4

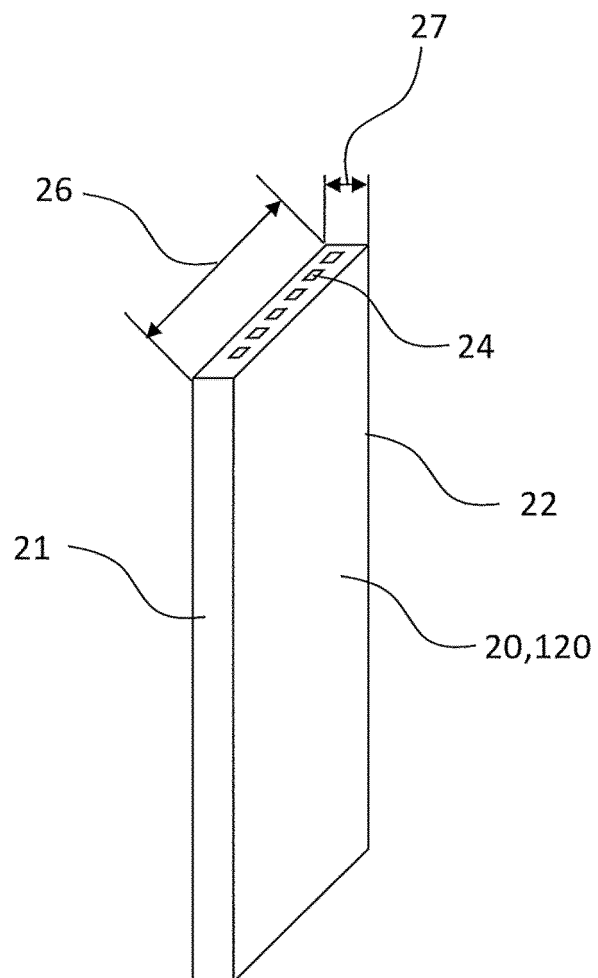


FIG. 5

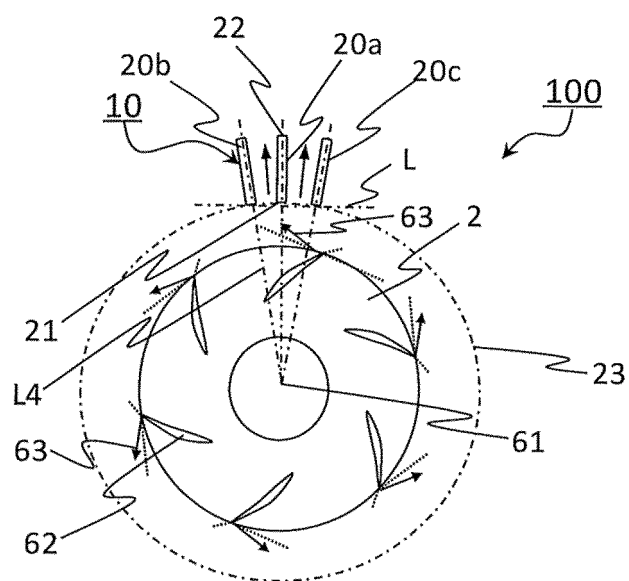


FIG. 6

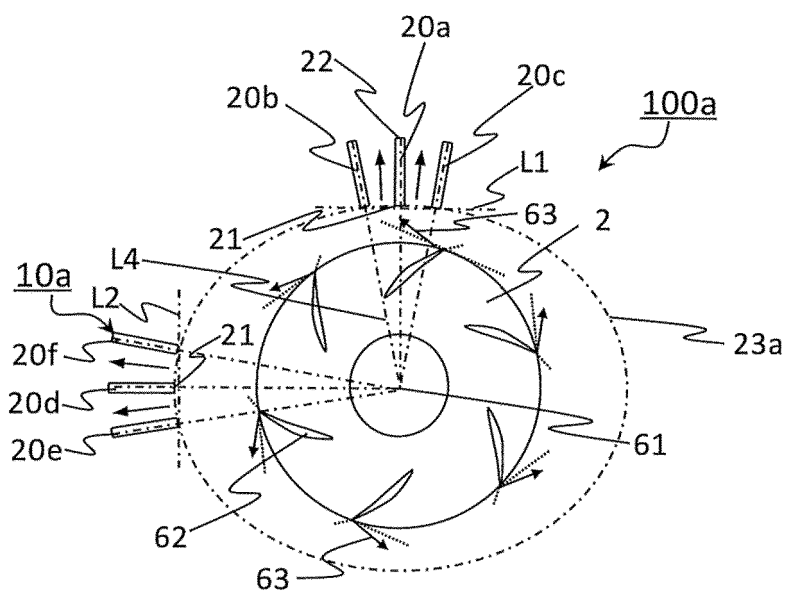


FIG. 7

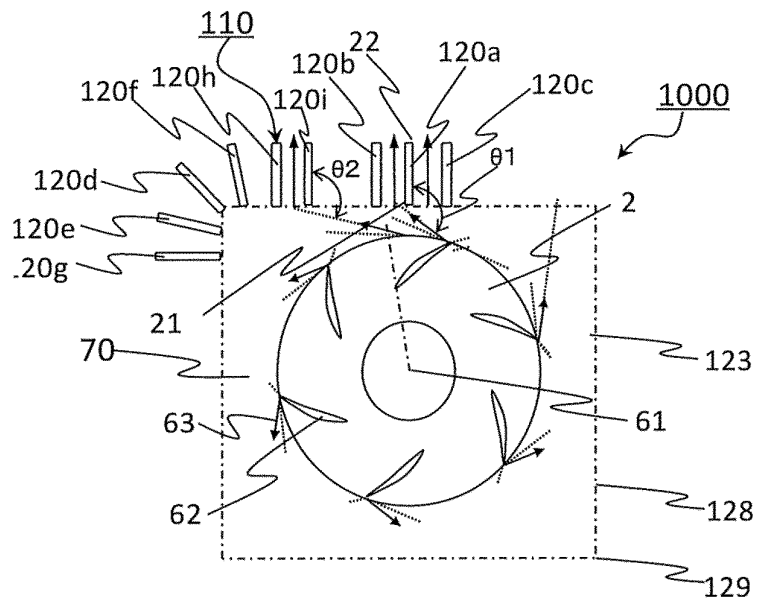


FIG. 8

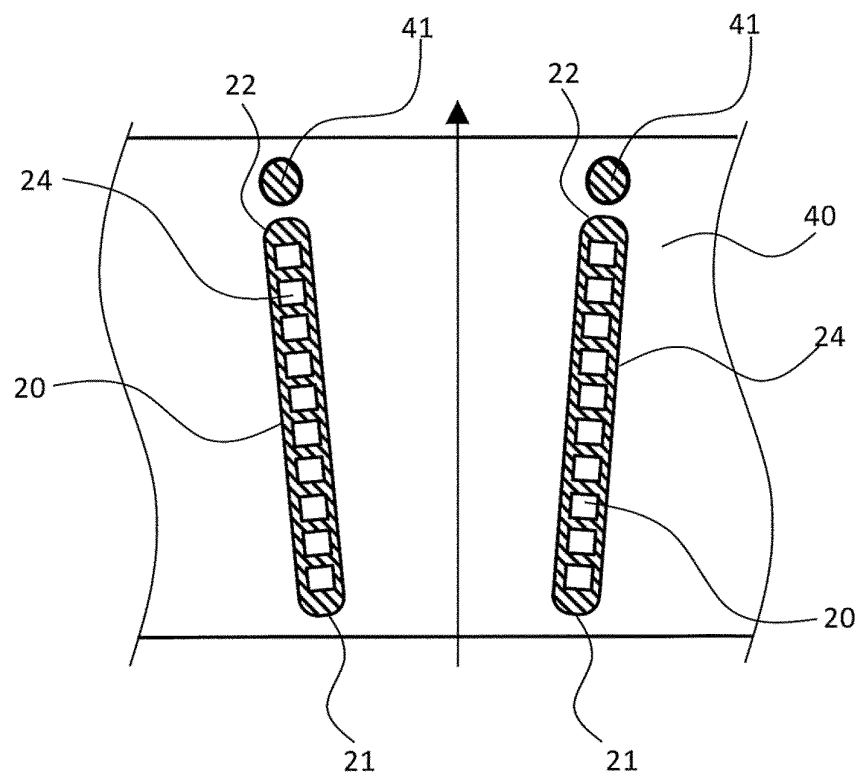


FIG. 9

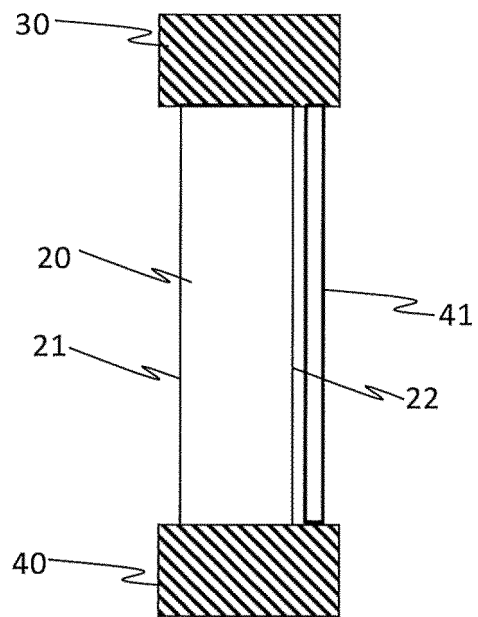


FIG. 10

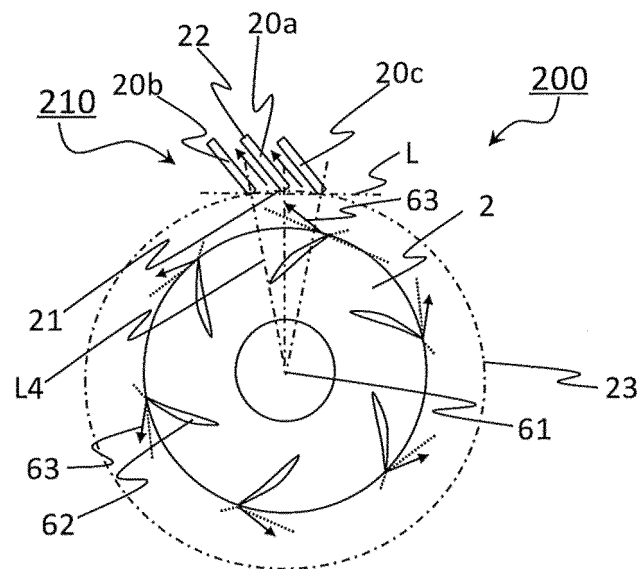


FIG. 11

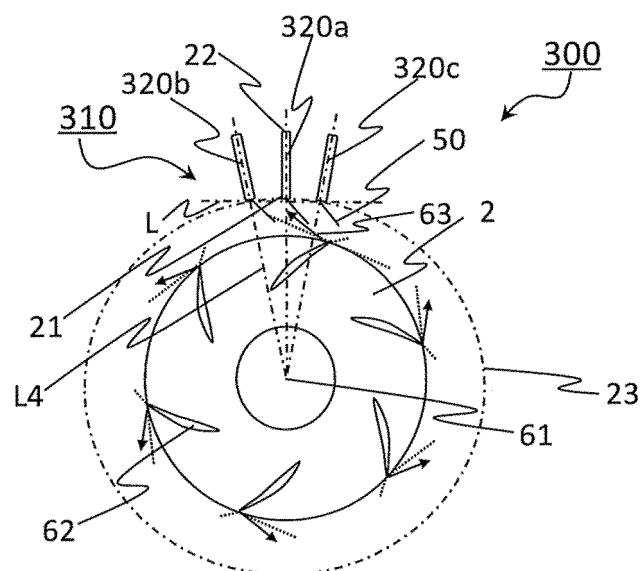


FIG. 12

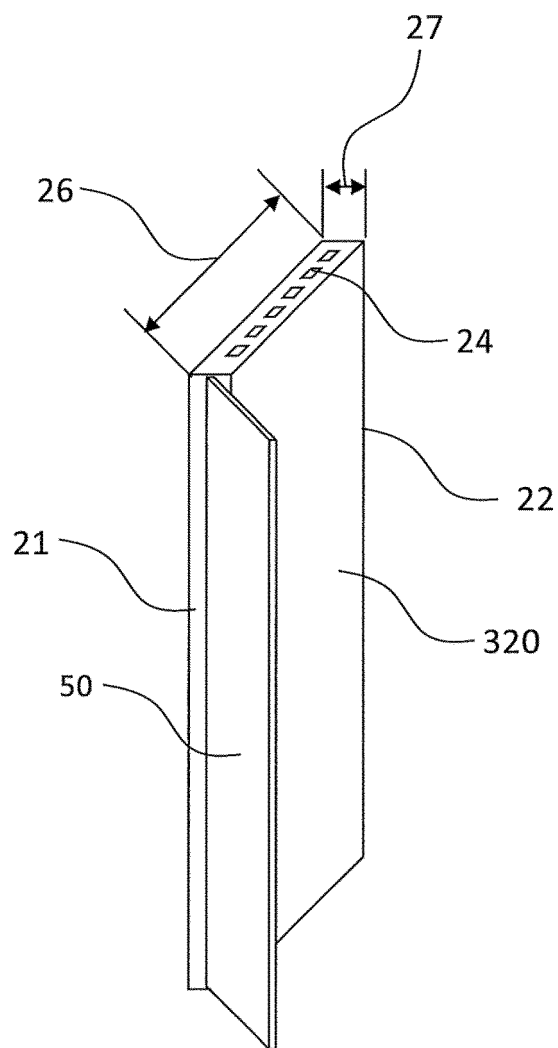


FIG. 13

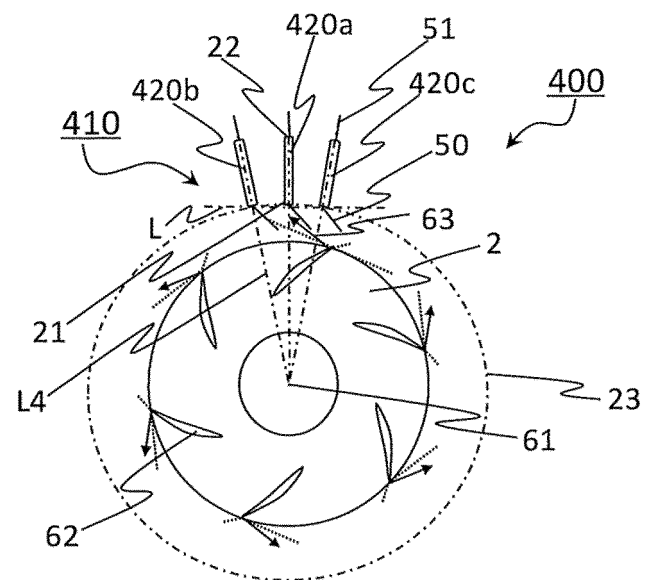


FIG. 14

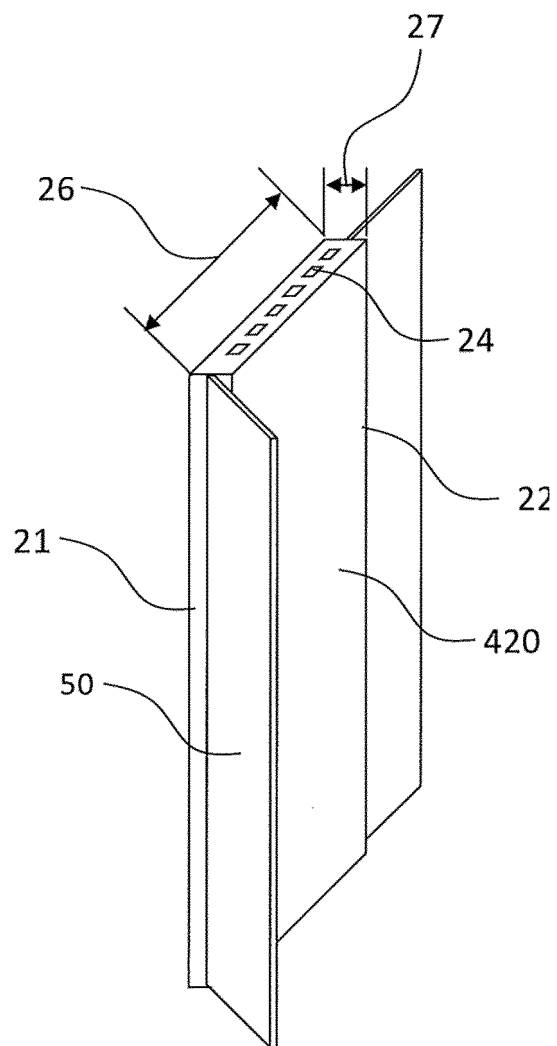
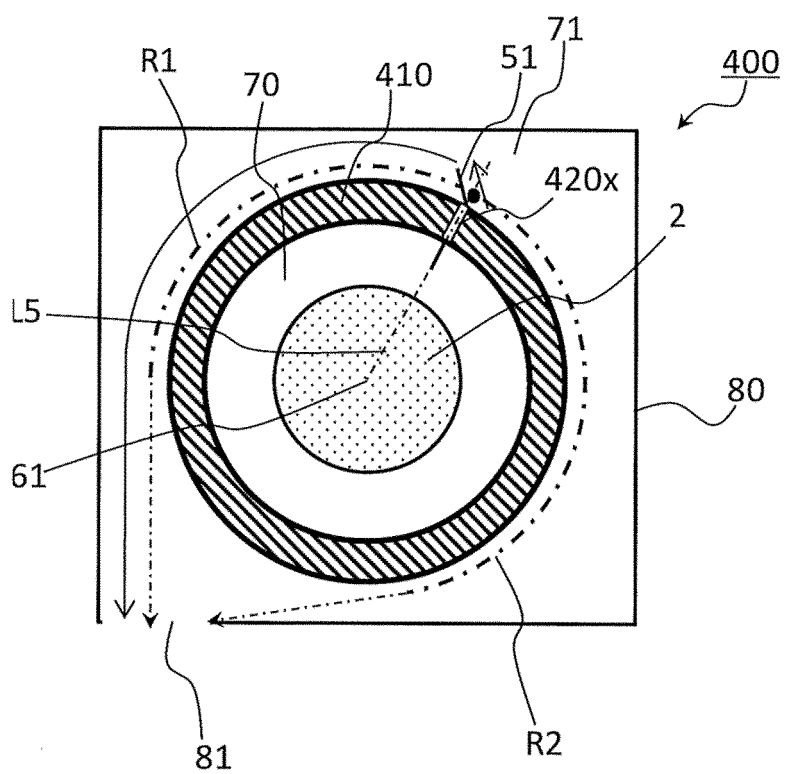


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/031151

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F24F1/14 (2011.01) i, F24F1/00 (2011.01) i, F24F1/18 (2011.01) i,
F24F13/30 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl. F24F1/14, F24F1/00, F24F1/18, F24F13/30

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 1971-2018
Registered utility model specifications of Japan 1996-2018
Published registered utility model applications of Japan 1994-2018

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2013-139971 A (MITSUBISHI ELECTRIC CORP.) 18	1-2, 12
Y	July 2013, paragraphs [0009]-[0036], fig. 1-5	3-5
A	(Family: none)	6-11
Y	JP 11-153344 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 08 June 1999, fig. 1 (Family: none)	3-5
Y	JP 9-89363 A (SANYO ELECTRIC CO., LTD.) 04 April 1997, fig. 2, 3 (Family: none)	3-5
Y	JP 2001-124359 A (HITACHI, LTD.) 11 May 2001, fig. 3, 5 (Family: none)	3-5
A	JP 2013-19596 A (MITSUBISHI ELECTRIC CORP.) 31 January 2013, fig. 12 (Family: none)	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

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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

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

"&"

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Date of the actual completion of the international search
19.09.2018

Date of mailing of the international search report
02.10.2018

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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/031151

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005-90806 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 07 April 2005, entire text, all drawings & CN 1598467 A	1-12
A	JP 2002-195774 A (DAIKIN INDUSTRIES, LTD.) 10 July 2002, entire text, all drawings (Family: none)	1-12
A	JP 2004-60622 A (DAIKIN INDUSTRIES, LTD.) 26 February 2004, fig. 7 (Family: none)	6-11
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 26019/1982 (Laid-open No. 129424/1983) (KIMURA KOHKI CO., LTD.) 01 September 1983, fig. 3 (Family: none)	6-10
A	JP 2016-142431 A (JOHNSON CONTROLS HITACHI AIR CONDITIONING TECH (HONGKONG) LTD.) 08 August 2016, entire text, all drawings & US 2016/0223211 A1, entire text, all drawings & CN 105864885 A	6-7

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 4684085 B [0003]