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(54) **HEAT EXCHANGING UNIT**

(57) A plurality of flat tubes (63) constituting a heat exchanger (11) are divided into a plurality of heat exchange parts (60A to 60K) arranged one above the other. The heat exchange parts (60A to 60K) respectively include main heat exchange parts (61Ato 61K), and auxiliary heat exchange parts (62A to 62K) respectively disposed below the main heat exchange parts (61A to 61K) and connected in series through folded communication spaces (92A to 92K) of a header collecting pipe (90). The number of flat tubes (63) constituting each of the heat exchange parts (60A to 60D) disposed on an upper side of the heat exchanger (11) is set to be smaller than the number of flat tubes (63) constituting each of the heat exchange parts (601 to 60K) disposed on a lower side of the heat exchanger (11), in accordance with air velocity distribution.

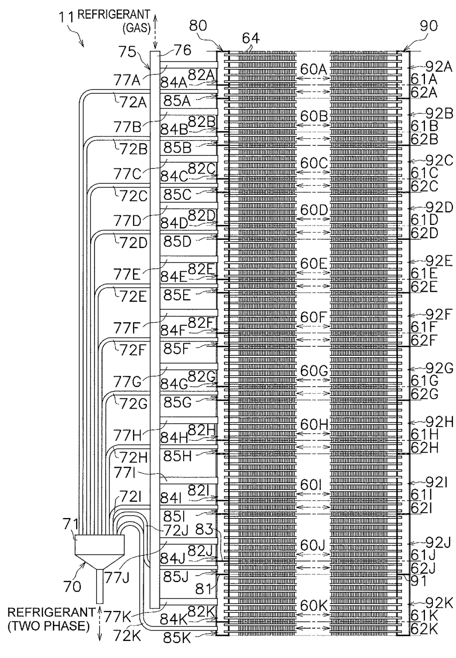


FIG. 6

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a heat exchange unit, particularly a heat exchange unit that includes: a casing having a suction port in its side surface, and a blow-out port in its top surface; a fan disposed facing the blow-out port; and a heat exchanger disposed below the fan.

### BACKGROUND ART

**[0002]** In the related art, a heat exchanger including a plurality of flat tubes arranged one above the other is sometimes employed as an outdoor heat exchanger housed in an outdoor unit of an air conditioning apparatus. Patent Literature 1 (JP 2012-163319 A) discloses such a heat exchanger including a plurality of flat tubes. The flat tubes are divided into a plurality of main heat exchange parts collectively disposed on an upper side of the heat exchanger, and a plurality of auxiliary heat exchange parts collectively disposed below the main heat exchange parts. The main heat exchange parts and the auxiliary heat exchange parts are connected via communication pipes to form a plurality of heat exchange parts.

**[0003]** Also in the related art, a heat exchange unit (an upward blowing-type heat exchange unit) is sometimes employed as an outdoor unit of an air conditioning apparatus. The heat exchange unit includes: a casing having a suction port in its side surface, and a blow-out port in its top surface; a fan disposed facing the blow-out port; and a heat exchanger disposed below the fan.

### SUMMARY OF THE INVENTION

**[0004]** The heat exchanger disclosed in Patent Literature 1 may be employed as the heat exchanger constituting the upward blowing-type heat exchange unit.

**[0005]** In the upward blowing-type heat exchange unit, however, the heat exchanger is disposed below the fan. Consequently, the velocity of air passing through the heat exchanger at the upper side of the heat exchanger tends to be higher than the velocity of air passing through the heat exchanger at the lower side of the heat exchanger. In cases where the heat exchanger disclosed in Patent Literature 1 is employed for the upward blowing-type heat exchange unit, when the heat exchanger functions as an evaporator for a refrigerant, the refrigerant flowing through each of the flat tubes disposed on the upper side of the heat exchanger is susceptible to heat exchange as compared with the refrigerant flowing through each of the flat tubes disposed on the lower side of the heat exchanger. This results in variations in degree of heat exchange among the flat tubes, leading to deviations in degree of heat exchange among the heat exchange parts.

**[0006]** In order to eliminate the deviations in degree of heat exchange among the heat exchange parts, the refrigerant should be appropriately shunted to the respective heat exchange parts in accordance with air velocity distribution in the heat exchanger. According to the heat exchanger disclosed in Patent Literature 1, however, all the main heat exchange parts constituting the respective heat exchange parts are collectively disposed on the upper side of the heat exchanger, and all the auxiliary heat exchange parts constituting the respective heat exchange parts are collectively disposed below the main heat exchange parts. With regard to the respective heat exchange parts, the heat exchange parts are disposed on the upper side of the heat exchanger where air flows at high velocity and the lower side of the heat exchanger where air flows at low velocity. This configuration hinders the appropriate shunt of the refrigerant according to the air velocity distribution in the heat exchanger. In addition, the main heat exchange parts and the auxiliary heat exchange parts are connected via the communication pipes. However, the communication pipes are significantly different in length and head difference from one another among the heat exchange parts. This configuration also hinders the appropriate shunt of the refrigerant according to the air velocity distribution in the heat exchanger.

**[0007]** As described above, in cases where the heat exchanger disclosed in Patent Literature 1 is employed as the heat exchanger constituting the upward blowing-type heat exchange unit, in causing the heat exchanger to function as the evaporator for the refrigerant, it is difficult to appropriately shunt the refrigerant to the respective heat exchange parts in accordance with the air velocity distribution in the heat exchanger. An improvement in shunting performance has therefore been required.

**[0008]** The present invention provides a heat exchange unit with improved shunting performance in causing a heat exchanger to function as an evaporator for a refrigerant, the heat exchange unit including: a casing having a suction port in its side surface, and a blow-out port in its top surface; a fan disposed facing the blow-out port; and a heat exchanger disposed below the fan.

**[0009]** A first aspect provides a heat exchange unit including a casing, a fan, and a heat exchanger. The casing has a suction port in its side surface, and a blow-out port in its top surface. The fan is disposed facing the blow-out port in the casing, is configured to feed air into the casing through the suction port, and is configured to discharge air from the casing through the blow-out port. The heat exchanger is disposed below the fan in the casing, and is configured to cause a refrigerant to exchange heat with air. The heat exchanger includes: a header collecting pipe disposed upright; a plurality of flat tubes each having one end connected to the header collecting pipe; and a plurality of fins each defining a space between adjoining the flat tubes as plurality airflow paths through which air flows. The flat tubes are arranged one above the other, and each include a passage through which the refrigerant flows. The flat tubes are divided into a plurality of heat exchange parts arranged one above the other. The header collecting pipe has an internal space partitioned vertically into a plurality of folded communication spaces for the heat exchange parts. The heat exchange parts respectively include main heat exchange parts, and auxiliary heat exchange parts respectively disposed below the main heat exchange parts and connected in series through the folded communication spaces. The number of flat tubes constituting each of the heat exchange parts disposed on an upper side of the heat exchanger is set to be smaller than the number of flat tubes constituting each of the heat exchange parts disposed on a lower side of the heat exchanger, in accordance with air velocity distribution in the heat exchanger.

**[0010]** According to the first aspect, the heat exchanger constituting an upward blowing-type heat exchange unit includes the plurality of heat exchange parts arranged one above the other. The heat exchange parts respectively include the main heat exchange parts, and the auxiliary heat exchange parts respectively disposed below the main heat exchange parts and connected in series through the folded communication spaces of the header collecting pipe. This configuration is therefore different from the configuration disclosed in Patent Literature 1. Specifically, the heat exchange parts are arranged in conformity with the air velocity distribution in the heat exchanger. In addition, this configuration eliminates the necessity of communication pipes for connecting the main heat exchange parts to the auxiliary heat exchange parts.

**[0011]** According to the first aspect, hence, the heat exchange parts are arranged in conformity with the air velocity distribution in the heat exchanger, and the number of flat tubes constituting each of the heat exchange parts disposed on the upper side of the heat exchanger is set to be smaller than the number of flat tubes constituting each of the heat exchange parts disposed on the lower side of the heat exchanger, in accordance with the air velocity distribution in the heat exchanger, as described above. Therefore, the heat exchange parts disposed on the upper side of the heat exchanger become smaller in heat transfer area than the heat exchange parts disposed on the lower side of the heat exchanger. This configuration thus eliminates deviations in degree of heat exchange between the heat exchange parts disposed on the upper side of the heat exchanger and the heat exchange parts disposed on the lower side of the heat exchanger.

**[0012]** This configuration therefore enables an appropriate shunt of the refrigerant to the respective heat exchange parts in accordance with the air velocity distribution in the heat exchanger, and thus improves shunting performance in causing the heat exchanger to function as an evaporator for the refrigerant.

**[0013]** A second aspect provides the heat exchange unit according to the first aspect, wherein the number of flat tubes constituting each of the main heat exchange parts of the heat exchange parts disposed on the upper side of the heat exchanger is smaller than the number of flat tubes constituting each of the main heat exchange parts of the heat exchange parts disposed on the lower side of the heat exchanger.

**[0014]** The degree of heat exchange among the heat exchange parts is significantly influenced by the size of heat transfer areas of the main heat exchange parts through which the gaseous refrigerant flows in large amounts, in causing the heat exchanger to function as the evaporator for the refrigerant.

**[0015]** According to the second aspect, hence, the number of flat tubes constituting each of the heat exchange parts disposed on the upper side of the heat exchanger is set to be smaller than the number of flat tubes constituting each of the heat exchange parts disposed on the lower side of the heat exchanger, by changing the number of flat tubes constituting each of the main heat exchange parts of the heat exchange parts, as described above.

**[0016]** This configuration thus improves the shunting performance in causing the heat exchanger to function as the evaporator for the refrigerant, by changing the number of flat tubes constituting each of the main heat exchange parts exerting a significant influence on the degree of heat exchange among the heat exchange parts.

**[0017]** A third aspect provides the heat exchange unit according to the first or second aspect, wherein the number of flat tubes constituting the heat exchange part disposed on an uppermost side of the heat exchanger is 0.6 to 0.9 times a value obtained by dividing the total number of flat tubes constituting the heat exchanger by the number of heat exchange parts.

**[0018]** Although a positional relation between the fan and the heat exchanger, and other conditions have an influence, the heat transfer area of the heat exchange part disposed on the uppermost side of the heat exchanger is preferably set to be about 0.6 to 0.9 times an average heat transfer area of all the heat exchange parts in view of the air velocity distribution in the heat exchanger.

**[0019]** According to the third aspect, hence, the number of flat tubes constituting the uppermost heat exchange part is set to be 0.6 to 0.9 times the average number of flat tubes constituting each heat exchange part, that is, the value obtained by dividing the total number of flat tubes constituting the heat exchanger by the number of heat exchange parts, as described above.

**[0020]** This configuration thus improves the shunting performance in causing the heat exchanger to function as the evaporator for the refrigerant, by appropriately setting the number of flat tubes constituting the uppermost heat exchange part in view of the air velocity distribution in the heat exchanger.

**[0021]** A fourth aspect provides the heat exchange unit according to any of the first to third aspects, wherein in each of the heat exchange parts, a ratio of the number of flat tubes constituting each of the main heat exchange parts to the number of flat tubes constituting each of the auxiliary heat exchange parts is 1.5 to 4.5.

**[0022]** In causing the heat exchanger to function as the evaporator for the refrigerant, in each of the heat exchange parts, the refrigerants flowing into the folded communication spaces through the auxiliary heat exchange parts are shunted and supplied to the flat tubes constituting the main heat exchange parts. At this time, the gaseous refrigerants flow in large amounts through the main heat exchange parts. Therefore, the number of flat tubes constituting each of the main heat exchange parts is preferably larger than the number of flat tubes constituting each of the auxiliary heat exchange parts, from the viewpoints of reducing pressure loss and ensuring a heat transfer area. However, if the number of flat tubes constituting the main heat exchange parts is considerably large, it is difficult to achieve a shunt from the folded communication spaces to the flat tubes constituting the main heat exchange parts. In view of this, preferably, in each of the heat exchange parts, the ratio of the number of flat tubes constituting each of the main heat exchange parts to the number of flat tubes constituting each of the auxiliary heat exchange parts falls within a certain range.

**[0023]** According to the fourth aspect, hence, in each of the heat exchange parts, the ratio of the number of flat tubes constituting each of the main heat exchange parts to the number of flat tubes constituting each of the auxiliary heat exchange parts falls within the range of 1.5 to 4.5, as described above.

**[0024]** This configuration thus improves the shunting performance in causing the heat exchanger to function as the evaporator for the refrigerant, by appropriately setting the ratio of the number of flat tubes constituting each of the main heat exchange parts to the number of flat tubes constituting each of the auxiliary heat exchange parts in each of the heat exchange parts in view of the shunt from the folded communication spaces to the flat tubes constituting the main heat exchange parts.

**[0025]** A fifth aspect provides the heat exchange unit according to any of the first to fourth aspects, wherein the fins have fin cut portions formed at positions corresponding to boundaries between the main heat exchange parts and the auxiliary heat exchange parts to suppress vertical heat conduction at the boundaries.

**[0026]** The heat exchanger includes the heat exchange parts arranged one above the other. The heat exchange parts respectively include the main heat exchange parts, and the auxiliary heat exchange parts respectively disposed below the main heat exchange parts and connected in series through the folded communication spaces of the header collecting pipe. According to this configuration, the fins conduct heat between the main heat exchange parts and the auxiliary heat exchange parts adjoining the main heat exchange parts. In causing the heat exchanger to function as the evaporator for the refrigerant, the main heat exchange parts are cooled by the auxiliary heat exchange parts due to the occurrence of heat conduction. Consequently, the refrigerants flowing through the main heat exchange parts are unsatisfactorily heated, which may lead to degradation in evaporating performance of the heat exchanger. In causing the heat exchanger to function as a radiator for the refrigerant, the auxiliary heat exchange parts are heated by the main heat exchange parts. Consequently, the refrigerants flowing through the auxiliary heat exchange parts are unsatisfactorily cooled, which may lead to degradation in heat radiating performance of the heat exchanger.

**[0027]** According to the fifth aspect, hence, the fins have the fin cut portions formed at the positions corresponding to the boundaries between the main heat exchange parts and the auxiliary heat exchange parts to suppress vertical heat conduction at the boundaries, as described above.

**[0028]** With this configuration, the fin cut portions suppress heat conduction between the main heat exchange parts and the auxiliary heat exchange parts through the fins. This configuration thus suppresses degradation in evaporating performance and heat radiating performance of the heat exchanger.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0029]**

FIG. 1 is a schematic configuration diagram of an air conditioning apparatus including an outdoor unit that is a heat exchange unit according to an embodiment of the present invention.

FIG. 2 is an external perspective view of the outdoor unit.

FIG. 3 is a front view of the outdoor unit, which depicts only an outdoor heat exchanger among components constituting a refrigerant circuit.

FIG. 4 is a schematic perspective view of the outdoor heat exchanger.

FIG. 5 is a partial enlarged view of heat exchange parts illustrated in FIG. 4.

FIG. 6 is a schematic configuration diagram of the outdoor heat exchanger.

FIG. 7 is a schematic configuration diagram of an outdoor heat exchanger of an outdoor unit that is a heat exchange unit according to a modification.

FIG. 8 is a partial sectional view of the outdoor heat exchanger, taken along line I-I in FIG. 7.

## DESCRIPTION OF EMBODIMENTS

**[0030]** With reference to the drawings, an embodiment and modifications thereof will be described below as to an outdoor unit that is a heat exchange unit according to the present invention. It should be noted that a specific configuration of the outdoor unit that is the heat exchange unit according to the present invention is not limited to the following embodiment and modifications, and may be changed without departing from the gist of the present invention.

(1) Configuration of Air Conditioning Apparatus

**[0031]** FIG. 1 is a schematic configuration diagram of an air conditioning apparatus 1 including an outdoor unit 2 that is a heat exchange unit according to an embodiment of the present invention.

**[0032]** The air conditioning apparatus 1 employs a vapor compression refrigeration cycle to cool and heat, for example, the interior of a building. The air conditioning apparatus 1 mainly includes: the outdoor unit 2; indoor units 3a and 3b; a liquid-refrigerant connection pipe 4 and a gas-refrigerant connection pipe 5 each connecting the outdoor unit 2 to the indoor units 3a and 3b; and a control unit 23 configured to control components constituting the outdoor unit 2, the indoor unit 3a, and the indoor unit 3b. In the air conditioning apparatus 1, the outdoor unit 2 and each of the indoor units 3a and 3b are connected to each other via the connection pipes 4 and 5 to constitute a vapor compression refrigerant circuit 6.

**[0033]** The outdoor unit 2 is installed outdoors. For example, the outdoor unit 2 is installed on the roof of a building or is installed near a wall surface of a building. The outdoor unit 2 constitutes a part of the refrigerant circuit 6. The outdoor unit 2 mainly includes an accumulator 7, a compressor 8, a four-way switching valve 10, an outdoor heat exchanger 11, an outdoor expansion valve 12 serving as an expansion mechanism, a liquid-side shutoff valve 13, a gas-side shutoff valve 14, and an outdoor fan 15. These components and valves are interconnected via refrigerant pipes 16 to 22.

**[0034]** Each of the indoor units 3a and 3b is installed indoors. For example, each of the indoor units 3a and 3b is installed inside a room or in an attic space. Each of the indoor units 3a and 3b constitutes a part of the refrigerant circuit 6. The indoor unit 3a mainly includes an indoor expansion valve 31a, an indoor heat exchanger 32a, and an indoor fan 33a. The indoor unit 3b mainly includes an indoor expansion valve 31b serving as an expansion mechanism, an indoor heat exchanger 32b, and an indoor fan 33b.

**[0035]** The connection pipes 4 and 5 are constructed on site in installing the air conditioning apparatus 1 in, for example, a building. The liquid-refrigerant connection pipe 4 has a first end connected to the liquid-side shutoff valve 13 of the indoor unit 2, and a second end connected to liquid-side ends of the indoor expansion valves 31a and 31b of the indoor units 3a and 3b. The gas-refrigerant connection pipe 5 has a first end connected to the gas-side shutoff valve 14 of the indoor unit 2, and a second end connected to gas-side ends of the indoor heat exchangers 32a and 32b of the indoor units 3a and 3b.

**[0036]** The control unit 23 is configured in such a manner that control boards and the like (not illustrated) of the outdoor unit 2, indoor unit 3a, and indoor unit 3b are connected by communication links. For convenience, FIG. 1 depicts the control unit 23 at a position away from the outdoor unit 2 and the indoor units 3a and 3b. The control unit 23 is configured to control the components 8, 10, 12, 15, 31a, 31b, 33a, and 33b of the outdoor unit 2, indoor unit 3a, and indoor unit 3b in the air conditioning apparatus 1. In other words, the control unit 23 is configured to control operation of the entire air conditioning apparatus 1.

(2) Operation of Air Conditioning Apparatus

**[0037]** With reference to FIG. 1, next, a description will be given of the operation of the air conditioning apparatus 1. The air conditioning apparatus 1 performs a cooling operation to cause a refrigerant to circulate through the compressor 8, the outdoor heat exchanger 11, the outdoor expansion valve 12, each of the indoor expansion valves 31a and 31b, and each of the indoor heat exchangers 32a and 32b in this order. The air conditioning apparatus 1 also performs a heating operation to cause the refrigerant to circulate through the compressor 8, each of the indoor heat exchangers 32a and 32b, each of the indoor expansion valves 31a and 31b, the outdoor expansion valve 12, and the outdoor heat exchanger 11 in this order. It should be noted that the cooling operation and the heating operation are performed by the control unit 23.

**[0038]** During the cooling operation, the four-way switching valve 10 is brought into an outdoor heat radiation state (indicated by a solid line in FIG. 1). In the refrigerant circuit 6, the gas refrigerant at a low pressure in the refrigeration cycle is sucked into the compressor 8. The compressor 8 compresses the low-pressure refrigerant to a high pressure in the refrigeration cycle. The resultant high-pressure gas refrigerant is then discharged from the compressor 8. When the high-pressure gas refrigerant is discharged from the compressor 8, then the high-pressure gas refrigerant is supplied to the outdoor heat exchanger 11 via the four-way switching valve 10. When the high-pressure gas refrigerant is supplied to the outdoor heat exchanger 11, the outdoor heat exchanger 11 functioning as a radiator for the refrigerant causes the high-pressure gas refrigerant to radiate heat by heat exchange with outdoor air supplied as a cooling source from the outdoor fan 15. The outdoor heat exchanger 11 thus turns the high-pressure gas refrigerant into the high-pressure liquid refrigerant. The high-pressure liquid refrigerant, which is obtained by the heat radiation in the outdoor heat exchanger 11, is supplied to each of the indoor expansion valves 31a and 31b via the outdoor expansion valve 12, the liquid-side shutoff valve 13, and the liquid-refrigerant connection pipe 4. When the refrigerant is supplied to each of the indoor expansion valves 31a and 31b, each of the indoor expansion valves 31a and 31b decompresses the refrigerant to the low pressure in the refrigeration cycle to turn the refrigerant into the low-pressure refrigerant in a gas-liquid two-phase state. The low-pressure refrigerant in the gas-liquid two-phase state, which is obtained by the decompression in each of the indoor expansion valves 31a and 31b, is supplied to each of the indoor heat exchangers 32a and 32b. When the low-pressure refrigerant in the gas-liquid two-phase state is supplied to each of the indoor heat exchangers 32a and 32b, each of the indoor heat exchangers 32a and 32b evaporates the low-pressure refrigerant by heat exchange with indoor air supplied as a heating source from each of the indoor fans 33a and 33b. The indoor air is thus cooled. Thereafter, the indoor air is supplied indoors to achieve the cooling operation. The low-pressure gas refrigerant, which is obtained by the evaporation in each of the indoor heat exchangers 32a and 32b, is sucked into the compressor 8 again via the gas-refrigerant connection pipe 5, the gas-side shutoff valve 14, the four-way switching valve 10, and the accumulator 7.

**[0039]** During the heating operation, the four-way switching valve 10 is brought into an outdoor evaporation state (indicated by a broken line in FIG. 1). In the refrigerant circuit 6, the gas refrigerant at the low pressure in the refrigeration cycle is sucked into the compressor 8. The compressor 8 compresses the gas refrigerant to the high pressure in the refrigeration cycle. The resultant high-pressure gas refrigerant is then discharged from the compressor 8. When the high-pressure gas refrigerant is discharged from the compressor 8, then the high-pressure gas refrigerant is supplied to each of the indoor heat exchangers 32a and 32b via the four-way switching valve 10, the gas-side shutoff valve 14, and the gas-refrigerant connection pipe 5. When the high-pressure gas refrigerant is supplied to each of the indoor heat exchangers 32a and 32b, each of the indoor heat exchangers 32a and 32b causes the high-pressure gas refrigerant to radiate heat by heat exchange with indoor air supplied as a cooling source from each of the indoor fans 33a and 33b. Each of the indoor heat exchangers 32a and 32b thus turns the high-pressure gas refrigerant into the high-pressure liquid refrigerant. The indoor air is thus heated. Thereafter, the indoor air is supplied indoors to achieve the heating operation. The high-pressure liquid refrigerant, which is obtained by the heat radiation in each of the indoor heat exchangers 32a and 32b, is supplied to the outdoor expansion valve 12 via each of the indoor expansion valves 31a and 31b, the liquid-refrigerant connection pipe 4, and the liquid-side shutoff valve 13. When the refrigerant is supplied to the outdoor expansion valve 12, the outdoor expansion valve 12 decompresses the refrigerant to the low pressure in the refrigeration cycle to turn the refrigerant into the low-pressure refrigerant in the gas-liquid two-phase state. The low-pressure refrigerant in the gas-liquid two-phase state, which is obtained by the decompression in the outdoor expansion valve 12, is supplied to the outdoor heat exchanger 11. When the low-pressure refrigerant in the gas-liquid two-phase state is supplied to the outdoor heat exchanger 11, the outdoor heat exchanger 11 functioning as an evaporator for the refrigerant evaporates the low-pressure refrigerant by heat exchange with outdoor air supplied as a heating source from the outdoor fan 15. The outdoor heat exchanger 11 thus turns the low-pressure liquid refrigerant into the low-pressure gas refrigerant. The low-pressure refrigerant, which is obtained by the evaporation in the outdoor heat exchanger 11, is sucked into the compressor 8 again via the four-way switching valve 10 and the accumulator 7.

(3) Configuration of Outdoor Unit

**[0040]** FIG. 2 is an external perspective view of the outdoor unit 2. FIG. 3 is a front view of the outdoor unit 2, which depicts only the outdoor heat exchanger 11 among the components constituting the refrigerant circuit. FIG. 4 is a schematic perspective view of the outdoor heat exchanger 11. FIG. 5 is a partial enlarged view of heat exchange parts 60A to 60K illustrated in FIG. 4. FIG. 6 is a schematic configuration diagram of the outdoor heat exchanger 11.

<General Configuration>

**[0041]** The outdoor unit 2 is an upward blowing-type heat exchange unit into which air is sucked through a side surface of a casing 40 and from which air is discharged through a top surface of the casing 40. The outdoor unit 2 mainly includes: the casing 40 having a substantially rectangular parallelepiped box shape; the outdoor fan 15 serving as a fan; the components 7, 8, and 11 such as the compressor and the outdoor heat exchanger; the valves 10, and 12 to 14 such as the four-way switching valve and the outdoor expansion valve; and the components including, for example, the refrigerant pipes 16 to 22 and constituting a part of the refrigerant circuit 6. In the following description, the terms "upper", "lower", "left", "right", "front", "rear", "front surface", and "rear surface" refer to orientations defined with the outdoor unit 2 of FIG. 2 viewed from the front (the left oblique front in FIG. 2) unless otherwise specified.

**[0042]** The casing 40 mainly includes: a pair of installation legs 41 extending laterally; a bottom frame 42 laid on the installation legs 41; supports 43 respectively extending vertically from corners of the bottom frame 42; a fan module 44 mounted to upper ends of the supports 43; and a front panel 45. In addition, the casing 40 has air suction ports 40a, 40b, and 40c formed in its side surfaces, that is, its rear surface, left surface, and right surface, and an air blow-out port 40d formed in its top surface.

**[0043]** The bottom frame 42 forms a bottom surface of the casing 40, and the outdoor heat exchanger 11 is disposed on the bottom frame 42. The outdoor heat exchanger 11 has a substantially U shape as seen in plan view so as to face the rear, left, and right surfaces of the casing 40, and substantially forms the rear, left, and right surfaces of the casing 40.

**[0044]** The fan module 44 is disposed above the outdoor heat exchanger 11. The fan module 44 forms the front, rear, left, and right surfaces of the casing 40 at a position above the supports 43. The fan module 44 also forms the top surface of the casing 40. The fan module 44 is an aggregate of a substantially rectangular parallelepiped box body having upper and lower openings, and the outdoor fan 15 housed in the box body. The upper opening of the fan module 44 corresponds to the blow-out port 40d on which a blow-out grille 46 is disposed. In the casing 40, the outdoor fan 15 is disposed facing the blow-out port 40d. The outdoor fan 15 is configured to feed air into the casing 40 through the suction ports 40a, 40b, and 40c, and to discharge air from the casing 40 through the blow-out port 40d.

**[0045]** The front panel 45 extends between the front-side supports 43, and forms the front surface of the casing 40.

**[0046]** In addition to the outdoor fan 15 and the outdoor heat exchanger 11, the components constituting the refrigerant circuit (the accumulator 7, the compressor 8, and the refrigerant pipes 16 to 18 in FIG. 2) are also housed in the casing 40. The compressor 8 and the accumulator 7 are disposed on the bottom frame 42.

**[0047]** As described above, the outdoor unit 2 includes: the casing 40 having the air suction ports 40a, 40b, and 40c in its side surfaces, that is, in its rear, left, and right surfaces, and the air blow-out port 40d in its top surface; the outdoor fan 15 disposed facing the blow-out port 40d in the casing 40; and the outdoor heat exchanger 11 disposed below the outdoor fan 15 in the casing 40. According to the configuration of the upward blowing-type heat exchange unit, the outdoor heat exchanger 11 is disposed below the outdoor fan 15. Therefore, the velocity of air passing through the outdoor heat exchanger 11 at the upper side of the outdoor heat exchanger 11 tends to become higher than the velocity of air passing through the outdoor heat exchanger 11 at the lower side of the outdoor heat exchanger 11 (see FIG. 3).

<Outdoor Heat Exchanger>

**[0048]** The outdoor heat exchanger 11 is configured to cause the refrigerant to exchange heat with outdoor air. The outdoor heat exchanger 11 mainly includes a first header collecting pipe 80, a second header collecting pipe 90, a plurality of flat tubes 63, and a plurality of fins 64. The first header collecting pipe 80, the second header collecting pipe 90, the flat tubes 63, and the fins 64 are each made of aluminum or an aluminum alloy, and are bonded together by, for example, brazing.

**[0049]** Each of the first header collecting pipe 80 and the second header collecting pipe 90 is a vertically-elongated, hollow, cylindrical member. The first header collecting pipe 80 is disposed upright on a first end side (i.e., the left front end side in FIG. 4 or the left end side in FIG. 6) of the outdoor heat exchanger 11. The second header collecting pipe 90 is disposed upright on a second end side (i.e., the right front end side in FIG. 4 or the right end side in FIG. 6) of the outdoor heat exchanger 11.

**[0050]** Each of the flat tubes 63 is a flat porous tube including a flat surface portion 63a serving as a heat transfer surface directed vertically, and a large number of small passages 63b though which the refrigerant flows. The flat tubes 63 are arranged one above the other, and each have two ends respectively connected to the first header collecting pipe 80 and the second header collecting pipe 90. Each of the fins 64 defines a space between adjoining two of the flat tubes 63 as plurality airflows path through which air flows. Each of the fins 64 has a plurality of elongated cutouts 64a extending horizontally to inserted into the cutouts 64a. The cutouts 64a of the fins 64 each have a shape almost equal to a sectional contour of each flat tube 63.

**[0051]** In the outdoor heat exchanger 11, the flat tubes 63 are divided into a plurality of, that is, 11 heat exchange parts 60A to 60K arranged one above the other. Specifically, a first heat exchange part 60A, a second heat exchange part 60B, ..., a tenth heat exchange part 60J, and an eleventh heat exchange part 60K are formed in this order from top to bottom. Each of the first to fourth heat exchange parts 60A to 60D includes seven flat tubes 63. Each of the fifth to eighth heat exchange parts 60E to 60H includes eight flat tubes 63. Each of the ninth to eleventh heat exchange parts 60I to 60K includes nine flat tubes 63.

**[0052]** In the first header collecting pipe 80, partition walls 81 partition an internal space of the first header collecting pipe 80 vertically into port communication spaces 82A to 82K for the heat exchange parts 60A to 60K. In each of the port communication spaces 82A to 82K, partition walls 83 partition each of the port communication spaces 82A to 82K vertically into upper gas-side port communication spaces 84A to 84K and lower liquid-side port communication spaces 85A to 85K. Each of the liquid-side port communication spaces 85A to 85K communicates with lower two of the flat tubes 63 constituting the corresponding one of the heat exchange parts 60A to 60K. Each of the gas-side port communication spaces 84A to 84K communicates with the remaining flat tubes 63 constituting the corresponding one of the heat exchange parts 60A to 60K. The flat tubes 63 communicating with each of the gas-side port communication spaces 84A to 84K are referred to as main heat exchange parts 61A to 61K. The flat tubes 63 communicating with each of the liquid-side port communication spaces 85A to 85K are referred to as auxiliary heat exchange parts 62A to 62K. Specifically, in each of the first to fourth port communication spaces 82A to 82D, each of the first to fourth liquid-side port communication spaces 85A to 85D communicates with lower two of the flat tubes 63 (the auxiliary heat exchange parts 62A to 62D) constituting the corresponding one of the first to fourth heat exchange parts 60A to 60D. In addition, each of the first to fourth gas-side port communication spaces 84A to 84D communicates with the remaining five flat tubes 63 (the main heat exchange parts 61A to 61D) constituting the corresponding one of the first to fourth heat exchange parts 60A to

60D. In each of the fifth to eighth port communication spaces 82E to 82H, each of the fifth to eighth liquid-side port communication spaces 85E to 85H communicates with lower two of the flat tubes 63 (the auxiliary heat exchange parts 62E to 62H) constituting the corresponding one of the fifth to eighth heat exchange parts 60E to 60H. In addition, each of the fifth to eighth gas-side port communication spaces 84E to 84H communicates with the remaining six flat tubes 63 (the main heat exchange parts 61E to 61H) constituting the corresponding one of the fifth to eighth heat exchange parts 60E to 60H. In each of the ninth to eleventh port communication spaces 821 to 82K, each of the ninth to eleventh liquid-side port communication spaces 851 to 85K communicates with lower two of the flat tubes 63 (the auxiliary heat exchange parts 621 to 62K) constituting the corresponding one of the ninth to eleventh heat exchange parts 60I to 60K. In addition, each of the ninth to eleventh gas-side port communication spaces 841 to 84K communicates with the remaining seven flat tubes 63 (the main heat exchange parts 611 to 61K) constituting the corresponding one of the ninth to eleventh heat exchange parts 60I to 60K.

**[0053]** The first header collecting pipe 80 is connected to a liquid-side shunt member 70 and a gas-side shunt member 75. The liquid-side shunt member 70 is configured to shunt the refrigerant supplied from the outdoor expansion valve 12 in the heating operation and to supply the shunted refrigerants to the liquid-side port communication spaces 85A to 85K. The gas-side shunt member 75 is configured to shunt the refrigerant supplied from the compressor 8 in the cooling operation and to supply the shunted refrigerants to the gas-side port communication spaces 84A to 84K.

**[0054]** The liquid-side shunt member 70 includes a liquid-side refrigerant shunt 71 connected to the refrigerant pipe 20 (see FIG. 1), and liquid-side refrigerant shunt pipes 72A to 72K each extending from the liquid-side refrigerant shunt 71 and respectively connected to the liquid-side port communication spaces 85A to 85K.

**[0055]** The gas-side shunt member 75 includes a gas-side refrigerant shunt main pipe 76 connected to the refrigerant pipe 19 (see FIG. 1), and gas-side refrigerant shunt branch pipes 77A to 77K each extending from the gas-side refrigerant shunt main pipe 76 and respectively connected to the gas-side port communication spaces 84A to 84K.

**[0056]** In the second header collecting pipe 90, partition walls 91 partition an internal space of the second header collecting pipe 90 vertically into folded communication spaces 92A to 92K for the heat exchange parts 60A to 60K. Each of the folded communication spaces 92A to 92K communicates with all the flat tubes 63 constituting the corresponding one of the heat exchange parts 60A to 60K. Specifically, each of the first to fourth folded communication spaces 92A to 92D communicates with all the seven flat tubes 63 constituting the corresponding one of the first to fourth heat exchange parts 60A to 60D. Each of the fifth to eighth folded communication spaces 92E to 92H communicates with all the eight flat tubes 63 constituting the corresponding one of the fifth to eighth heat exchange parts 60E to 60H. Each of the ninth to eleventh folded communication spaces 921 to 92K communicates with all the nine flat tubes 63 constituting the corresponding one of the ninth to eleventh heat exchange parts 60I to 60K.

**[0057]** According to this configuration, the heat exchange parts 60A to 60K respectively include the main heat exchange parts 61A to 61K, and the auxiliary heat exchange parts 62A to 62K respectively disposed below the main heat exchange parts 61A to 61K and connected in series through the folded communication spaces 92A to 92K. In the heat exchange parts 60A to 60D, the flat tubes 63 constituting the main heat exchange parts 61A to 61D communicating with the gas-side port communication spaces 84A to 84D and the flat tubes 63 constituting the auxiliary heat exchange parts 62A to 62D disposed immediately below the main heat exchange parts 61A to 61D and communicating with the liquid-side port communication spaces 85A to 85D are connected in series through the folded communication spaces 92A to 92D. In the heat exchange parts 60E to 60H, the flat tubes 63 constituting the main heat exchange parts 61E to 61H communicating with the gas-side port communication spaces 84E to 84H and the flat tubes 63 constituting the auxiliary heat exchange parts 62E to 62H disposed immediately below the main heat exchange parts 61E to 61H and communicating with the liquid-side port communication spaces 85E to 85H are connected in series through the folded communication spaces 92E to 92H. In the heat exchange parts 60I to 60K, the flat tubes 63 constituting the main heat exchange parts 611 to 61K communicating with the gas-side port communication spaces 841 to 84K and the flat tubes 63 constituting the auxiliary heat exchange parts 621 to 62K disposed immediately below the main heat exchange parts 611 to 61K and communicating with the liquid-side port communication spaces 851 to 85K are connected in series through the folded communication spaces 921 to 92K.

**[0058]** As described above, the number (7 in this embodiment) of flat tubes 63 constituting each of the heat exchange parts 60A to 60D disposed on the upper side of the outdoor heat exchanger 11 is set to be smaller than the number (9 in this embodiment) of flat tubes 63 constituting each of the heat exchange parts 60I to 60K disposed on the lower side of the outdoor heat exchanger 11, in accordance with the air velocity distribution in the outdoor heat exchanger 11.

**[0059]** The number (7 in this embodiment) of flat tubes 63 constituting the first heat exchange part 60A disposed on the uppermost side of the outdoor heat exchanger 11 is 0.6 to 0.9 times a value obtained by dividing the total number (87 in this embodiment) of flat tubes 63 constituting the outdoor heat exchanger 11 by the number (11 in this embodiment) of heat exchange parts 60A to 60K. The number of heat exchange parts in the outdoor heat exchanger 11 may be equal or less than 10 or may be equal to or more than 12. The number of heat exchange parts in the outdoor heat exchanger 11 is set in accordance with, for example, the height of the outdoor heat exchanger 11.

**[0060]** In addition, the number (5 in this embodiment) of flat tubes 63 constituting each of the main heat exchange parts 61A to 61D of the heat exchange parts 60A to 60D disposed on the upper side of the outdoor heat exchanger 11 is smaller than the number (7 in this embodiment) of flat tubes 63 constituting each of the main heat exchange parts 611 to 61K of the heat exchange parts 60I to 60K disposed on the lower side of the outdoor heat exchanger 11.

**[0061]** In each of the heat exchange parts 60A to 60K, a ratio of the number (5 to 7 in this embodiment) of flat tubes 63 constituting each of the main heat exchange parts 61A to 61K to the number (2 in this embodiment) of flat tubes 63 constituting each of the auxiliary heat exchange parts 62A to 62K is 1.5 to 4.5.

**[0062]** Next, a description will be given of a flow of the refrigerant in the outdoor heat exchanger 11 having the configuration described above.

**[0063]** During the cooling operation, the outdoor heat exchanger 11 functions as the radiator for the refrigerant discharged from the compressor 8.

**[0064]** The refrigerant discharged from the compressor 8 is supplied to the gas-side shunt member 75 via the refrigerant pipe 19 (see FIG. 1). When the refrigerant is supplied to the gas-side shunt member 75, the gas-side shunt member 75 shunts the refrigerant from the gas-side refrigerant shunt main pipe 76, and supplies the shunted refrigerants to the gas-side refrigerant shunt branch pipes 77A to 77K. The shunted refrigerants are then supplied to the gas-side port communication spaces 84A to 84K of the first header collecting pipe 80.

**[0065]** When the refrigerants are supplied to the gas-side port communication spaces 84A to 84K, then the refrigerants are shunted to the flat tubes 63 constituting each of the main heat exchange parts 61A to 61K of the heat exchange parts 60A to 60K. When the refrigerants are supplied to the flat tubes 63, then the refrigerants radiate heat by heat exchange with outdoor air while flowing through the passages 63b, and merge with one another in the folded communication spaces 92A to 92K of the second header collecting pipe 90. In other words, the refrigerants pass through the main heat exchange parts 61A to 61K. At this time, the refrigerants radiate heat so as to be brought into a gas-liquid two-phase state or a liquid state close to a saturated state from a superheated gas state.

**[0066]** The merged refrigerant in the folded communication spaces 92A to 92K is shunted to the flat tubes 63 constituting each of the auxiliary heat exchange parts 62A to 62K of the heat exchange parts 60A to 60K. When the shunted refrigerants are supplied to the flat tubes 63, then the refrigerants radiate heat by heat exchange with outdoor air while flowing through the passages 63b, and merge with one another in the liquid-side port communication spaces 85A to 85K of the first header collecting pipe 80. In other words, the refrigerants pass through the auxiliary heat exchange parts 62A to 62K. At this time, the refrigerants further radiate heat so as to be brought into a subcooled liquid state from the gas-liquid two-phase state or the liquid state close to the saturated state.

**[0067]** When the refrigerants are supplied to the liquid-side port communication spaces 85A to 85K, the refrigerants are supplied to the liquid-side refrigerant shunt pipes 72A to 72K of the liquid-side refrigerant shunt member 70, and merge with one another in the liquid-side refrigerant shunt 71. The merged refrigerant in the liquid-side refrigerant shunt 71 is supplied to the outdoor expansion valve 12 (see FIG. 1) via the refrigerant pipe 20 (see FIG. 1).

**[0068]** During the heating operation, the outdoor heat exchanger 11 functions as the evaporator for the refrigerant decompressed by the outdoor expansion valve 12 (see FIG. 1).

**[0069]** When the refrigerant is decompressed by the outdoor expansion valve 12, then the refrigerant is supplied to the liquid-side refrigerant shunt member 70 via the refrigerant pipe 20 (see FIG. 1). When the refrigerant is supplied to the liquid-side refrigerant shunt member 70, the liquid-side refrigerant shunt member 70 shunts the refrigerant from the liquid-side refrigerant shunt 71, and supplies the shunted refrigerants to the liquid-side refrigerant shunt pipes 72A to 72K. The shunted refrigerants are then supplied to the liquid-side port communication spaces 85A to 85K of the first header collecting pipe 80.

**[0070]** When the refrigerants are supplied to the liquid-side port communication spaces 85A to 85K, then the refrigerants are shunted to the flat tubes 63 constituting each of the auxiliary heat exchange parts 62A to 62K of the heat exchange parts 60A to 60K. When the refrigerants are supplied to the flat tubes 63, then the refrigerants evaporate by heat exchange with outdoor air while flowing through the passages 63b, and merge with one another in the folded communication spaces 92A to 92K of the second header collecting pipe 90. In other words, the refrigerants pass through the auxiliary heat exchange parts 62A to 62K. At this time, the refrigerants evaporate so as to be brought into a gas-liquid two-phase state in which a gas component is relatively large or a gas state close to a saturated state from a gas-liquid two-phase state in which a liquid component is relatively large.

**[0071]** The merged refrigerant in the folded communication spaces 92A to 92K is shunted to the flat tubes 63 constituting each of the main heat exchange parts 61A to 61K of the heat exchange parts 60A to 60K. When the shunted refrigerants are supplied to the flat tubes 63, then the refrigerants evaporate, that is, are heated by heat exchange with outdoor air while flowing through the passages 63b, and merge with one another in the gas-side port communication spaces 84A to 84K of the first header collecting pipe 80. In other words, the refrigerants pass through the main heat exchange parts 61A to 61K.

At this time, the refrigerants further evaporate, that is, are further heated so as to be brought into a superheated gas state from the gas-liquid two-phase state in which the gas component is relatively large or the gas state close to the saturated state.

**[0072]** When the refrigerants are supplied to the gas-side port communication spaces 84A to 84K, then the refrigerants are supplied to the gas-side refrigerant shunt branch pipes 77A to 77K of the gas-side refrigerant shunt member 75, and merge with one another in the gas-side refrigerant shunt main pipe 76. The merged refrigerant in the gas-side refrigerant shunt main pipe 76 is supplied to a suction side of the compressor 8 (see FIG. 1) via the refrigerant pipe 19 (see FIG. 1).

(4) Features

**[0073]** The outdoor unit 2 according to this embodiment has the following features.

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**[0074]** In this embodiment, as described above, the outdoor heat exchanger 11 (the heat exchanger) constituting the upward blowing-type outdoor unit 2 (the heat exchange unit) includes the plurality of heat exchange parts 60A to 60K arranged one above the other. The heat exchange parts 60A to 60K respectively include the main heat exchange parts 61A to 61K, and the auxiliary heat exchange parts 62A to 62K respectively disposed below the main heat exchange parts 61A to 61K and connected in series through the folded communication spaces 92A to 92K of the header collecting pipe 90. This configuration is therefore different from the configuration disclosed in Patent Literature 1. Specifically, the heat exchange parts 60A to 60K are arranged in conformity with the air velocity distribution in the heat exchanger. In addition, this configuration eliminates the necessity of communication pipes for connecting the main heat exchange parts 61A to 61K to the auxiliary heat exchange parts 62A to 62K.

**[0075]** According to this embodiment, hence, the heat exchange parts 60A to 60K are arranged in conformity with the air velocity distribution in the outdoor heat exchanger 11, and the number of flat tubes 63 constituting each of the heat exchange parts 60A to 60D disposed on the upper side of the outdoor heat exchanger 11 is set to be smaller than the number of flat tubes 63 constituting each of the heat exchange parts 60I to 60K disposed on the lower side of the outdoor heat exchanger 11, in accordance with the air velocity distribution in the outdoor heat exchanger 11, as described above. Therefore, the heat exchange parts 60A to 60D disposed on the upper side of the outdoor heat exchanger 11 become smaller in heat transfer area than the heat exchange parts 60I to 60K disposed on the lower side of the outdoor heat exchanger 11. This configuration thus eliminates deviations in degree of heat exchange between the heat exchange parts 60A to 60D disposed on the upper side of the outdoor heat exchanger 11 and the heat exchange parts 60I to 60K disposed on the lower side of the outdoor heat exchanger 11.

**[0076]** This configuration therefore enables an appropriate shunt of the refrigerant to the respective heat exchange parts 60A to 60K in accordance with the air velocity distribution in the outdoor heat exchanger 11, and thus improves the shunting performance in causing the outdoor heat exchanger 11 to function as the evaporator for the refrigerant, that is, during the heating operation.

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**[0077]** The degree of heat exchange among the heat exchange parts 60A to 60K is significantly influenced by the size of heat transfer areas of the main heat exchange parts 61A to 61K through which the gaseous refrigerant flows in large amounts, in causing the outdoor heat exchanger 11 to function as the evaporator for the refrigerant.

**[0078]** According to this embodiment, hence, the number of flat tubes 63 constituting each of the heat exchange parts 60A to 60D disposed on the upper side of the outdoor heat exchanger 11 is set to be smaller than the number of flat tubes 63 constituting each of the heat exchange parts 60I to 60K disposed on the lower side of the outdoor heat exchanger 11, by changing the number of flat tubes 63 constituting each of the main heat exchange parts 61Ato 61K of the heat exchange parts 60A to 60K, as described above.

**[0079]** This configuration thus improves the shunting performance in causing the outdoor heat exchanger 11 to function as the evaporator for the refrigerant, by changing the number of flat tubes 63 constituting each of the main heat exchange parts 61A to 61K exerting a significant influence on the degree of heat exchange among the heat exchange parts 60A to 60K.

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**[0080]** Although a positional relation between the outdoor fan 15 (the fan) and the outdoor heat exchanger 11, and other conditions have an influence, the heat transfer area of the heat exchange part 60A disposed on the uppermost side of the outdoor heat exchanger 11 is preferably set to be about 0.6 to 0.9 times an average heat transfer area of all the heat exchange parts 60A to 60K in view of the air velocity distribution in the outdoor heat exchanger 11.

**[0081]** According to this embodiment, hence, the number of flat tubes 63 constituting the uppermost heat exchange part 60A is set to be 0.6 to 0.9 times the average number of flat tubes 63 constituting each of the heat exchange parts 60A to 60K, that is, the value obtained by dividing the total number of flat tubes 63 constituting the outdoor heat exchanger 11 by the number of heat exchange parts 60A to 60K, as described above.

**[0082]** This configuration thus improves the shunting performance in causing the outdoor heat exchanger 11 to function as the evaporator for the refrigerant, by appropriately setting the number of flat tubes 63 constituting the uppermost heat exchange part 60A in view of the air velocity distribution in the outdoor heat exchanger 11.

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**[0083]** In causing the outdoor heat exchanger 11 to function as the evaporator for the refrigerant, in each of the heat exchange parts 60A to 60K, the refrigerants flowing into the folded communication spaces 92A to 92K through the auxiliary heat exchange parts 62A to 62K are shunted and supplied to the flat tubes 63 constituting the main heat exchange parts 61A to 6K. At this time, the gaseous refrigerants flow in large amounts through the main heat exchange parts 61A to 61K. Therefore, the number of flat tubes 63 constituting each of the main heat exchange parts 61A to 61K is preferably larger than the number of flat tubes 63 constituting each of the auxiliary heat exchange parts 62A to 62K, from the viewpoints of reducing pressure loss and ensuring a heat transfer area. However, if the number of flat tubes 63 constituting the main heat exchange parts 61A to 61K is considerably large, it is difficult to achieve a shunt from the folded communication spaces 92A to 62K to the flat tubes 63 constituting the main heat exchange parts 61A to 61K. In view of this, preferably, in each of the heat exchange parts 60A to 60K, the ratio of the number of flat tubes 63 constituting each of the main heat exchange parts 61A to 61K to the number of flat tubes 63 constituting each of the auxiliary heat exchange parts 62A to 62K falls within a certain range.

**[0084]** According to this embodiment, hence, in each of the heat exchange parts 60A to 60K, the ratio of the number of flat tubes 63 constituting each of the main heat exchange parts 61A to 61K to the number of flat tubes 63 constituting each of the auxiliary heat exchange parts 62A to 62K falls within the range of 1.5 to 4.5, as described above.

**[0085]** This configuration thus improves the shunting performance in causing the outdoor heat exchanger 11 to function as the evaporator for the refrigerant, by appropriately setting the ratio of the number of flat tubes 63 constituting each of the main heat exchange parts 61A to 61K to the number of flat tubes 63 constituting each of the auxiliary heat exchange parts 62A to 62K in each of the heat exchange parts 60A to 60K in view of the shunt from the folded communication spaces 92A to 92K to the flat tubes 63 constituting the main heat exchange parts 61Ato 61K.

(5) Modifications

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**[0086]** The outdoor heat exchanger 11 (the heat exchanger) includes the heat exchange parts 60A to 60K arranged one above the other. The heat exchange parts 60A to 60K respectively include the main heat exchange parts 61A to 61K, and the auxiliary heat exchange parts 62A to 62K respectively disposed below the main heat exchange parts 61A to 61K and connected in series through the folded communication spaces 92A to 92K in the header collecting pipe 90. According to this configuration, the fins 64 conduct heat between the main heat exchange parts 61A to 61K and the auxiliary heat exchange parts 62A to 62K adjoining the main heat exchange parts 61A to 61K. In causing the outdoor heat exchanger 11 to function as the evaporator for the refrigerant, that is, during the heating operation, the main heat exchange parts 61A to 61K are cooled by the auxiliary heat exchange parts 62A to 62K due to the occurrence of heat conduction. Consequently, the refrigerants flowing through the main heat exchange parts 61A to 61K are unsatisfactorily heated, which may lead to degradation in evaporating performance of the outdoor heat exchanger 11. In causing the outdoor heat exchanger 11 to function as the radiator for the refrigerant, that is, during the cooling operation, the auxiliary heat exchange parts 62A to 62K are heated by the main heat exchange parts 61A to 61K. Consequently, the refrigerants flowing through the auxiliary heat exchange parts 62A to 62K are unsatisfactorily cooled, which may lead to degradation in heat radiating performance of the outdoor heat exchanger 11.

**[0087]** In view of this, as illustrated in FIGS. 7 and 8, fins 64 have fin cut portions 64b formed at positions corresponding to boundaries between main heat exchange parts 61A to 61K and auxiliary heat exchange parts 62A to 62K in order to suppress vertical heat conduction at the boundaries. As illustrated in FIG. 7, the fin cut portions 64b are formed to extend from first ends to the second ends of the heat exchange parts 60A to 60K in a direction in which a refrigerant flows, that is, a longitudinal direction of flat tubes 63. The fin cut portions 64b are each formed in an elongated slit shape extending horizontally so as to cross between the flat tubes 63 constituting the main heat exchange parts 61A to 61K and the flat tubes 63 constituting the auxiliary heat exchange parts 62A to 62K adjoining the main heat exchange parts 61A to 61K. However, the fin cut portion 64b are not necessarily formed to extend from first ends to the second ends of the heat exchange parts 60A to 60K in the direction in which the refrigerant flows. For example, the fin cut portions 64b may be formed at first header collecting pipe 80-end portions of the heat exchange parts 60A to 60K (portions near refrigerant ports) where the main heat exchange parts 61A to 61K and the auxiliary heat exchange parts 62A to 62K are most different in temperature from each other. Each of the fin cut portions 64b is not necessarily formed in the shape of continuous slit, but may be formed in a shape of intermittent slits, that is, a shape of perforations.

**[0088]** With this configuration, the fin cut portions 64b suppress heat conduction between the main heat exchange parts 61A to 61K and the auxiliary heat exchange parts 62A to 62K through the fins 64. This configuration thus suppresses degradation in evaporating performance and heat radiating performance of the outdoor heat exchanger 11.

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**[0089]** In the foregoing embodiment and Modification A, the auxiliary heat exchange parts 61A to 61K are equal in number (i.e., two) of flat tubes 63 to one another, but may be different in number of flat tubes 63 from one another.

## INDUSTRIAL APPLICABILITY

**[0090]** The present invention is widely applicable to heat exchange units each including: a casing having a suction port in its side surface, and a blow-out port in its top surface; a fan disposed facing the blow-out port; and a heat exchanger disposed below the fan.

## REFERENCE SIGNS LIST

**[0091]**

2: outdoor unit (heat exchange unit)
11: outdoor heat exchanger (heat exchanger)
15: outdoor fan (fan)
40: casing
40a, 40b, 40c: suction port
40d: blow-out port
60A to 60K: heat exchange part
61Ato 61K: main heat exchange part
62A to 62K: auxiliary heat exchange part
63: flat tube
64: fin
64b: fin cut portion
90: second header collecting pipe (header collecting pipe)

## CITATION LIST

## PATENT LITERATURE

**[0092]** Patent Literature 1: JP 2012-163319A

## Claims

**1.** A heat exchange unit (2) comprising:

a casing (40) having a suction port (40a, 40b, 40c) in its side surface, and a blow-out port (40d) in its top surface;
a fan (15) disposed facing the blow-out port in the casing, configured to feed air into the casing through the suction port, and configured to discharge air from the casing through the blow-out port; and
a heat exchanger (11) disposed below the fan in the casing, and configured to cause a refrigerant to exchange heat with air,
wherein
the heat exchanger includes:

a header collecting pipe (90) disposed upright;
a plurality of flat tubes (63) arranged one above the other, each including a passage through which the refrigerant flows, and each having one end connected to the header collecting pipe; and
a plurality of fins (64) each defining a space between adjoining the flat tubes as plurality airflow paths through which air flows,

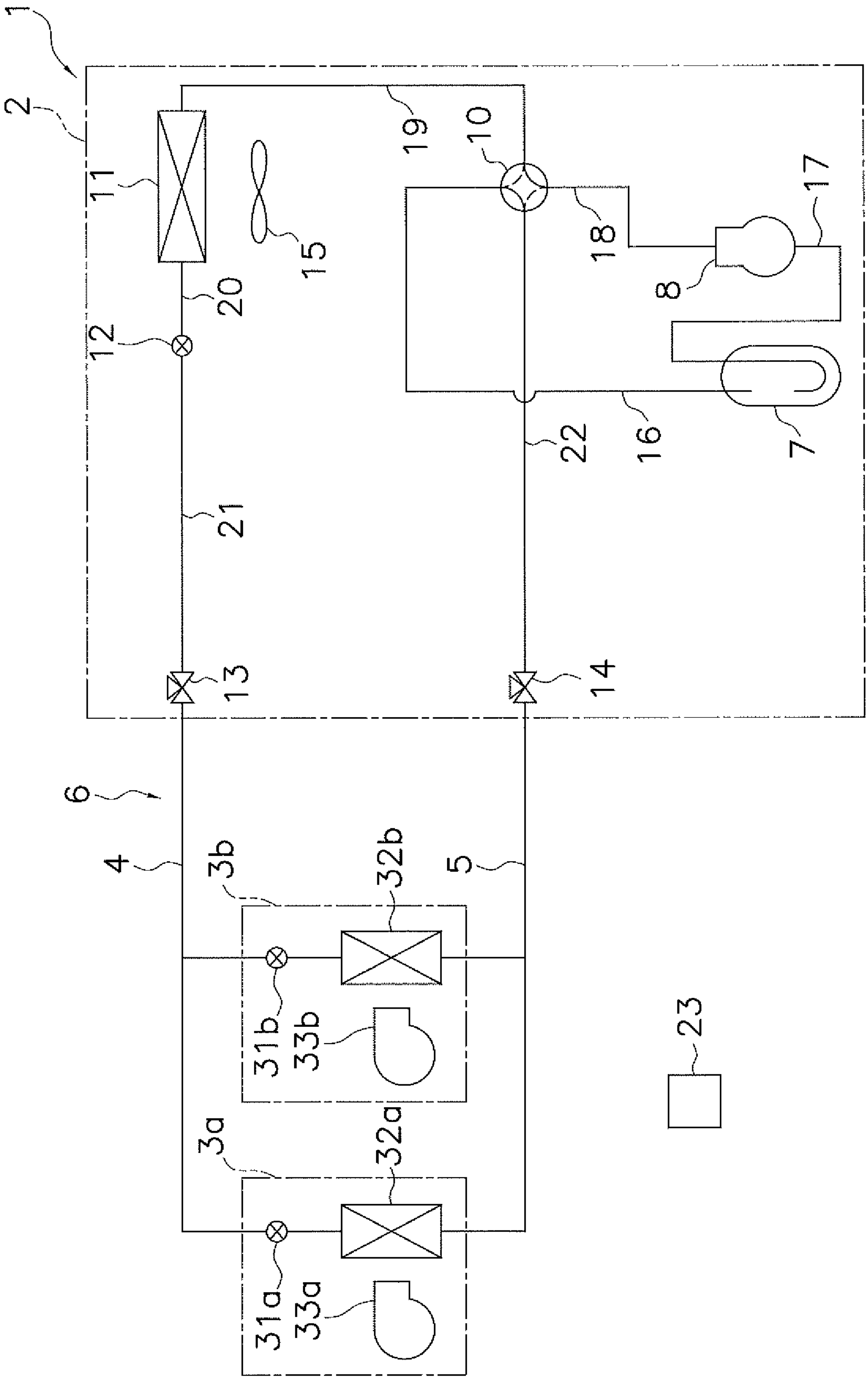
the flat tubes are divided into a plurality of heat exchange parts (60A to 60K) arranged one above the other,
the header collecting pipe has an internal space partitioned vertically into a plurality of folded communication spaces (92A to 92K) for the heat exchange parts,
the heat exchange parts respectively include main heat exchange parts (61A to 61K), and auxiliary heat exchange parts (62A to 62K) respectively disposed below the main heat exchange parts and connected in series through the folded communication spaces, and
the number of flat tubes constituting each of the heat exchange parts disposed on an upper side of the heat exchanger is set to be smaller than the number of flat tubes constituting each of the heat exchange parts disposed on a lower side of the heat exchanger, in accordance with air velocity distribution in the heat exchanger.

**2.** The heat exchange unit according to claim 1, wherein
the number of flat tubes constituting each of the main heat exchange parts of the heat exchange parts disposed on the upper side of the heat exchanger is smaller than the number of flat tubes constituting each of the main heat exchange parts of the heat exchange parts disposed on the lower side of the heat exchanger.

**3.** The heat exchange unit according to claim 1 or 2, wherein
the number of flat tubes constituting the heat exchange part disposed on an uppermost side of the heat exchanger is 0.6 to 0.9 times a value obtained by dividing the total number of flat tubes constituting the heat exchanger by the number of heat exchange parts.

**4.** The heat exchange unit according to any one of claims 1 to 3, wherein
in each of the heat exchange parts, a ratio of the number of flat tubes constituting each of the main heat exchange parts to the number of flat tubes constituting each of the auxiliary heat exchange parts is 1.5 to 4.5.

**5.** The heat exchange unit according to any one of claims 1 to 4, wherein
the fins have fin cut portions (64b) formed at positions corresponding to boundaries between the main heat exchange parts and the auxiliary heat exchange parts to suppress vertical heat conduction at the boundaries.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2
19
10
11
15
18
17
8
20
12
7
16
22
21
13
14
6
4
3b
32b
5
31b
33b
23
3a
32a
31a
33a

FIG. 1

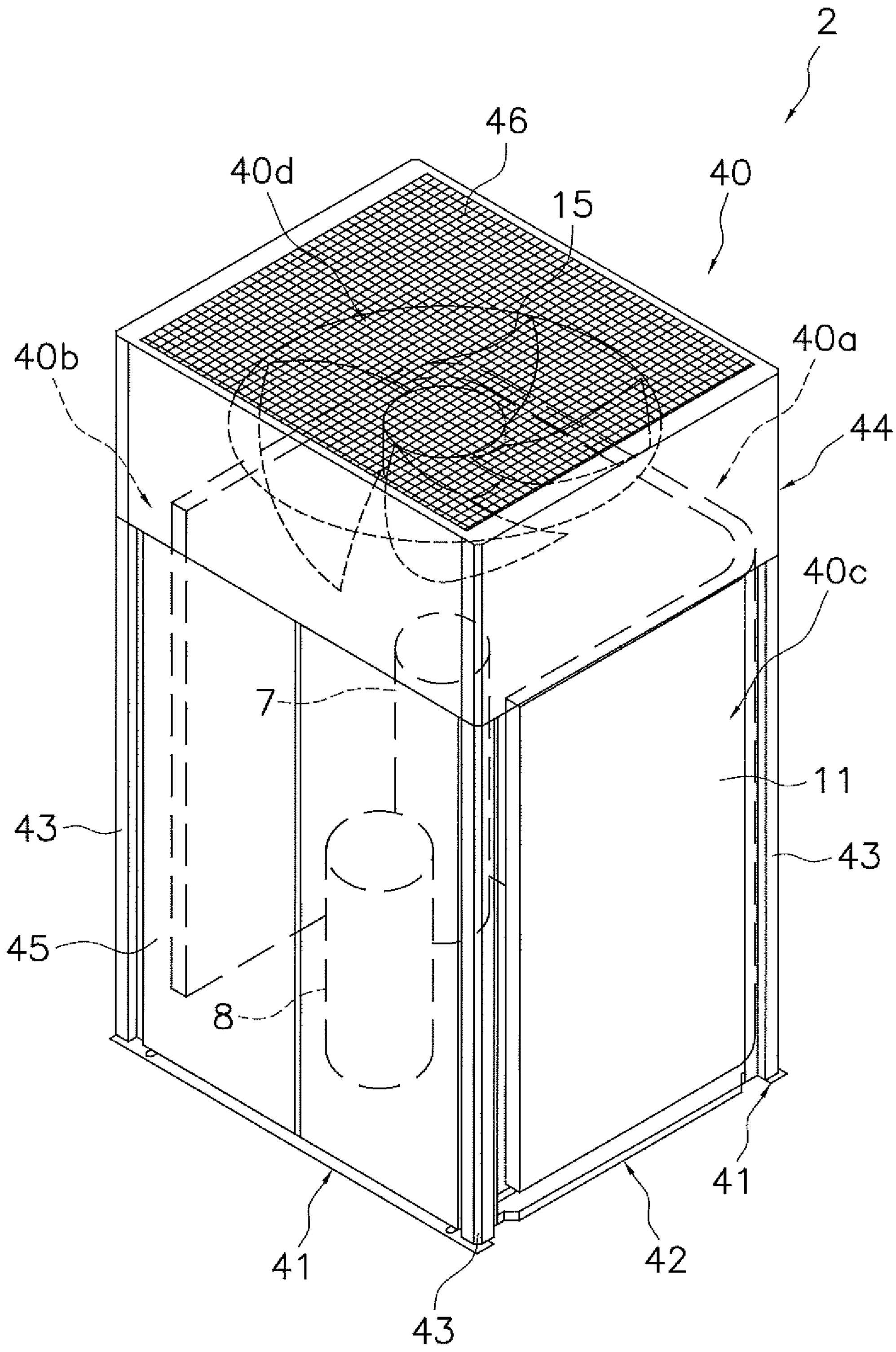



FIG. 2

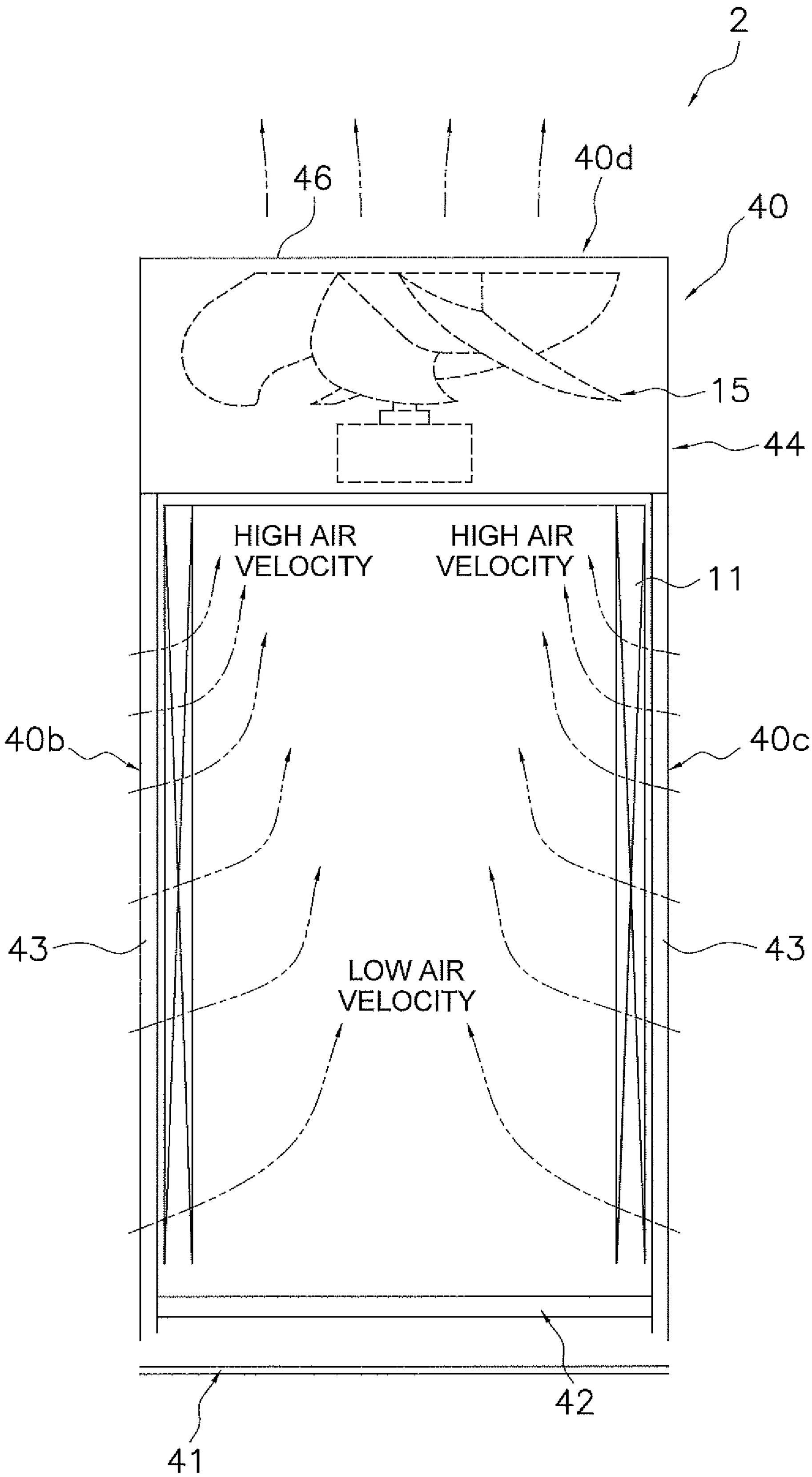
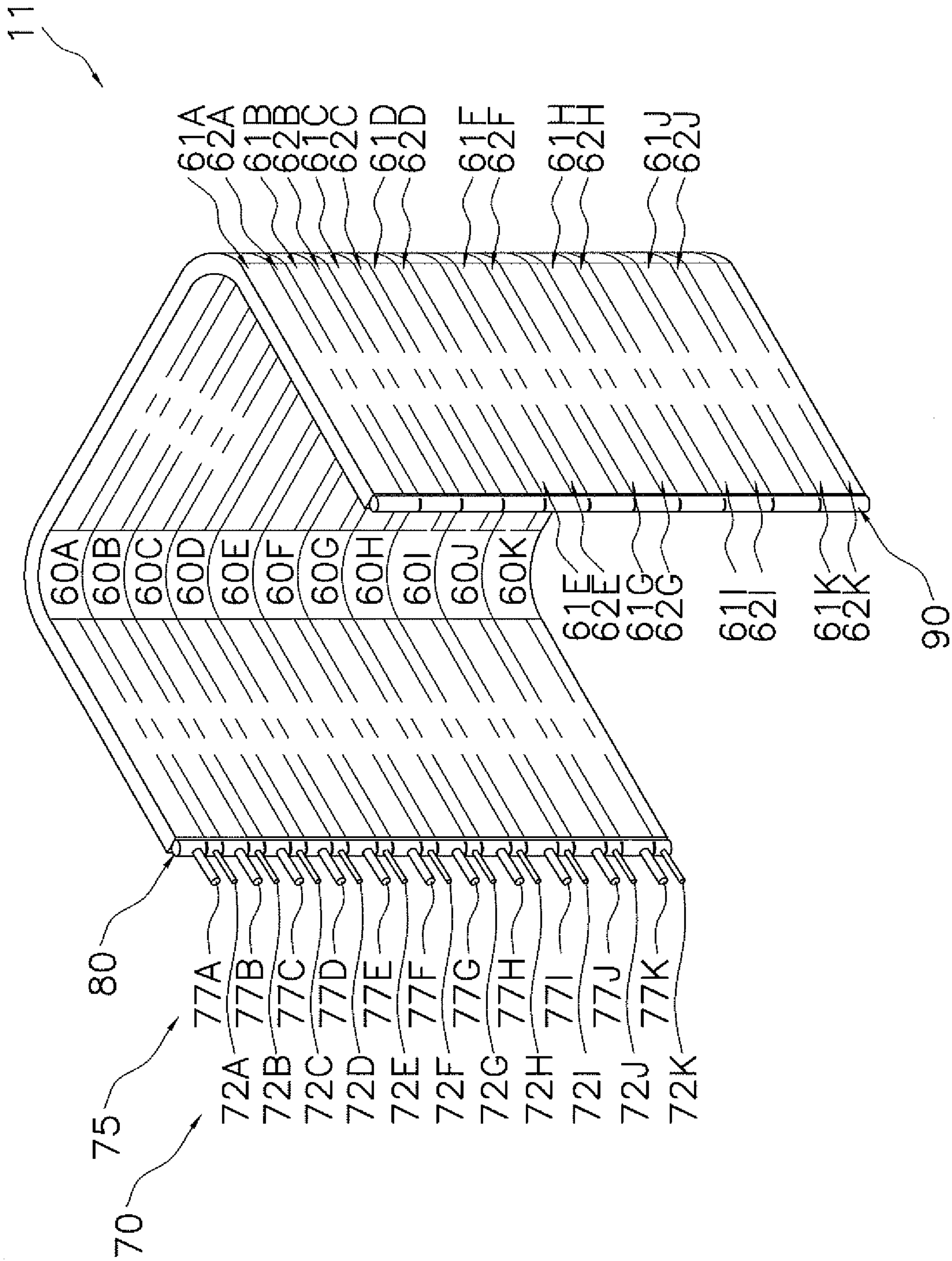

2
46
40d
40
15
44
HIGH AIR VELOCITY
HIGH AIR VELOCITY
11
40b
40c
43
43
LOW AIR VELOCITY
42
41

FIG. 3


11
61A
62A
61B
62B
61C
62C
61D
62D
61F
62F
61H
62H
61J
62J
60A
60B
60C
60D
60E
60F
60G
60H
60I
60J
60K
61E
62E
61G
62G
61I
62I
61K
62K
90
80
75
70
77A
77B
77C
77D
77E
77F
77G
77H
77I
77J
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72B
72C
72D
72E
72F
72G
72H
72I
72J
72K

FIG. 4

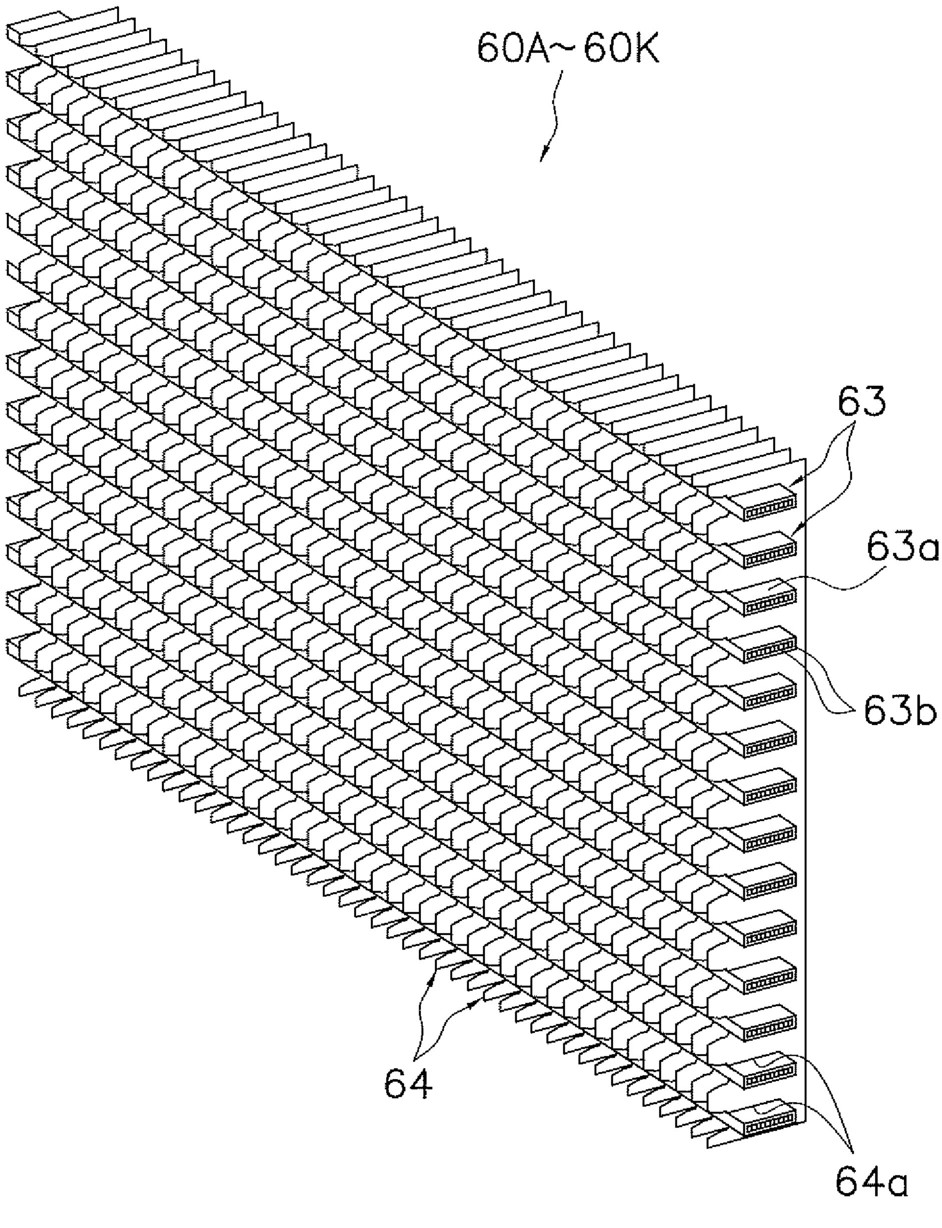



FIG. 5

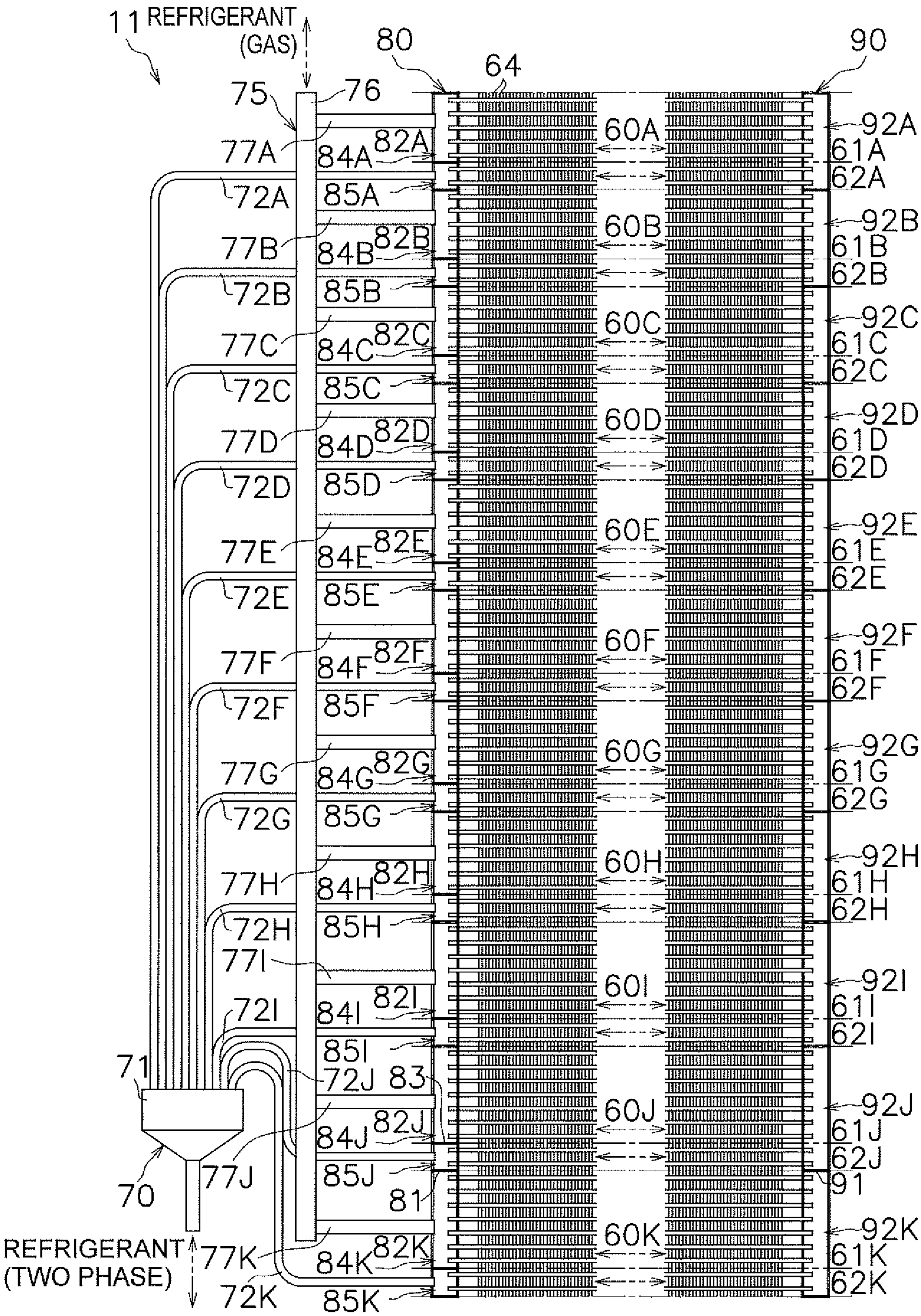
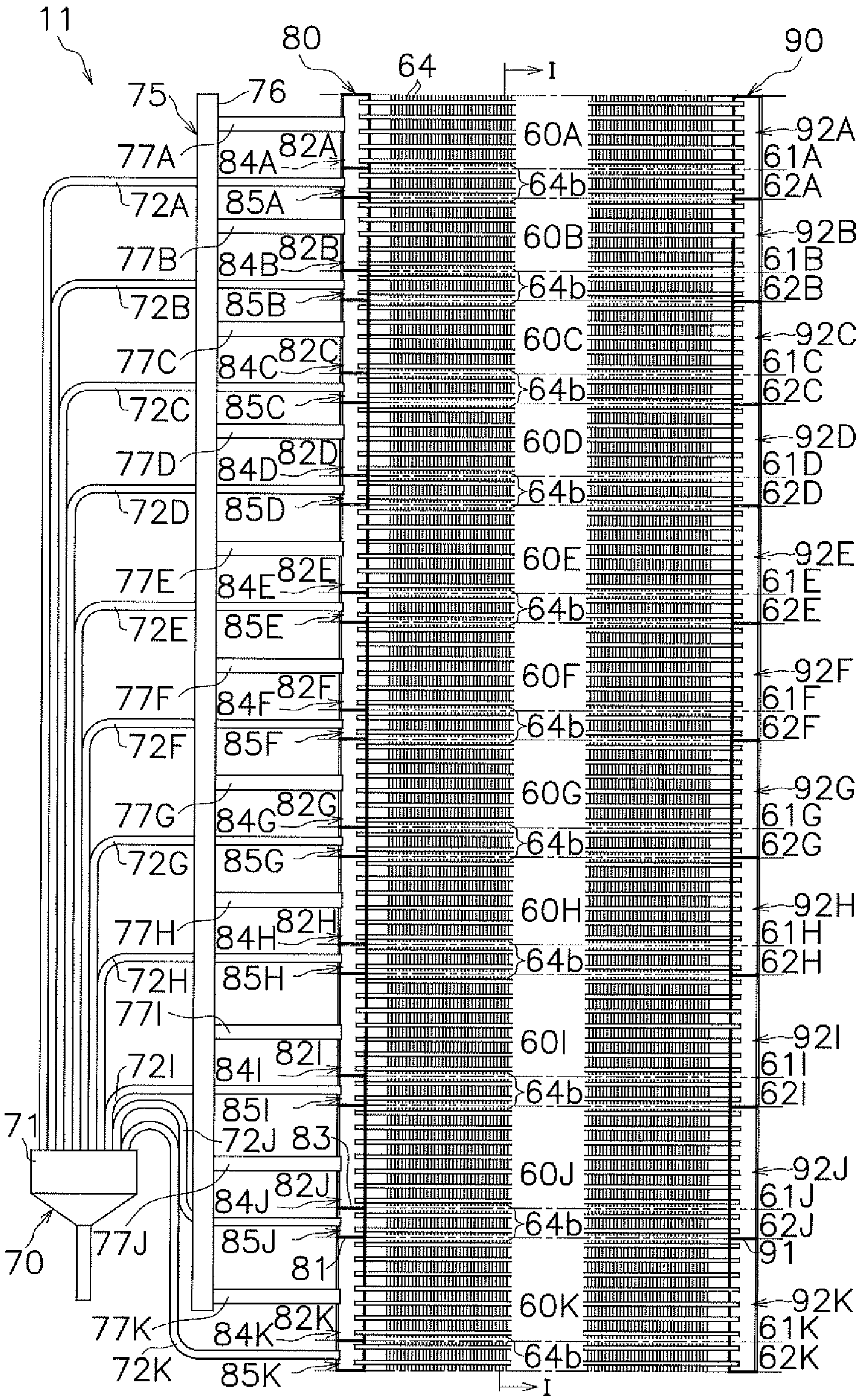

11
REFRIGERANT
(GAS)
80
90
64
75
76
77A
84A
82A
60A
92A
61A
62A
72A
85A
77B
84B
82B
60B
92B
61B
62B
72B
85B
77C
84C
82C
60C
92C
61C
62C
72C
85C
77D
84D
82D
60D
92D
61D
62D
72D
85D
77E
84E
82E
60E
92E
61E
62E
72E
85E
77F
84F
82F
60F
92F
61F
62F
72F
85F
77G
84G
82G
60G
92G
61G
62G
72G
85G
77H
84H
82H
60H
92H
61H
62H
72H
85H
77I
84I
82I
60I
92I
61I
62I
72I
85I
71
72J
83
60J
92J
61J
62J
84J
82J
70
77J
85J
81
91
REFRIGERANT
(TWO PHASE)
77K
84K
82K
60K
92K
61K
62K
72K
85K

FIG. 6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76
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60H
60I
60J
60K
64b
92A
61A
62A
92B
61B
62B
92C
61C
62C
92D
61D
62D
92E
61E
62E
92F
61F
62F
92G
61G
62G
92H
61H
62H
92I
61I
62I
92J
61J
62J
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92K
61K
62K
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84A
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85A
77B
72B
84B
82B
85B
77C
72C
84C
82C
85C
77D
72D
84D
82D
85D
77E
72E
84E
82E
85E
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82F
85F
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72G
84G
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85G
77H
72H
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82H
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72I
84I
82I
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82K
72K
85K

FIG. 7

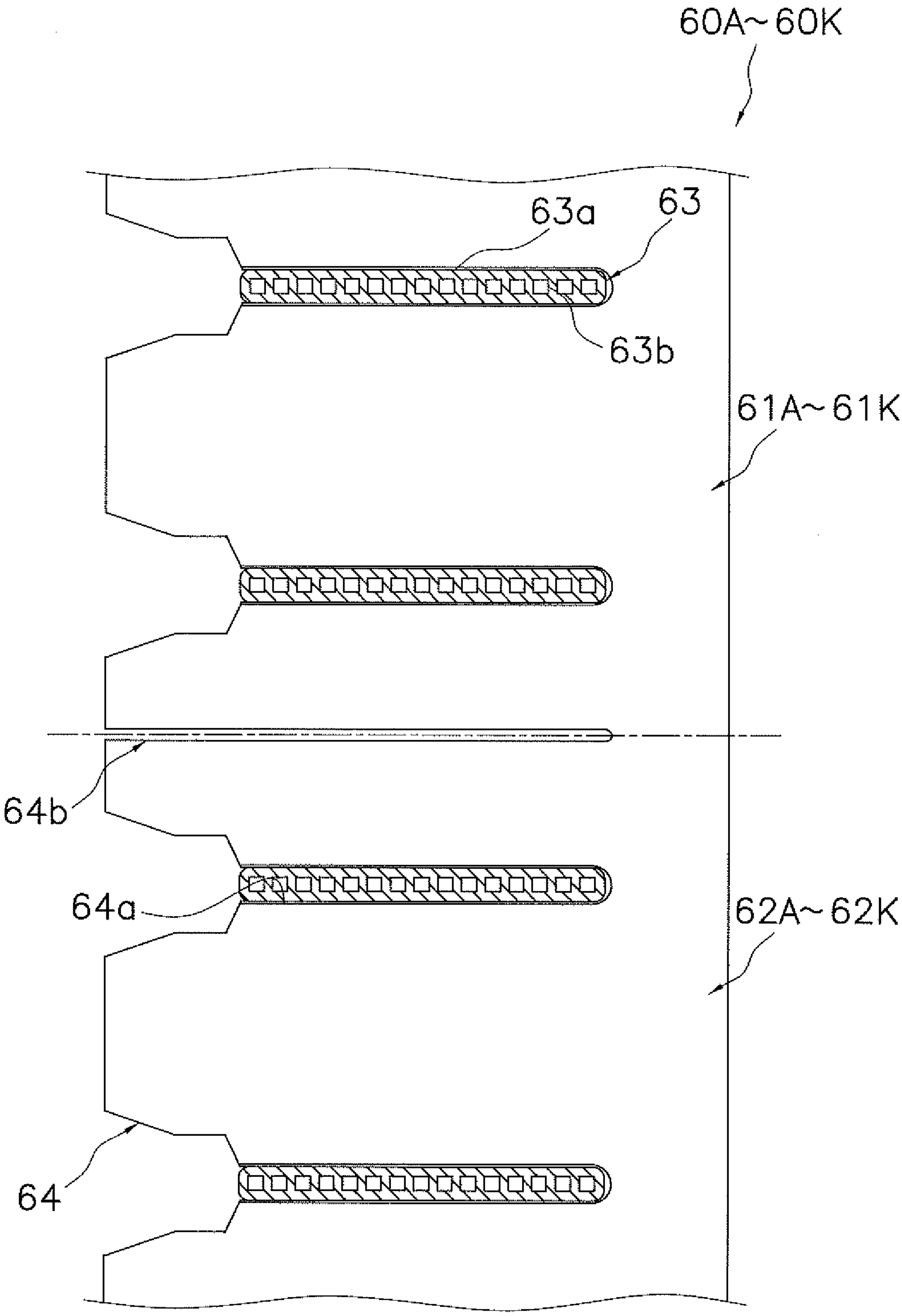


FIG. 8

**INTERNATIONAL SEARCH REPORT**

International application No. PCT/JP2018/047238

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F28D1/047(2006.01)i, F24F1/14(2011.01)i, F25B39/00(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. F28D1/047, F24F1/14, F25B39/00

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. |
|---|---|---|
| Y | JP 2013-83420 A (DAIKIN INDUSTRIES, LTD.) 09 May 2013, paragraphs [0074]-[0093], fig. 8-9 & WO 2013/046729 A1 | 1-5 |
| Y | WO 2012/098912 A1 (DAIKIN INDUSTRIES, LTD.) 26 July 2012, fig. 15-16 & US 2013/0292098 A1 fig. 15-16 & EP 2667134 A1 | 1-5 |
| Y | JP 2014-31944 A (HITACHI APPLIANCES, INC.) 20 February 2014, paragraph [0032], fig. 4 & EP 2693139 A1 paragraph [0031], fig. 4 & CN 103574952 A | 1-5 |

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 02 March 2018 (02.03.2018) | 13 March 2018 (13.03.2018) |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Japan Patent Office<br>3-4-3, Kasumigaseki, Chiyoda-ku,<br>Tokyo 100-8915, Japan | Telephone No. |

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

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2012163319 A **[0002] [0092]**