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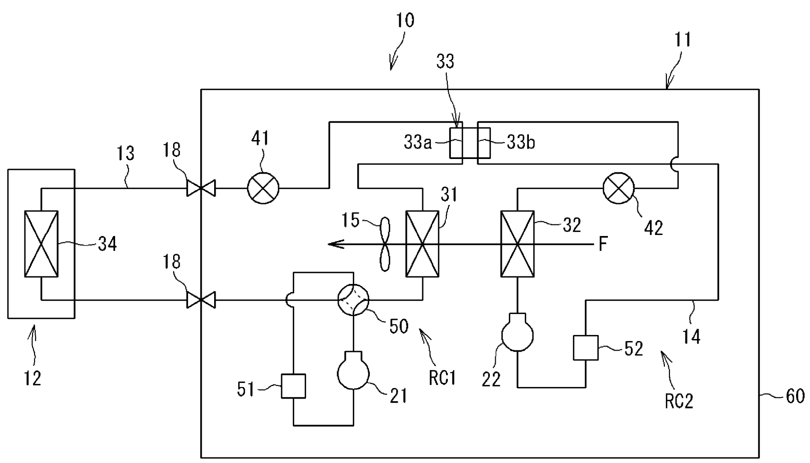
(54) **REFRIGERATION DEVICE**

(57) The disclosure provides a refrigeration apparatus 10 including: a first refrigerant circuit RC1 including a first compressor 21, a first heat exchanger 31, a first expansion valve 41, and a utilization-side heat exchanger 34, and using a first refrigerant R1; a second refrigerant circuit RC2 including a second compressor 22, a second heat exchanger 32, and a second expansion valve 42, and using a second refrigerant R2; a third heat exchanger 33 configured to cause heat exchange between the first refrigerant R1 and the second refrigerant R2; and a fan 15, in which the second heat exchanger 32 includes a heat transfer tube constituted by a flat multi-hole tube 32a, and the second heat exchanger 32 is disposed windward of the first heat exchanger 31 in an air flow direction F of an air flow generated by the fan 15.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration apparatus.

BACKGROUND ART

[0002] There is disclosed a refrigeration apparatus including a unit having a first refrigerant circuit configured to exhibit main cooling capability, a second refrigerant circuit configured to assist the first refrigerant circuit in the cooling capability, and a heat exchanger configured to cause heat exchange between a first refrigerant in the first refrigerant circuit and a second refrigerant in the second refrigerant circuit (see PATENT LITERATURE 1). The first refrigerant and the second refrigerant are different from each other in terms of refrigerant types in the refrigeration apparatus.

CITATION LIST

[PATENT LITERATURE]

[0003] PATENT LITERATURE 1: WO 2014/181399 A

SUMMARY OF THE INVENTION

[TECHNICAL PROBLEM]

[0004] In the unit of the refrigeration apparatus, a first air heat exchanger included in the first refrigerant circuit and a second air heat exchanger included in the second refrigerant circuit may be aligned windward and leeward in an air flow direction of air subject to heat exchange. The air heat exchanger is provided with a region having a stagnant air flow and generated leeward of a heat transfer tube. The region will hereinafter be referred to as a "dead water zone". When the first and second air heat exchangers are aligned windward and leeward, the air heat exchanger disposed leeward may be deteriorated in heat exchange efficiency due to influence of the dead water zone.

[0005] It is an object of the present disclosure to provide a refrigeration apparatus including air heat exchangers aligned windward and leeward of an air flow, and the refrigeration apparatus inhibits deterioration in heat exchange efficiency of the air heat exchanger disposed leeward.

[SOLUTION TO PROBLEM]

[0006]

(1) A refrigeration apparatus according to the present disclosure includes: a first refrigerant circuit including a first compressor, a first heat exchanger, a first expansion valve, and a utilization-side heat exchanger, and using a first refrigerant; a second refrigerant circuit including a second compressor, a second heat exchanger, and a second expansion valve, and using a second refrigerant; a third heat exchanger configured to cause heat exchange between the first refrigerant and the second refrigerant; and a fan, in which the second heat exchanger includes a heat transfer tube constituted by a flat multi-hole tube, and the second heat exchanger is disposed windward of the first heat exchanger in an air flow direction of an air flow generated by the fan.

[0007] The refrigeration apparatus according to the present disclosure includes the second heat exchanger including the flat multi-hole tube as a heat transfer tube. A heat exchanger including a flat multi-hole tube as a heat transfer tube can have a smaller dead water zone formed leeward in comparison to a heat exchanger including a circular tube as a heat transfer tube. In the refrigeration apparatus according to the present disclosure, the second heat exchanger including the flat multi-hole tube is disposed windward of the first heat exchanger, to inhibit interference between the heat transfer tube and the dead water zone in the first heat exchanger disposed leeward. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger positioned leeward in the air flow direction.

[0008] (2) In the refrigeration apparatus according to (1) described above of the present disclosure, preferably, the refrigeration apparatus includes a plurality of the flat multi-hole tubes and a plurality of heat transfer tubes constituting the first heat exchanger, and the refrigeration apparatus includes a portion where a center position of each of the flat multi-hole tubes in an array direction of the plurality of the flat multi-hole tubes and a center position of each of the heat transfer tubes in an array direction of the plurality of heat transfer tubes constituting the first heat exchanger are misaligned with each other in the air flow direction.

[0009] In the refrigeration apparatus according to the present disclosure, in the portion where the center position of the flat multi-hole tube and the center position of the heat transfer tube are misaligned with each other, a dead water zone formed leeward of the second heat exchanger is positioned to be misaligned with the heat transfer tube of the first heat exchanger. The refrigeration apparatus according to the present embodiment can thus inhibit interference between the dead water zone formed leeward of the second heat exchanger and the heat transfer tube in the first heat exchanger disposed leeward. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger positioned leeward in the air flow direction.

[0010] (3) In the refrigeration apparatus according to (2) described above of the present disclosure, preferably, the heat transfer tubes constituting the first heat exchanger are circular tubes, and a first pitch of the circular tubes in the array direction of the plurality of circular tubes is different from a second pitch of the flat multi-hole tubes in the array direction of the plurality of the flat multi-hole tubes.

[0011] In the refrigeration apparatus thus configured, the first pitch of the plurality of circular tubes positioned leeward is differentiated from the second pitch of the plurality of flat multi-hole tubes positioned windward to provide the portion where the center position of each of the flat multi-hole tubes and the center position of each of the heat transfer tubes are misaligned with each other, so as to inhibit interference between the dead water zone formed leeward of the second heat exchanger and the circular tube constituting the first heat exchanger disposed leeward. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger positioned leeward in the air flow direction.

[0012] (4) In the refrigeration apparatus according to any one of (1) to (3) described above of the present disclosure, preferably, the second heat exchanger is constituted by a heat exchanger including a plurality of the flat multi-hole tubes and a fin meanderingly disposed between the flat multi-hole tubes adjacent to each other.

[0013] The refrigeration apparatus according to the present disclosure achieves efficient heat exchange with use of the second heat exchanger. The refrigeration apparatus according to the present disclosure can reduce used quantity of the second refrigerant.

[0014] (5) In the refrigeration apparatus according to (1) described above of the present disclosure, preferably, the refrigeration apparatus includes a plurality of the flat multi-hole tubes and a plurality of heat transfer tubes constituting the first heat exchanger, the heat transfer tubes constituting the first heat exchanger are circular tubes, the first heat exchanger includes a first heat transfer tube group including the plurality of circular tubes aligned in a first array direction, and a second heat transfer tube group provided leeward of and adjacent to the first heat transfer tube group in the air flow direction and including the plurality of circular tubes aligned in a second array direction parallel to the first array direction, a center position in the first array direction of each of the circular tubes included in the first heat transfer tube group is misaligned in the air flow direction with a center position in the second array direction of each of the circular tubes included in the second heat transfer tube group, and a center position of each of the flat multi-hole tubes in an array direction of the plurality of the flat multi-hole tubes and a center position in the first array direction of each of the circular tubes included in the first heat transfer tube group are misaligned with each other in the air flow direction.

[0015] The refrigeration apparatus according to the present disclosure can inhibit interference between the dead water zone formed leeward of the second heat exchanger and the circular tube included in the first heat transfer tube group. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger positioned leeward in the air flow direction.

[0016] (6) In the refrigeration apparatus according to (1) described above of the present disclosure, preferably, the refrigeration apparatus includes a plurality of the flat multi-hole tubes and a plurality of heat transfer tubes constituting the first heat exchanger, the heat transfer tubes constituting the first heat exchanger are flat multi-hole tubes, and the refrigeration apparatus includes a portion where a center position of each of the flat multi-hole tubes in an array direction of the plurality of the flat multi-hole tubes in the second heat exchanger and a center position of each of the flat multi-hole tubes in an array direction of the plurality of flat multi-hole tubes in the first heat exchanger are aligned with each other in the air flow direction.

[0017] When both the heat transfer tubes of the first heat exchanger and the heat transfer tubes of the second heat exchanger are flat multi-hole tubes, the refrigeration apparatus thus configured can inhibit deterioration in heat exchange efficiency of the first heat exchanger positioned leeward in the air flow direction.

[0018] (7) In the refrigeration apparatus according to any one of (1) to (6) described above of the present disclosure, preferably, the second refrigerant is combustible, is toxic, or has a global warming potential of 4 or more.

[0019] The refrigeration apparatus thus configured can reduce used quantity of the second refrigerant when using, as the second refrigerant, a natural refrigerant that is combustible, is toxic, or has a global warming potential of 4 or more.

BRIEF DESCRIPTION OF DRAWINGS

[0020]

FIG. 1 is an explanatory view of refrigerant circuits in a refrigeration apparatus according to an embodiment of the present disclosure.

FIG. 2 is an explanatory sectional plan view of a heat source-side unit in the refrigeration apparatus.

FIG. 3 is an explanatory sectional side view of the heat source-side unit in the refrigeration apparatus.

FIG. 4 is a schematic view of a first heat exchanger according to first and second embodiments.

FIG. 5A is a schematic partial sectional view depicting heat transfer tubes and fins constituting the first heat exchanger according to the first embodiment.

FIG. 5B is a schematic partial sectional view depicting heat transfer tubes and fins constituting the first heat exchanger according to the second embodiment.

FIG. 6 is a schematic view of a first heat exchanger according to a third embodiment.

FIG. 7 is a schematic partial sectional view depicting heat transfer tubes and fins constituting the first heat exchanger according to the third embodiment.

FIG. 8 is a schematic view of a second heat exchanger.

FIG. 9 is a schematic partial sectional view depicting heat transfer tubes and fins constituting the second heat exchanger.

FIG. 10A is an explanatory view on a dead water zone formation situation in a case where the heat transfer tubes are circular tubes.

FIG. 10B is an explanatory view on a dead water zone formation situation in another case where the heat transfer tubes are flat multi-hole tubes.

FIG. 11 is an explanatory view of a case where the first heat exchanger according to the first embodiment is disposed leeward of the second heat exchanger.

FIG. 12 is an explanatory view of a case where the first heat exchanger according to the second embodiment is disposed leeward of the second heat exchanger.

FIG. 13 is an explanatory view of a case where the first heat exchanger according to the third embodiment is disposed leeward of the second heat exchanger.

DETAILED DESCRIPTION

(Regarding entire configuration of refrigeration apparatus)

[0021] A refrigeration apparatus according to each of embodiments of the present disclosure will be described in detail hereinafter with reference to the accompanying drawings. FIG. 1 is an explanatory view of refrigerant circuits in a refrigeration apparatus according to an embodiment of the present disclosure. As depicted in FIG. 1, the present disclosure provides a refrigeration apparatus 10 including a heat source-side unit 11, a utilization-side unit 12, a refrigerant pipe 13 connecting the heat source-side unit 11 and the utilization-side unit 12, and a fan 15. The refrigeration apparatus 10 exemplified in the present embodiment is an air conditioner configured to condition air in a target space with use of the utilization-side unit 12. The refrigeration apparatus 10 is an air conditioner of a separate type separately including the heat source-side unit (outdoor unit) 11 and the utilization-side unit (indoor unit) 12. The present embodiment exemplifies the air conditioner as the refrigeration apparatus 10, although the refrigeration apparatus according to the present embodiment may be a refrigerated case or the like, without being limited to the air conditioner. The refrigerant pipe 13 includes a gate valve 18 disposed at each of portions entering and exiting a case of the heat source-side unit 11.

[0022] The heat source-side unit 11 includes a first compressor 21, a second compressor 22, a first heat exchanger 31, a second heat exchanger 32, a third heat exchanger 33, a first expansion valve 41, a second expansion valve 42, a four-way switching valve 50, a first accumulator 51, and a second accumulator 52. The utilization-side unit 12 includes a utilization-side heat exchanger 34.

[0023] The refrigeration apparatus 10 includes a first refrigerant circuit RC1 including the first compressor 21, the first heat exchanger 31, the first expansion valve 41, the utilization-side heat exchanger 34, and the refrigerant pipe 13 connecting these devices, and a second refrigerant circuit RC2 including the second compressor 22, the second heat exchanger 32, the second expansion valve 42, and a refrigerant pipe 14 connecting these devices. The first refrigerant circuit RC1 uses a first refrigerant R1 as a refrigerant and is configured to execute refrigeration cycle operation. The second refrigerant circuit RC2 uses a second refrigerant R2 as a refrigerant different from the first refrigerant R1 and is configured to execute refrigeration cycle operation.

[0024] Each of the first compressor 21 and the second compressor 22 sucks a low-pressure gas refrigerant and discharges a high-pressure gas refrigerant. Each of the first compressor 21 and the second compressor 22 includes a motor (not depicted) having a number of operating revolutions adjustable through inverter control. Each of the first compressor 21 and the second compressor 22 is of a variable capacity type (capability variable type) having capacity (capability) variable through inverter control of the motor. Each of the first compressor 21 and the second compressor 22 may alternatively be of a constant capacity type.

[0025] The four-way switching valve 50 is configured to reverse a flow of the first refrigerant R1 in the refrigerant pipe 13 of the first refrigerant circuit RC1, and switchingly supply one of the first heat exchanger 31 and the utilization-side heat exchanger 34 with the first refrigerant R1 discharged from the first compressor 21. The refrigeration apparatus 10 is configured to switch between cooling operation and heating operation by switching a flow direction of the first refrigerant R1 with use of the four-way switching valve 50. The refrigeration apparatus 10 according to the present embodiment may alternatively include no four-way switching valve, and may be used exclusively for cooling.

[0026] The first expansion valve 41 is constituted by a motor valve configured to adjust a flow rate of the first refrigerant R1. During cooling operation, a control device (not depicted) included in the refrigeration apparatus 10 adjusts an opening degree of the first expansion valve 41 to adjust cooling capability exhibited by the first refrigerant circuit RC1. During heating operation, the control device (not depicted) in the refrigeration apparatus 10 maximizes the opening degree of the first expansion valve 41.

[0027] The second expansion valve 42 is constituted by a motor valve configured to adjust a flow rate of the second refrigerant R2. During cooling operation, the control device (not depicted) in the refrigeration apparatus 10 adjusts an opening degree of the second expansion valve 42 to adjust cooling capability exhibited by the second refrigerant circuit RC2.

[0028] The refrigeration apparatus 10 causes heat exchange between the first refrigerant R1 and the second refrigerant R2 in the third heat exchanger 33 to assist cooling capability of the first refrigerant circuit RC1 with cooling capability of the second refrigerant circuit RC2. During cooling operation, the control device (not depicted) in the refrigeration apparatus 10 adjusts the opening degree of the second expansion valve 42 to adjust heat exchange quantity between the first refrigerant R1 and the second refrigerant R2.

[Heat source-side unit]

[0029] FIG. 2 is an explanatory sectional plan view of the heat source-side unit in the refrigeration apparatus. FIG. 3 is an explanatory sectional side view of the heat source-side unit in the refrigeration apparatus. FIG. 3 depicts a section taken along line A-A indicated in FIG. 2. The following description includes expressions of up, down, front, rear, left, and right that follow arrows indicated in FIG. 2 and FIG. 3. Specifically, FIG. 2, FIG. 3 and the like include arrows X, Y, and Z perpendicular to one another. The arrow X indicates a direction (first direction) assumed as a lateral direction, the arrow Y indicates a direction (second direction) assumed as an anteroposterior direction, and the arrow Z indicates a direction (third direction) assumed as a vertical direction. In the following description, the lateral direction will also be referred to as a first direction X, the anteroposterior direction will also be referred to as a second direction Y, and the vertical direction will also be referred to as a third direction Z. These expressions are merely exemplary. Alternatively, the direction X may be assumed as the anteroposterior direction, and the direction Y may be assumed as the lateral direction.

[0030] As depicted in FIG. 1 to FIG. 3, the heat source-side unit 11 includes a case 60. As depicted in FIG. 2 and FIG. 3, the case 60 has a rectangular parallelepiped shape, and has a rectangular shape in a planar view. The case 60 has an interior provided with a sectioning wall 61 zoning a machine chamber S1 and a heat exchange chamber S2. The case 60 includes two adjacent side walls 62 and 63 disposed at the heat exchange chamber S2 and provided with air intake ports 64 and 65, respectively. There is provided another side wall 66 that is disposed adjacent to the side wall 63 having the air intake port 65 and is provided with an air blow-out port 67.

[0031] The machine chamber S1 accommodates the first compressor 21, the second compressor 22, the third heat exchanger 33, the first accumulator 51, and the second accumulator 52. The machine chamber S1 further accommodates, in addition to the above, the four-way switching valve 50 (not depicted), the first expansion valve 41 (not depicted), the second expansion valve 42 (not depicted), an oil separator, and the like. The machine chamber S1 is provided with a control board (not depicted) configured to control devices constituting the refrigeration apparatus 10.

[0032] The heat exchange chamber S2 accommodates the first heat exchanger 31, the second heat exchanger 32, the fan 15, and a fan motor 16. The fan 15 is connected to a shaft of the fan motor 16, and is rotationally driven by the fan motor 16.

[0033] The first heat exchanger 31 includes a heat transfer tube (a heat transfer tube 31a to be described later) in which the first refrigerant R1 circulating in the first refrigerant circuit RC1 flows. The first heat exchanger 31 is connected to the first compressor 21 in the machine chamber S1 via the refrigerant pipe 13 (see FIG. 1). The second heat exchanger 32 includes a heat transfer tube (a heat transfer tube 32a to be described later) in which the second refrigerant R2 circulating in the second refrigerant circuit RC2 flows. The second heat exchanger 32 is connected to the second compressor 22 in the machine chamber S1 via the refrigerant pipe 14 (see FIG. 1).

[0034] The fan 15 is disposed in a posture to cause a positive pressure surface to face the side wall 66 provided with the air blow-out port 67 and cause a negative pressure surface to face the side wall 62 provided with the air intake port 64. When the fan motor 16 is actuated, the fan 15 rotates to import air to the heat exchange chamber S2 via the air intake ports 64 and 65. The air imported to the heat exchange chamber S2 passes through the first heat exchanger 31 to exchange heat with the first refrigerant R1, then further passes through the second heat exchanger 32 to exchange heat with the second refrigerant R2, and is subsequently exhausted via the air blow-out port 67. The fan 15 generates an air flow passing through the first heat exchanger 31 and the second heat exchanger 32. The refrigerants passing through the first heat exchanger 31 and the second heat exchanger 32 exchange heat with the air passing through the first heat exchanger 31 and the second heat exchanger 32. As depicted in FIG. 1 to FIG. 3, the air flow generated by the fan 15 has a direction indicated by arrow F. In the following description, the direction of the air flow will be referred to as an air flow direction F.

[0035] The first heat exchanger 31 according to the present embodiment includes a portion extending in the lateral direction and a portion extending in the anteroposterior direction, and is bent at around a corner 68 to have an L shape in a planar view. The first heat exchanger 31 included in the refrigeration apparatus 10 according to the present disclosure is not limited to this case, and may alternatively have a rectangular shape or the like in a planar view.

[0036] The second heat exchanger 32 according to the present embodiment has a rectangular shape in a planar view. The second heat exchanger 32 extends along the side wall 62 provided with the air intake port 64 and is disposed windward of the first heat exchanger 31 in the air flow direction F.

[First heat exchanger (first embodiment)]

[0037] FIG. 4 is a schematic view of a first heat exchanger according to first and second embodiments. FIG. 5A is a schematic partial sectional view depicting heat transfer tubes and fins constituting the first heat exchanger according to the first embodiment. FIG. 4 and FIG. 5A depict a first heat exchanger 31 according to the first embodiment, which constitutes the refrigeration apparatus 10 according to the present disclosure. In the following description, the first heat exchanger 31 according to the first embodiment will also be referred to as a first heat exchanger 31A. The first heat exchanger 31A according to the first embodiment is a so-called fin-and-tube heat exchanger of a cross-fin type. The first heat exchanger 31A includes the heat transfer tube 31a, a plurality of fins 31b, and a pair of tube plates 31c and 31d. The first heat exchanger 31A causes heat exchange between the first refrigerant R1 in the first refrigerant circuit RC1 and air passing through the first heat exchanger 31.

[0038] The heat transfer tube 31a is a metal circular tube. Examples of the metal constituting the heat transfer tube 31a can include copper, a copper alloy, stainless steel, aluminum, and an aluminum alloy. Hereinafter, the heat transfer tube 31a will also be referred to as a circular tube 31a. The plurality of fins 31b is thin plates made of a metal, has an oblong shape in a side view, and is aligned parallel to each other at predetermined intervals in a width direction. Examples of the metal constituting the fins 3 1b can include aluminum and an aluminum alloy.

[0039] The circular tube (heat transfer tube) 3 1a includes a plurality of linear tube portions 31x having a linear shape and a plurality of curved tube portions 31y having a U shape. The linear tube portions 31x penetrate the fins 3 1b in a direction in which a large number of fins 31b are aligned. The curved tube portions 31y are disposed at end portions in a width direction of the first heat exchanger 31, and each connect the two linear tube portions 31x adjacent to each other.

[0040] The tube plates 31c and 31d are metal boards, have an oblong shape in a side view, and are disposed to be paired on respective sides in the width direction of the first heat exchanger 31. The tube plates 31c and 31d are connected to respective end portions of the linear tube portions 31x in the circular tube 31a to support the circular tube 31a. As depicted in FIG. 4, the tube plates 31c and 31d are disposed parallel to the fins 31b.

[First heat exchanger (second embodiment)]

[0041] FIG. 5B is a schematic partial sectional view depicting heat transfer tubes and fins constituting the first heat exchanger according to the second embodiment. FIG. 4 and FIG. 5B depict the first heat exchanger 31 according to the second embodiment, which constitutes the refrigeration apparatus 10 according to the present disclosure. In the following description, the first heat exchanger 31 according to the second embodiment will also be referred to as a first heat exchanger 31B. The first heat exchanger 31B according to the second embodiment is a so-called fin-and-tube heat exchanger of a cross-fin type. The first heat exchanger 31B includes a heat transfer tube 31a, a plurality of fins 31b, and a pair of tube plates 31c and 31d. The first heat exchanger 31B causes heat exchange between the first refrigerant R1 in the first refrigerant circuit RC1 and air passing through the first heat exchanger 31. The first heat exchanger 31B according to the present embodiment includes the heat transfer tube 31a, the fins 31b, and the tube plates 31c and 31d in common with the first heat exchanger 31A according to the first embodiment.

[First heat exchanger (third embodiment)]

[0042] FIG. 6 is a schematic view of a first heat exchanger according to the third embodiment. FIG. 7 is a schematic partial sectional view depicting heat transfer tubes and fins constituting the first heat exchanger according to the third embodiment. FIG. 6 and FIG. 7 depict the first heat exchanger 31 according to the third embodiment, which constitutes the refrigeration apparatus 10 according to the present disclosure. In the following description, the first heat exchanger 31 according to the third embodiment will also be referred to as a first heat exchanger 31C. The refrigeration apparatus 10 according to the present embodiment may include, as the first heat exchanger 31, a microchannel heat exchanger in place of the fin-and-tube heat exchanger of the cross-fin type (see FIG. 4, FIG. 5A, and FIG. 5B).

[0043] As depicted in FIG. 6 and FIG. 7, the first heat exchanger 31C according to the third embodiment is a microchannel heat exchanger. The first heat exchanger 31C includes a plurality of heat transfer tubes 31e, a fin 31f, and a pair of headers 31g and 31h. The heat transfer tubes 31e, the fin 31f, and the headers 31g and 31h are made of aluminum or an aluminum alloy. The first heat exchanger 31C causes heat exchange between the first refrigerant R1 in the first refrigerant circuit RC1 and air passing through the first heat exchanger 31C.

[0044] As depicted in FIG. 7, the heat transfer tubes 3 1e in the first heat exchanger 31C according to the third embodiment are constituted by multi-hole tubes each provided therein with a plurality of refrigerant flow paths 35. The heat transfer tubes 31e each have a section in a flat shape having a short direction and a longitudinal direction. The heat transfer tubes 31e have the longitudinal direction in which the plurality of refrigerant flow paths 35 is aligned. The plurality of refrigerant flow paths 35 is aligned in the air flow direction F. Hereinafter, the heat transfer tubes 31e in the first heat exchanger 31 according to the third embodiment will also be referred to as flat multi-hole tubes 31e.

[0045] As depicted in FIG. 6 and FIG. 7, the first heat exchanger 31C includes the plurality of heat transfer tubes 31e aligned in the longitudinal direction. The headers 31g and 31h are disposed to have longitudinal directions aligned with the short direction of the heat transfer tubes 31e. Each of the heat transfer tubes 31e has a first end connected to the header 31g, and a second end connected to the header 31h. The fin 31f is disposed meanderingly between the heat transfer tubes 31e and 31e adjacent to each other.

[0046] The first heat exchanger 31C according to the present embodiment is a so-called parallel flow heat exchanger in microchannel heat exchangers. The heat transfer tubes 31e constituting the first heat exchanger 31C are flat multi-hole tubes, and the fin 31f is disposed meanderingly between the flat multi-hole tubes adjacent to each other. The fin 31f constituting the first heat exchanger 31C is a so-called corrugate fin. When a cross-fin heat exchanger and a parallel flow heat exchanger equal in heat exchange quantity are compared with each other, the parallel flow heat exchanger is typically smaller in volume (internal holding liquid quantity) in the heat exchanger than the cross-fin heat exchanger. The refrigeration apparatus 10 adopting the first heat exchanger 31C of the parallel flow type can therefore reduce used quantity of the first refrigerant R1 in comparison to the refrigeration apparatus adopting the cross-fin heat exchanger.

[Second heat exchanger]

[0047] FIG. 8 is a schematic view of a second heat exchanger. FIG. 9 is a schematic partial sectional view depicting heat transfer tubes and fins constituting the second heat exchanger. The second heat exchanger 32 constituting the refrigeration apparatus 10 according to the present disclosure is a microchannel heat exchanger. As depicted in FIG. 8 and FIG. 9, the second heat exchanger 32 includes a plurality of heat transfer tubes 32a, a fin 32b, and a pair of headers 32c and 32d. The heat transfer tubes 32a, the fin 32b, and the headers 32c and 32d are made of aluminum or an aluminum alloy. The second heat exchanger 32 causes heat exchange between the second refrigerant R2 in the second refrigerant circuit RC2 and air passing through the second heat exchanger 32. The refrigeration apparatus 10 according to the present embodiment supports the second heat exchanger 32 with use of a support 70 (see FIG. 2 and FIG. 3) configured to support the fan 15.

[0048] As depicted in FIG. 9, the heat transfer tubes 32a are constituted by multi-hole tubes each provided therein with a plurality of refrigerant flow paths 36. The heat transfer tubes 32a each have a section in a flat shape having a short direction and a longitudinal direction. The heat transfer tubes 32a have the longitudinal direction in which the plurality of refrigerant flow paths 36 is aligned. The plurality of refrigerant flow paths 36 is aligned in the air flow direction F. As depicted in FIG, 8 and FIG. 9, the plurality of refrigerant flow paths 36 is aligned in the second direction Y and extends in the first direction X. Hereinafter, the heat transfer tubes 32a will also be referred to as flat multi-hole tubes 32a.

[0049] As depicted in FIG. 8 and FIG. 9, the second heat exchanger 32 includes the plurality of heat transfer tubes 32a aligned in the third direction Z. The headers 32c and 32d are disposed to have longitudinal directions aligned to the third direction Z. Each of the heat transfer tubes 32a has a first end connected to the header 32c, and a second end connected to the header 32d. The fin 32b is disposed meanderingly between the heat transfer tubes 32a and 32a disposed vertically adjacent to each other. In the refrigeration apparatus 10 according to the present embodiment, the second heat exchanger 32 is not limited to the above in terms of its posture, and may be provided in a posture having the third direction Z aligned to the lateral direction.

[0050] As depicted in FIG. 9, the flat multi-hole tubes 32a each have end surfaces in the third direction Z, in other words, upper and lower surfaces that are even surfaces expanding in the first direction X and the second direction Y Each of the flat multi-hole tubes 32a has respective end surfaces in the first direction X each having a section as a curved surface curved into a semicircular shape.

[0051] The fin 32b is substantially equal in length in the second direction Y to the flat multi-hole tubes 32a. Accordingly in the second heat exchanger 32, the flat multi-hole tubes 32a and the fin 32b are flush with each other in respective end surfaces in the second direction Y

[0052] The second heat exchanger 32 according to the present embodiment is a so-called parallel flow heat exchanger in microchannel heat exchangers. The heat transfer tubes constituting the second heat exchanger 32 are the flat multi-hole tubes 32a, and the fin 32b is disposed meanderingly between the flat multi-hole tubes adjacent to each other. The fin 32b is a so-called corrugate fin. When a cross-fin heat exchanger and a parallel flow heat exchanger equal in heat exchange quantity are compared with each other, the parallel flow heat exchanger is typically smaller in volume (internal holding liquid quantity) in the heat exchanger than the cross-fin heat exchanger. The refrigeration apparatus 10 adopting the parallel flow heat exchanger as the second heat exchanger 32 can therefore reduce used quantity of the second refrigerant R2 in comparison to the refrigeration apparatus adopting the cross-fin heat exchanger.

[Third heat exchanger]

[0053] The third heat exchanger 33 constituting the refrigeration apparatus 10 according to the present disclosure is a plate heat exchanger. As depicted in FIG. 1, the third heat exchanger 33 includes a first flow path 33a and a second flow path 33b provided between stacked plates. In the third heat exchanger 33, the first flow path 33a is connected to the first refrigerant circuit RC1, and the first refrigerant R1 flows to the first flow path 33a. In the third heat exchanger 33, the second flow path 33b is connected to the second refrigerant circuit RC2, and the second refrigerant R2 flows to the second flow path 33b. The third heat exchanger 33 causes heat exchange between the first refrigerant R1 flowing in the first flow path 33a and the second refrigerant R2 flowing in the second flow path 33b. The refrigeration apparatus 10 causes heat exchange between the first refrigerant R1 and the second refrigerant R2 with use of the third heat exchanger 33 to assist cooling capability of the first refrigerant circuit RC1 with cooling capability of the second refrigerant circuit RC2.

(Regarding first refrigerant and second refrigerant)

[0054] The refrigeration apparatus 10 according to the present disclosure is preferred to use natural refrigerants as the first refrigerant R1 and the second refrigerant R2. A natural refrigerant includes a substance originally existing in nature, and examples thereof include ammonia (NH_3), carbon dioxide (CO_2), water (H_2O), and hydrocarbon (HC). The refrigeration apparatus 10 according to the present embodiment uses carbon dioxide (CO_2: R744) as the first refrigerant R1, and propane (C_3H_8: R290) as the second refrigerant R2. Carbon dioxide (CO_2) has a global warming potential (GWP) of "1", and propane (C_3H_8) has a global warming potential of "3". The first refrigerant R1 used in the refrigeration apparatus according to the present disclosure is not limited to carbon dioxide (CO_2), and the second refrigerant R2 used in the refrigeration apparatus according to the present disclosure is not limited to propane (C_3H_8). The second refrigerant R2 used in the refrigeration apparatus according to the present disclosure may be R32, R1234yf, R474a, R600a (isobutane), R454B, R454C, or the like.

[0055] The refrigeration apparatus 10 according to the present disclosure is configured to suitably adopt a natural refrigerant having harmfulness as the second refrigerant R2. Herein, "having harmfulness" means properties having combustibility (including lower flammability), toxicity, and a global warming potential of four or more. The refrigeration apparatus 10 according to the present disclosure includes the second heat exchanger 32 configured as a "parallel flow heat exchanger", and can thus reduce used quantity of the second refrigerant R2 "having harmfulness".

(Regarding dead water zone)

[0056] FIG. 10A is an explanatory view on a dead water zone formation situation in a case where the heat transfer tubes are circular tubes. FIG. 10B is an explanatory view on a dead water zone formation situation in another case where the heat transfer tubes are flat multi-hole tubes. When air passes through the first heat exchanger 31, a "dead water zone" is formed leeward of the heat transfer tube (each of the heat transfer tubes 31a and 31e) as depicted in FIG. 10A and FIG. 10B. A "dead water zone" is a region formed downstream of an object disposed in a flow, and includes large and small eddies. Fluid is in a stationary state in this region. The "dead water zone" is irrelevant to a fluid flow. When a heat transfer tube interferes with the dead water zone, heat exchange efficiency between the heat transfer tube and air decreases in a region of such interference as a degree of the interference is larger.

[0057] As depicted in FIG. 10A, in the following description, a "dead water zone" formed leeward of each of the heat transfer tubes (circular tube) 31a constituting the first heat exchanger 31 will be referred to as a first dead water zone D1, and a formed length of the first dead water zone D1 in the air flow direction F will be referred to as a first formed length L1. As depicted in FIG. 10B, in the following description, a "dead water zone" formed leeward of each of the heat transfer tubes 31e constituting the first heat exchanger 31 will be referred to as a second dead water zone D2, and a formed length of the second dead water zone D2 in the air flow direction F will be referred to as a second formed length L2. Note that the heat transfer tubes 31e are flat multi-hole tubes. In the following description, the heat transfer tubes 31e configured as flat multi-hole tubes will also be referred to as flat multi-hole tubes 31e.

[0058] When comparing heat exchangers equal in heat exchange quantity, specifically, a heat exchanger including the heat transfer tube 31a as a heat transfer tube and a heat exchanger including the flat multi-hole tube 31e as a heat transfer tube, the first formed length L1 of the first dead water zone D1 at the heat transfer tube 31a is typically larger than the second formed length L2 of the second dead water zone D2 at the heat transfer tube 31e.

(Regarding disposition of first heat exchanger and second heat exchanger)

[0059] As depicted in FIG. 1 to FIG. 3, the second heat exchanger 32 in the refrigeration apparatus 10 is disposed windward of the first heat exchanger 31 in the air flow direction F of the air flow generated by the fan 15. Described hereinafter is a relationship between the second dead water zone D2 formed leeward of the second heat exchanger 32 and the heat transfer tube of the first heat exchanger 31 in cases where there are adopted three types of first heat exchangers 31 configured differently.

(Regarding case of disposing first heat exchanger according to first embodiment)

[0060] FIG. 11 is an explanatory view of a case where the first heat exchanger according to the first embodiment is disposed leeward of the second heat exchanger. FIG. 11 depicts disposition of the first heat exchanger 31A and the second heat exchanger 32 in a case where the refrigeration apparatus 10 adopts the first heat exchanger 31A according to the first embodiment. In the following description, a center position of each of the heat transfer tubes 31a in an array direction (the third direction Z) of the plurality of heat transfer tubes 31a constituting the first heat exchanger 31 will be referred to as a center position z1. In the following description, a center position of each of the heat transfer tubes 32a in an array direction (the third direction Z) of the plurality of heat transfer tubes 32a constituting the second heat exchanger 32 will be referred to as a center position z2. The center position z2 corresponds to a center in a thickness direction of the flat multi-hole tube 32a. FIG. 11 does not depict the fin 31b and the fin 32b.

[0061] When the refrigeration apparatus 10 according to the present disclosure adopts the first heat exchanger 31A, the first heat exchanger 31C and the second heat exchanger 32 are disposed to have a portion where the center position z1 of each of the heat transfer tubes 31a and the center position z2 of each of the heat transfer tubes 32a are misaligned with each other. The present embodiment exemplifies a case where there is no portion where the center position z1 and the center position z2 are aligned with each other. Alternatively, the first heat exchanger 31A and the second heat exchanger 32 may be disposed to partially have a portion where the center position z1 and the center position z2 are aligned with each other.

[0062] As depicted in FIG. 11, in the portion where the center position z2 of the flat multi-hole tube 32a and the center position z1 of the heat transfer tube 31a are misaligned with each other, the second dead water zone D2 formed leeward of the second heat exchanger 32 is positioned to be misaligned with the heat transfer tube 31a of the first heat exchanger 31. The refrigeration apparatus 10 thus configured can inhibit interference between the second dead water zone D2 formed leeward of the second heat exchanger 32 and the heat transfer tube 31a. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31 positioned leeward in the air flow direction F.

[0063] As depicted in FIG. 11, in the refrigeration apparatus 10 according to the present disclosure, the heat transfer tubes 31a of the first heat exchanger 31 have a first pitch P1 that is preferably different from a second pitch P2 of the heat transfer tubes 32a of the second heat exchanger 32. Differentiating between the first pitch P1 and the second pitch P2 inevitably generates the portion where the center position z2 of the flat multi-hole tube 32a and the center position z1 of the heat transfer tube 31a are misaligned with each other. The refrigeration apparatus 10 thus configured can inhibit interference between the second dead water zone D2 formed leeward of the second heat exchanger 32 and the heat transfer tube 31a. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31 positioned leeward in the air flow direction F.

(Regarding case of disposing first heat exchanger according to second embodiment)

[0064] FIG. 12 is an explanatory view of a case where the first heat exchanger according to the second embodiment is disposed leeward of the second heat exchanger. FIG. 12 depicts disposition of the first heat exchanger 31B and the second heat exchanger 32 in a case where the refrigeration apparatus 10 adopts the first heat exchanger 31B according to the second embodiment. The first heat exchanger 31B (see FIG. 5B) includes the heat transfer tube 31a having the linear tube portions 31x disposed staggeredly in a side view. As depicted in FIG. 12, the heat transfer tube 31a in the first heat exchanger 31B includes a first heat transfer tube group G1 including a plurality of circular tubes (the linear tube portions 31x) aligned in a first array direction (the third direction Z) and a second heat transfer tube group G2 including a plurality of circular tubes (the linear tube portions 31x) aligned in a second array direction (the third direction Z) leeward of the first array direction. In the first heat exchanger 31B, the first array direction and the second array direction are parallel to each other. In the following description, a center position of each of the heat transfer tubes 31a in the first array direction (the third direction Z) of the plurality of heat transfer tubes 31a constituting the first heat exchanger 31B will be referred to as a center position z1a. In the following description, a center position of each of the heat transfer tubes 31a in the second array direction (the third direction Z) of the plurality of heat transfer tubes 31a constituting the first heat exchanger 31B will be referred to as a center position z1b. In the first heat exchanger 31B, the center position z1a of each of the heat transfer tubes 31a in the first array direction (the third direction Z) of the heat transfer tubes 31a included in the first heat transfer tube group G1 is misaligned with the center position z1b of each of the heat transfer tubes 31a in the second array direction (the third direction Z) of the heat transfer tubes 31a included in the second heat transfer tube group G2. FIG. 12 does not depict the fin 31b and the fin 32b.

[0065] When the refrigeration apparatus 10 adopts the first heat exchanger 31B, the first heat exchanger 31A and the second heat exchanger 32 are disposed to have a portion where the center position z1a of each of the heat transfer tubes 31a and the center position z2 of each of the heat transfer tubes 32a are misaligned with each other in the first array direction (the third direction Z). The present embodiment exemplifies a case where there is no portion where the center position z1a and the center position z2 are aligned with each other. Alternatively, the first heat exchanger 31B and the second heat exchanger 32 may be disposed to partially have a portion where the center position z1a and the center position z2 are aligned with each other.

[0066] When the refrigeration apparatus 10 adopts the first heat exchanger 31B, in the first heat exchanger 31A and the second heat exchanger 32, the center position z1b of each of the heat transfer tubes 31a in the array direction of the heat transfer tubes 31a included in the second heat transfer tube group G2 in the plurality of heat transfer tubes 31a may be aligned with the center position z2 of each of the heat transfer tubes 32a in the array direction of the plurality of heat transfer tubes 32a constituting the second heat exchanger 32.

[0067] As depicted in FIG. 12, in the portion where the center position z2 of the flat multi-hole tube 32a and the center position z1a of the heat transfer tube 31a included in the first heat transfer tube group G1 are misaligned with each other, the second dead water zone D2 formed leeward of the second heat exchanger 32 is positioned to be misaligned with the heat transfer tube 3 1a included in the first heat transfer tube group G1. The refrigeration apparatus 10 thus configured can inhibit interference between the second dead water zone D2 formed leeward of the second heat exchanger 32 and the heat transfer tube 31a included in the first heat transfer tube group G1. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31B positioned leeward in the air flow direction F.

(Regarding case of disposing first heat exchanger according to third embodiment)

[0068] FIG. 13 is an explanatory view on a disposition relationship between the first heat exchanger according to the third embodiment and the second heat exchanger. FIG. 13 depicts disposition of the first heat exchanger 31C and the second heat exchanger 32 in a case where the refrigeration apparatus 10 adopts the first heat exchanger 31C according to the third embodiment. In the following description, a center position of each of the heat transfer tubes 3 1e in an array direction (the third direction Z) of the plurality of heat transfer tubes 3 1e constituting the first heat exchanger 31 will be referred to as the center position z1. The center position z1 corresponds to a center in a thickness direction of the heat transfer tube (flat multi-hole tube) 31e. FIG. 13 does not depict the fin 31f and the fin 32b.

[0069] When the refrigeration apparatus 10 according to the present disclosure adopts the first heat exchanger 31C, the first heat exchanger 31C and the second heat exchanger 32 are disposed to have a portion where the center position z1 of each of the heat transfer tubes 31a and the center position z2 of each of the heat transfer tubes 32a are aligned with each other. The present embodiment exemplifies a case where the center positions z1 and the center positions z2 are all aligned with each other. Alternatively, the first heat exchanger 31C and the second heat exchanger 32 may partially have a portion where the center position z1 and the center position z2 are misaligned with each other.

[0070] When both the heat transfer tube 3 1a of the first heat exchanger 31 and the heat transfer tubes 32a of the second heat exchanger 32 are flat multi-hole tubes and the first heat exchanger 31 and the second heat exchanger 32 are disposed as depicted in FIG. 13, deterioration in heat exchange efficiency is inhibited in the first heat exchanger 31 positioned leeward in the air flow direction F.

[Functional effects of embodiments]

[0071]

(1) The refrigeration apparatus 10 according to the embodiment described above includes the first refrigerant circuit RC1 having the first compressor 21, the first heat exchanger 31, the first expansion valve 41, and the utilization-side heat exchanger 34, and adopting the first refrigerant R1, the second refrigerant circuit RC2 having the second compressor 22, the second heat exchanger 32, and the second expansion valve 42, and adopting the second refrigerant R2, the third heat exchanger 33 configured to cause heat exchange between the first refrigerant R1 and the second refrigerant R2, and the fan 15. In the refrigeration apparatus 10, the heat transfer tube constituting the second heat exchanger 32 is the flat multi-hole tube 32a, and the second heat exchanger 32 is disposed windward of the first heat exchanger 31 in the air flow direction F of the air flow generated by the fan 15.

[0072] The refrigeration apparatus 10 according to the above embodiment includes the second heat exchanger 32 including the flat multi-hole tube 32a as a heat transfer tube. A heat exchanger including a flat multi-hole tube as a heat transfer tube can have a smaller dead water zone formed leeward in comparison to a heat exchanger including a circular tube as a heat transfer tube. In the refrigeration apparatus 10, the second heat exchanger 32 including the flat multi-hole tube 32a is disposed windward of the first heat exchanger 31 to inhibit interference with the dead water zone of the heat transfer tube 31a of the first heat exchanger 31 disposed leeward. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31 positioned leeward in the air flow direction F.

[0073] (2) The refrigeration apparatus 10 according to the above embodiment includes the plurality of flat multi-hole tubes 32a and the plurality of heat transfer tubes 31a constituting the first heat exchanger 31. The refrigeration apparatus 10 includes the portion where the center position z2 of each of the flat multi-hole tubes 32a in the array direction of the plurality of flat multi-hole tubes 32a and the center position z1 of each of the heat transfer tubes 31a in the array direction of the plurality of heat transfer tubes 31a constituting the first heat exchanger 31 are misaligned with each other in the air flow direction F.

[0074] In the portion where the center position z2 of the flat multi-hole tube 32a and the center position z1 of the heat transfer tube 31a are misaligned with each other, the second dead water zone D2 formed leeward of the second heat exchanger 32 is positioned to be misaligned with the heat transfer tube 31a constituting the first heat exchanger 31. The refrigeration apparatus 10 according to the present embodiment can thus inhibit interference between the second dead water zone D2 formed leeward of the second heat exchanger 32 and the heat transfer tube 31a of the first heat exchanger 31 disposed leeward. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31 positioned leeward in the air flow direction F.

[0075] (3) In the refrigeration apparatus 10 according to the above embodiment, the heat transfer tubes constituting the first heat exchanger 31 are the circular tubes 31a, and the first pitch P1 of the circular tubes 31a in the array direction of the plurality of circular tubes 31a is different from the second pitch P2 of the flat multi-hole tubes 32a in the array direction of the plurality of flat multi-hole tubes 32a.

[0076] In the refrigeration apparatus 10 according to the above embodiment, the first pitch P1 of the plurality of circular tubes 31a positioned leeward is differentiated from the second pitch P2 of the plurality of flat multi-hole tubes 32a positioned windward to provide the portion where the dead water zone formed leeward of the second heat exchanger 32 is misaligned with the circular tubes 31a of the first heat exchanger 31. The refrigeration apparatus 10 according to the present embodiment can thus inhibit interference between the dead water zone formed leeward of the second heat exchanger 32 and the circular tube 31a constituting the first heat exchanger 31 disposed leeward. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31 positioned leeward in the air flow direction F.

[0077] (4) In the refrigeration apparatus 10 according to the above embodiment, the second heat exchanger 32 includes the plurality of flat multi-hole tubes 32a and the fin 32b meanderingly disposed between the flat multi-hole tubes 32a adjacent to each other.

[0078] The refrigeration apparatus 10 thus configured achieves efficient heat exchange with use of the second heat exchanger 32. Furthermore, the refrigeration apparatus 10 thus configured can reduce used quantity of the second refrigerant R2.

[0079] (5) The refrigeration apparatus 10 according to the above embodiment includes the plurality of flat multi-hole tubes 32a and the plurality of heat transfer tubes 31a constituting the first heat exchanger 31. In the refrigeration apparatus 10, the heat transfer tubes constituting the first heat exchanger 31 are the circular tubes 31a. The first heat exchanger 31 includes the first heat transfer tube group G1 including the plurality of circular tubes 31a aligned in the first array direction, and the second heat transfer tube group G2 disposed adjacent to and leeward of the first heat transfer tube group G1 in the air flow direction F and including the plurality of circular tubes 31a aligned in the second array direction parallel to the first array direction. In the refrigeration apparatus 10, the center position z1a in the first array direction of the circular tube 31a included in the first heat transfer tube group G1 and the center position z1b in the second array direction of the circular tube 31a included in the second heat transfer tube group G2 are misaligned with each other in the air flow direction F. The refrigeration apparatus 10 according to the present embodiment includes the portion where the center position z2 of each of the flat multi-hole tubes 32a in the array direction of the plurality of flat multi-hole tubes 32a and the center position z1a of the circular tube 31a included in the first heat transfer tube group G1 in the first array direction are misaligned with each other in the air flow direction F.

[0080] The refrigeration apparatus 10 thus configured can inhibit interference between the dead water zone formed leeward of the second heat exchanger 32 and the circular tube 31a included in the first heat transfer tube group G1. This can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31 positioned leeward in the air flow direction F.

[0081] (6) The refrigeration apparatus 10 according to the above embodiment includes the plurality of flat multi-hole tubes 32a and the plurality of heat transfer tubes 31e constituting the first heat exchanger 31. In the refrigeration apparatus 10, the heat transfer tubes constituting the first heat exchanger 31 are the flat multi-hole tubes 31e. The refrigeration apparatus 10 includes the portion where the center position z2 of each of the flat multi-hole tubes 32a in the array direction of the plurality of flat multi-hole tubes 32a in the second heat exchanger 32 and the center position z1 of each of the flat multi-hole tubes 31e in the array direction of the plurality of flat multi-hole tubes 31e in the first heat exchanger 31 are aligned with each other in the air flow direction F.

[0082] When both the heat transfer tubes 3 1e of the first heat exchanger 31 and the heat transfer tubes 32a of the second heat exchanger 32 are flat multi-hole tubes, the refrigeration apparatus 10 thus configured can inhibit deterioration in heat exchange efficiency of the first heat exchanger 31 positioned leeward in the air flow direction F.

[0083] (7) In the refrigeration apparatus 10 according to the above embodiment, the second refrigerant R2 is combustible, is toxic, or has a global warming potential of 4 or more.

[0084] The refrigeration apparatus 10 thus configured can reduce used quantity of the second refrigerant R2 when adopting, as the second refrigerant R2, a natural refrigerant "having harmfulness", such as being combustible, being toxic, or having a global warming potential of 4 or more.

[0085] While various embodiments have been described herein above, it is to be appreciated that various changes in form and detail may be made without departing from the spirit and scope presently or hereafter claimed.

REFERENCE SIGNS LIST

[0086]

10 refrigeration apparatus
15 fan
21 first compressor
22 second compressor
31 first heat exchanger
31a circular tube (heat transfer tube)
31e flat multi-hole tube (heat transfer tube)
32 second heat exchanger
32a flat multi-hole tube (heat transfer tube)
32b fin
33 third heat exchanger
34 utilization-side heat exchanger
41 first expansion valve
42 second expansion valve
70 support
R1 first refrigerant
R2 second refrigerant
RC1 first refrigerant circuit
RC2 second refrigerant circuit
G1 first heat transfer tube group
G2 second heat transfer tube group
F air flow direction
z1 center position
z1a center position
z1b center position
z2 center position
P1 first pitch
P2 second pitch

Claims

1. A refrigeration apparatus (10) comprising:

   a first refrigerant circuit (RC1) including a first compressor (21), a first heat exchanger (31), a first expansion valve (41), and a utilization-side heat exchanger (34), and using a first refrigerant (R1);
   a second refrigerant circuit (RC2) including a second compressor (22), a second heat exchanger (32), and a second expansion valve (42), and using a second refrigerant (R2);
   a third heat exchanger (33) configured to cause heat exchange between the first refrigerant (R1) and the second refrigerant (R2); and
   a fan (15),
   wherein the second heat exchanger (32) includes a heat transfer tube constituted by a flat multi-hole tube (32a), and
   the second heat exchanger (32) is disposed windward of the first heat exchanger (31) in an air flow direction (F) of an air flow generated by the fan (15).

2. The refrigeration apparatus (10) according to claim 1, the refrigeration apparatus comprising

   a plurality of the flat multi-hole tubes (32a) and a plurality of heat transfer tubes (31a) constituting the first heat exchanger (31), and
   the refrigeration apparatus including a portion where a center position (z2) of each of the flat multi-hole tubes (32a) in an array direction of the plurality of the flat multi-hole tubes (32a) and a center position (z1) of each of the heat transfer tubes (31a) in an array direction of the plurality of heat transfer tubes (31a) constituting the first heat exchanger (31) are misaligned with each other in the air flow direction (F).

3. The refrigeration apparatus (10) according to claim 2, wherein

   the heat transfer tubes constituting the first heat exchanger (31) are circular tubes (31a), and
   a first pitch (P1) of the circular tubes (31a) in the array direction of the plurality of circular tubes (31a) is different from a second pitch (P2) of the flat multi-hole tubes (32a) in the array direction of the plurality of the flat multi-hole tubes (32a).

4. The refrigeration apparatus (10) according to claim 1 or 2, wherein the second heat exchanger (32) is constituted by a heat exchanger including a plurality of the flat multi-hole tubes (32a) and a fin (32b) meanderingly disposed between the flat multi-hole tubes (32a) adjacent to each other.

5. The refrigeration apparatus (10) according to claim 1, the refrigeration apparatus comprising a plurality of the flat multi-hole tubes (32a) and a plurality of heat transfer tubes (3 1a) constituting the first heat exchanger (31),

   wherein the heat transfer tubes constituting the first heat exchanger (31) are circular tubes (31a),
   the first heat exchanger (31) includes
   a first heat transfer tube group (G1) including the plurality of circular tubes (31a) aligned in a first array direction, and
   a second heat transfer tube group (G2) provided leeward of and adjacent to the first heat transfer tube group (G1) in the air flow direction (F) and including the plurality of circular tubes (31a) aligned in a second array direction parallel to the first array direction,
   a center position (z1a) in the first array direction of each of the circular tubes (31a) included in the first heat transfer tube group (G1) is misaligned in the air flow direction (F) with a center position (z1b) in the second array direction of each of the

circular tubes (31a) included in the second heat transfer tube group (G2), and

a center position (z2) of each of the flat multi-hole tubes (32a) in an array direction of the plurality of the flat multi-hole tubes (32a) and a center position (z1a) in the first array direction of each of the circular tubes included in the first heat transfer tube group (G1) are misaligned with each other in the air flow direction (F).

6. The refrigeration apparatus (10) according to claim 1, the refrigeration apparatus comprising a plurality of the flat multi-hole tubes (32a) and a plurality of heat transfer tubes (31e) constituting the first heat exchanger (31),

wherein the heat transfer tubes constituting the first heat exchanger (31) are flat multi-hole tubes (31e), and

the refrigeration apparatus includes a portion where a center position (z2) of each of the flat multi-hole tubes (32a) in an array direction of the plurality of the flat multi-hole tubes (32a) in the second heat exchanger (32) and a center position (z1) of each of the flat multi-hole tubes (31e) in an array direction of the plurality of flat multi-hole tubes (31e) in the first heat exchanger (31) are aligned with each other in the air flow direction (F).

7. The refrigeration apparatus (10) according to claim 1 or 2, wherein the second refrigerant (R2) is combustible, is toxic, or has a global warming potential of 4 or more.

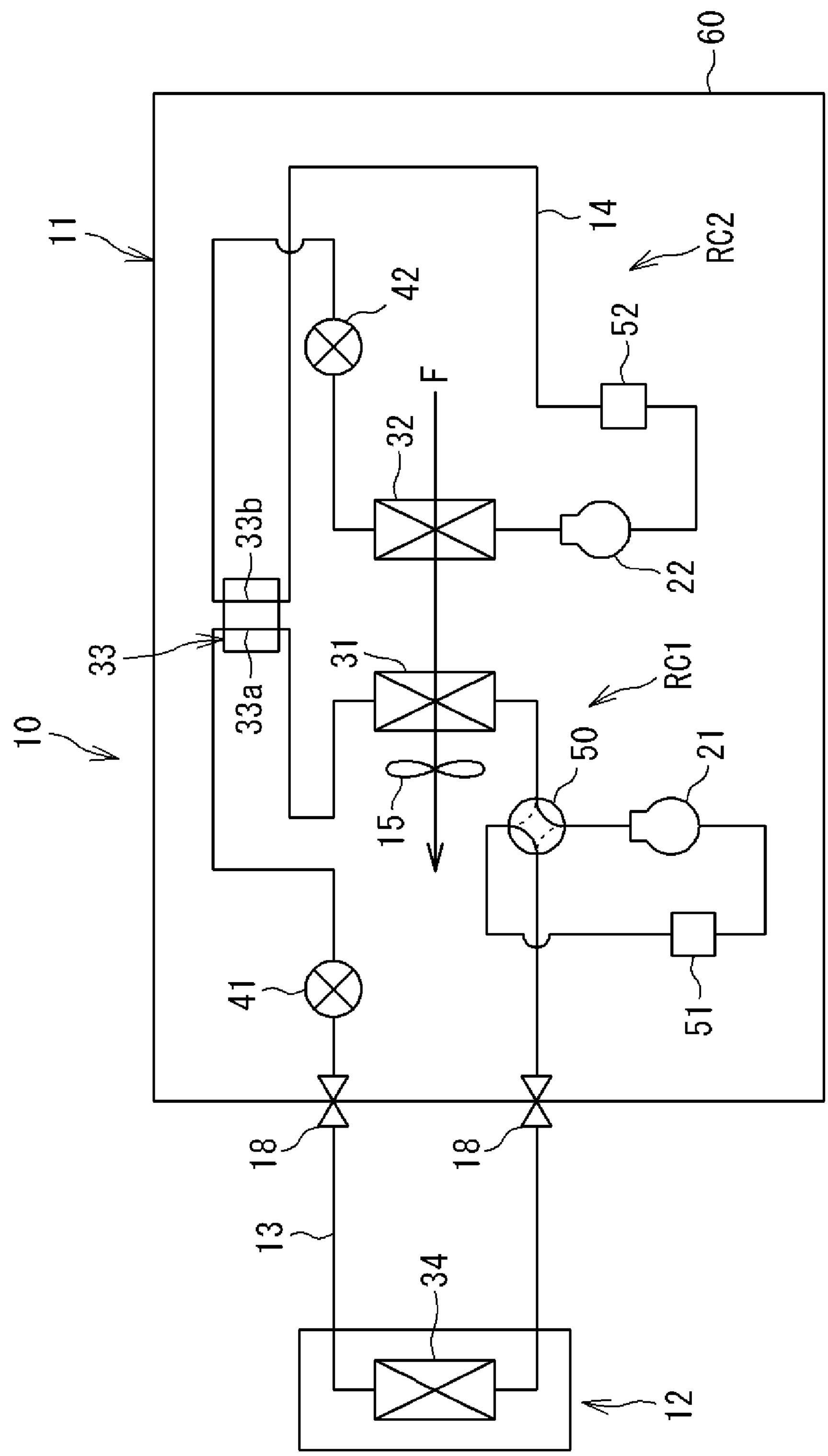

60
11
14
RC2
42
52
F
32
33b
22
33
31
RC1
33a
10
50
21
15
41
51
18
18
13
34
12

FIG. 1

FIG. 2

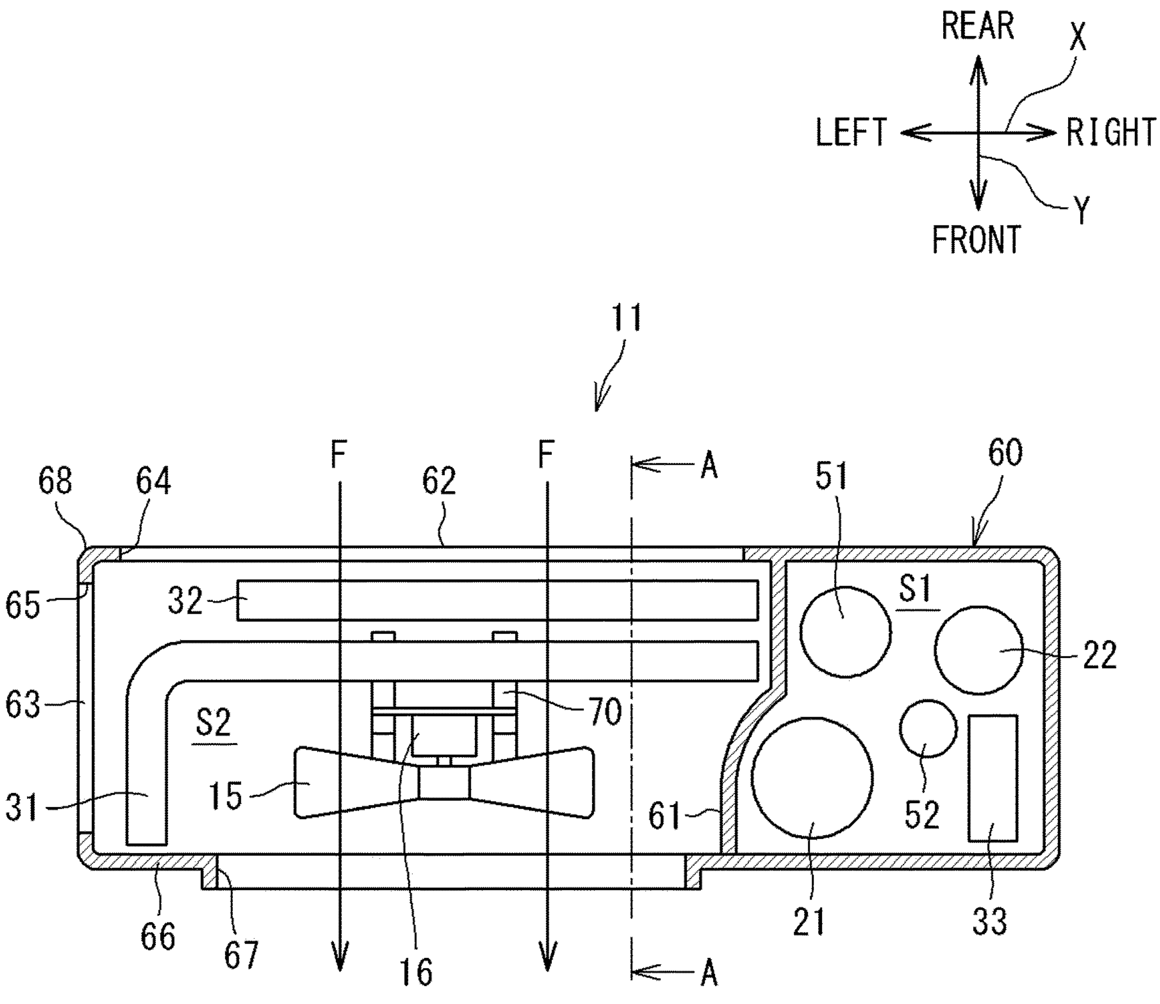

REAR
X
LEFT
RIGHT
Y
FRONT
11
F
F
A
A
68
64
62
60
51
S1
65
32
22
63
70
S2
31
15
61
52
66
67
16
21
33

FIG. 3

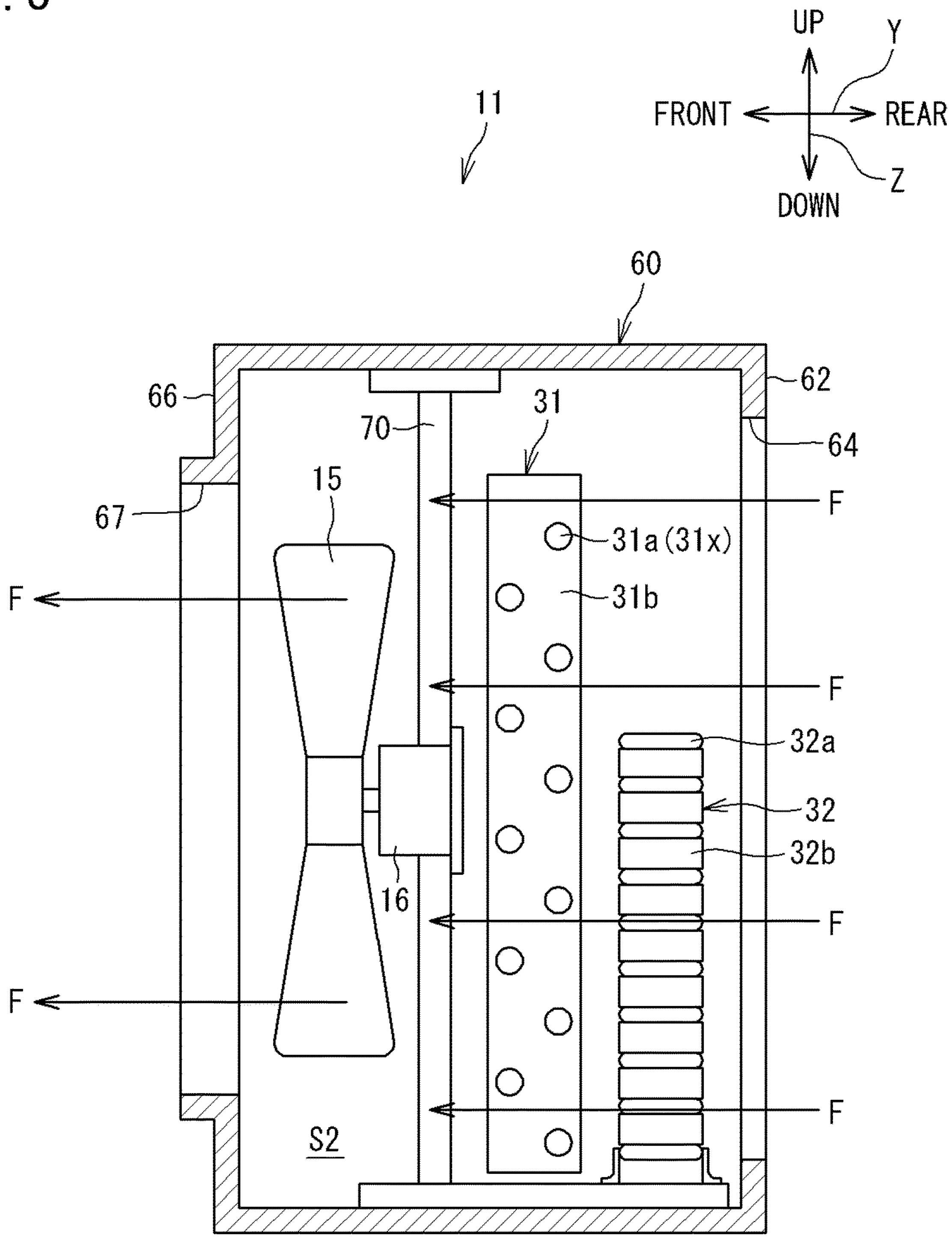

UP
Y
FRONT
REAR
Z
DOWN
11
60
62
64
66
67
70
31
15
F
31a (31x)
31b
32a
32
32b
16
S2

FIG. 4

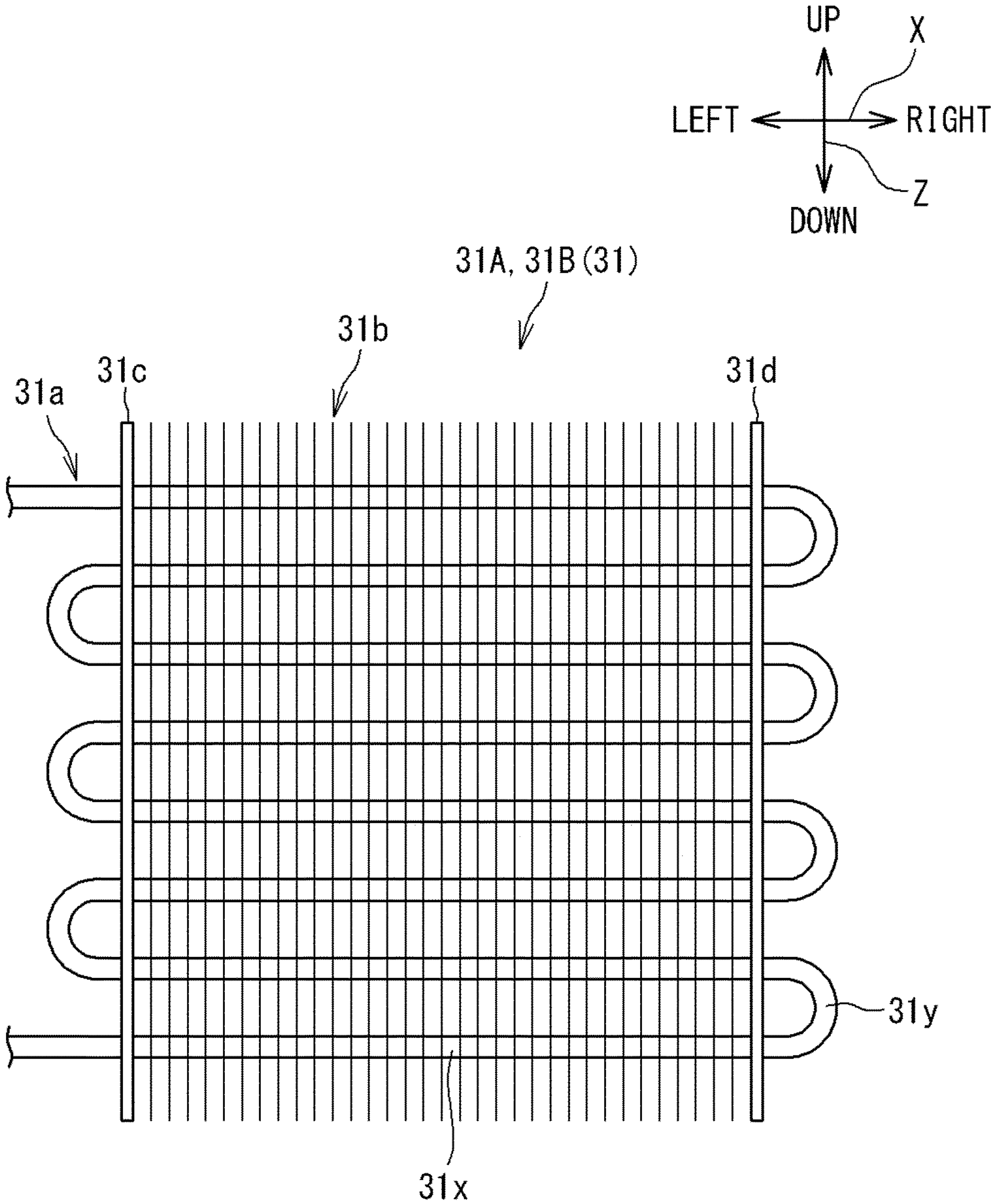


FIG. 5A

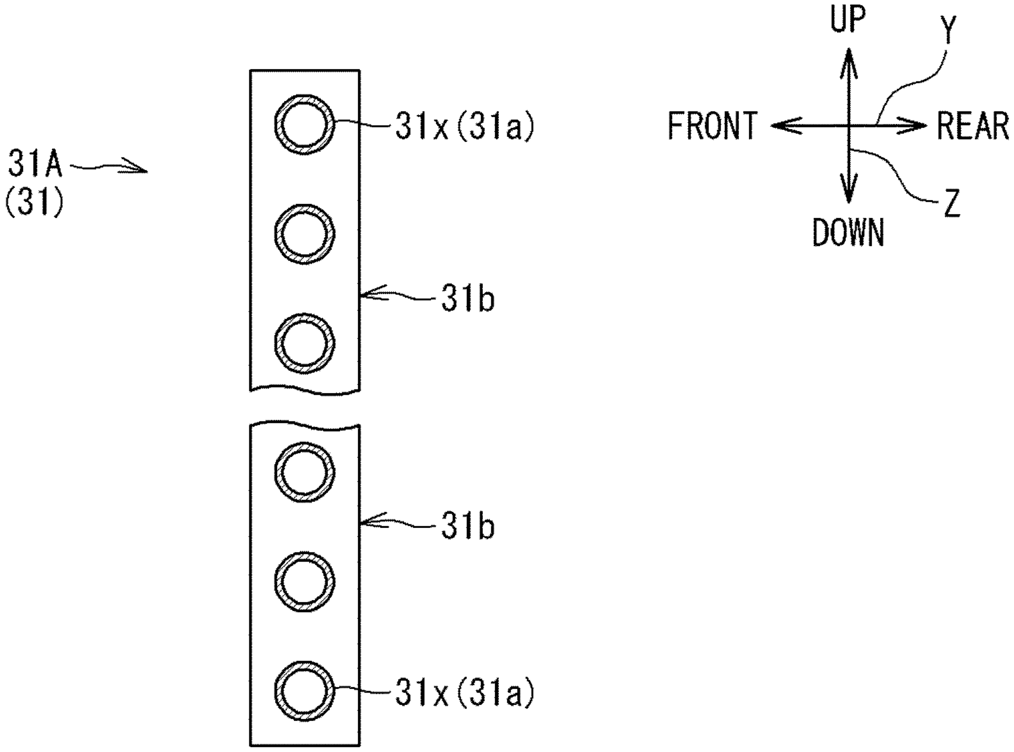

31A
(31)
31x (31a)
31b
31b
31x (31a)
UP
Y
FRONT
REAR
Z
DOWN

FIG. 5B

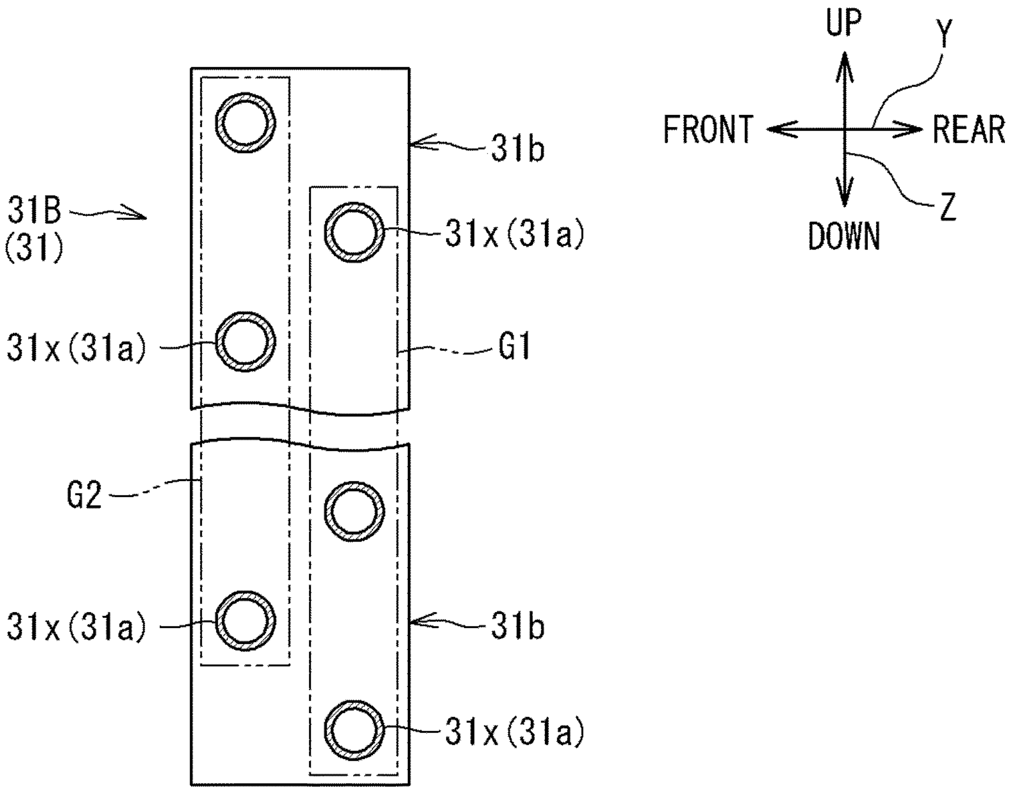

31b
31B
(31)
31x (31a)
31x (31a)
G1
G2
31x (31a)
31b
31x (31a)
UP
Y
FRONT
REAR
Z
DOWN

FIG. 6

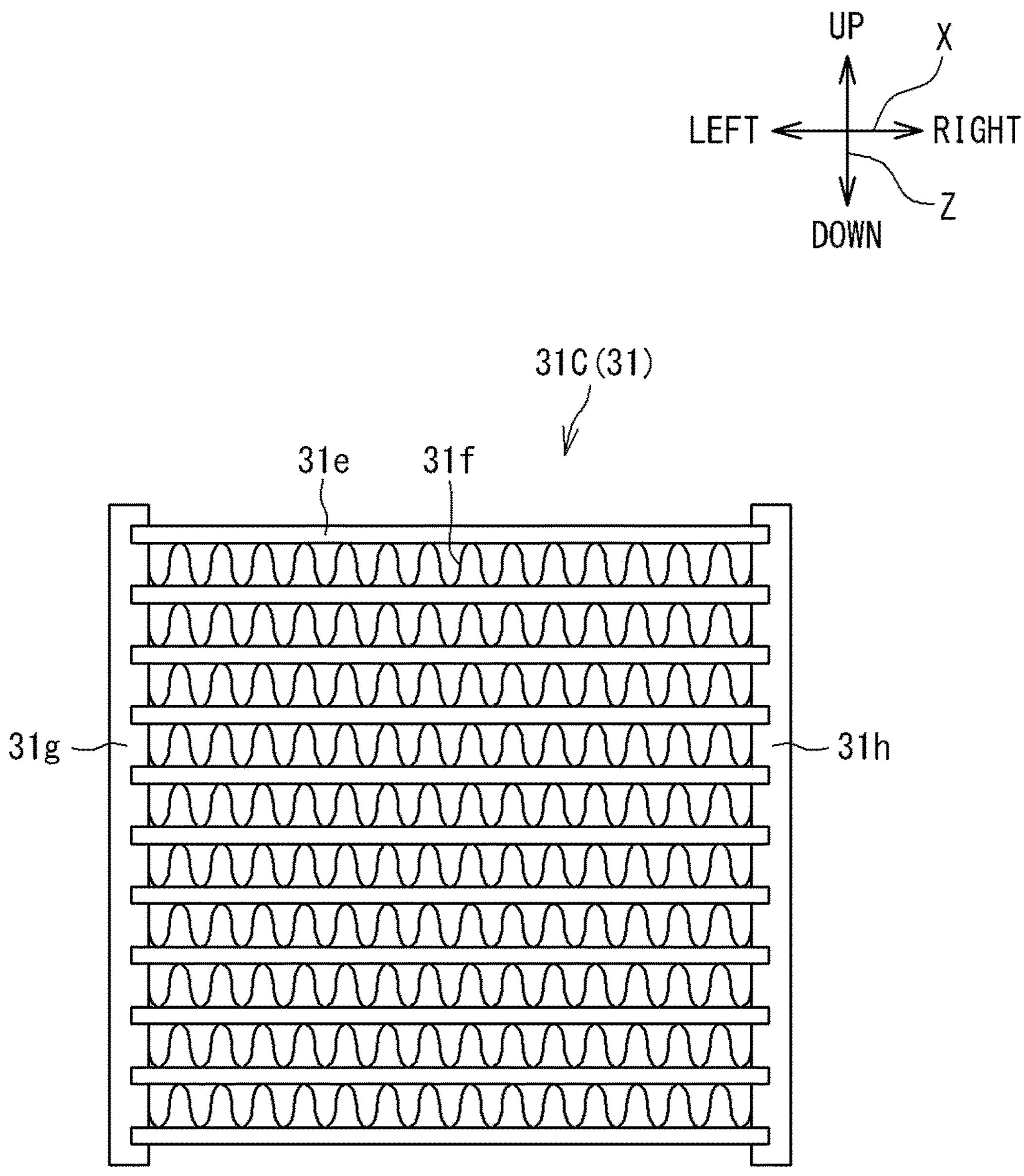


FIG. 7

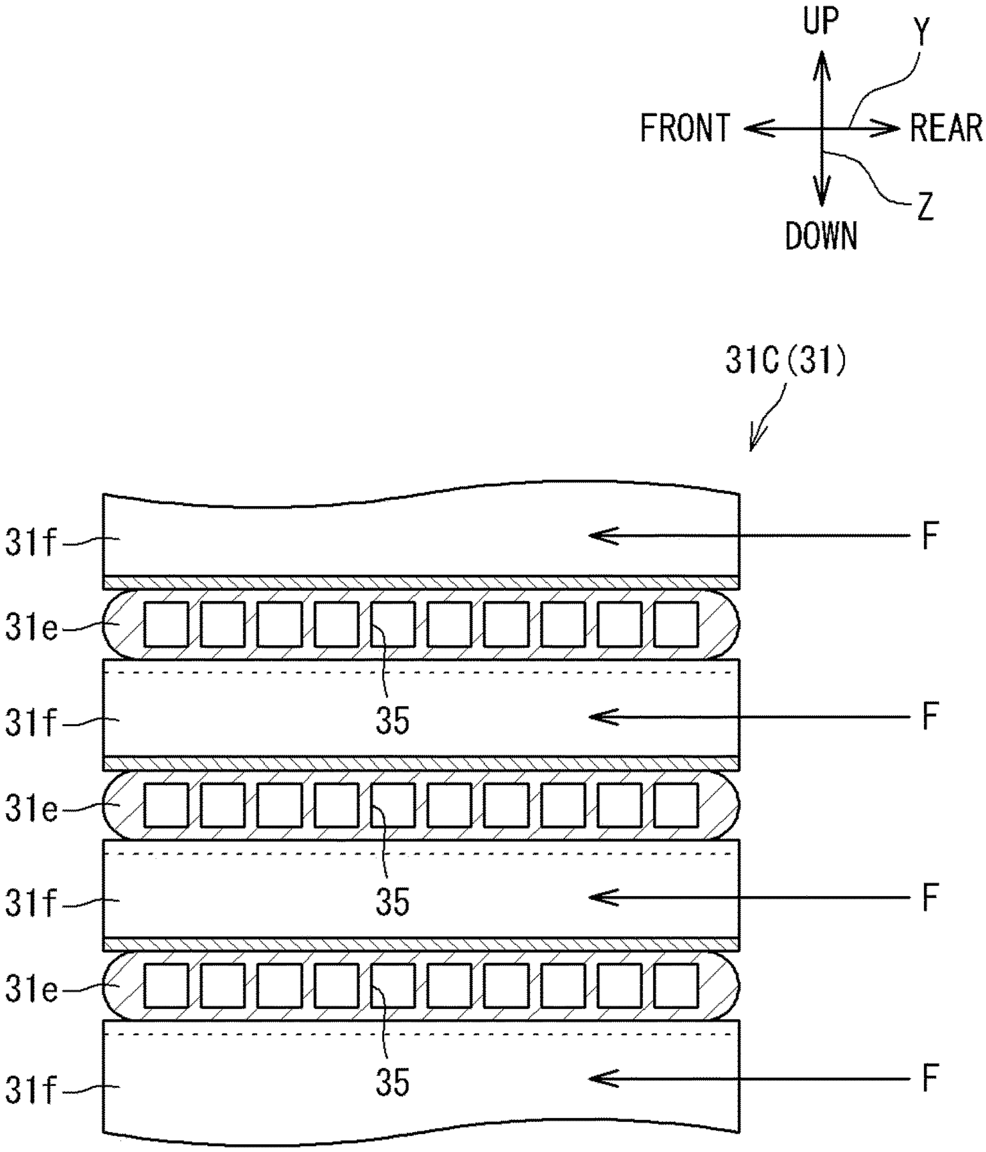


FIG. 8

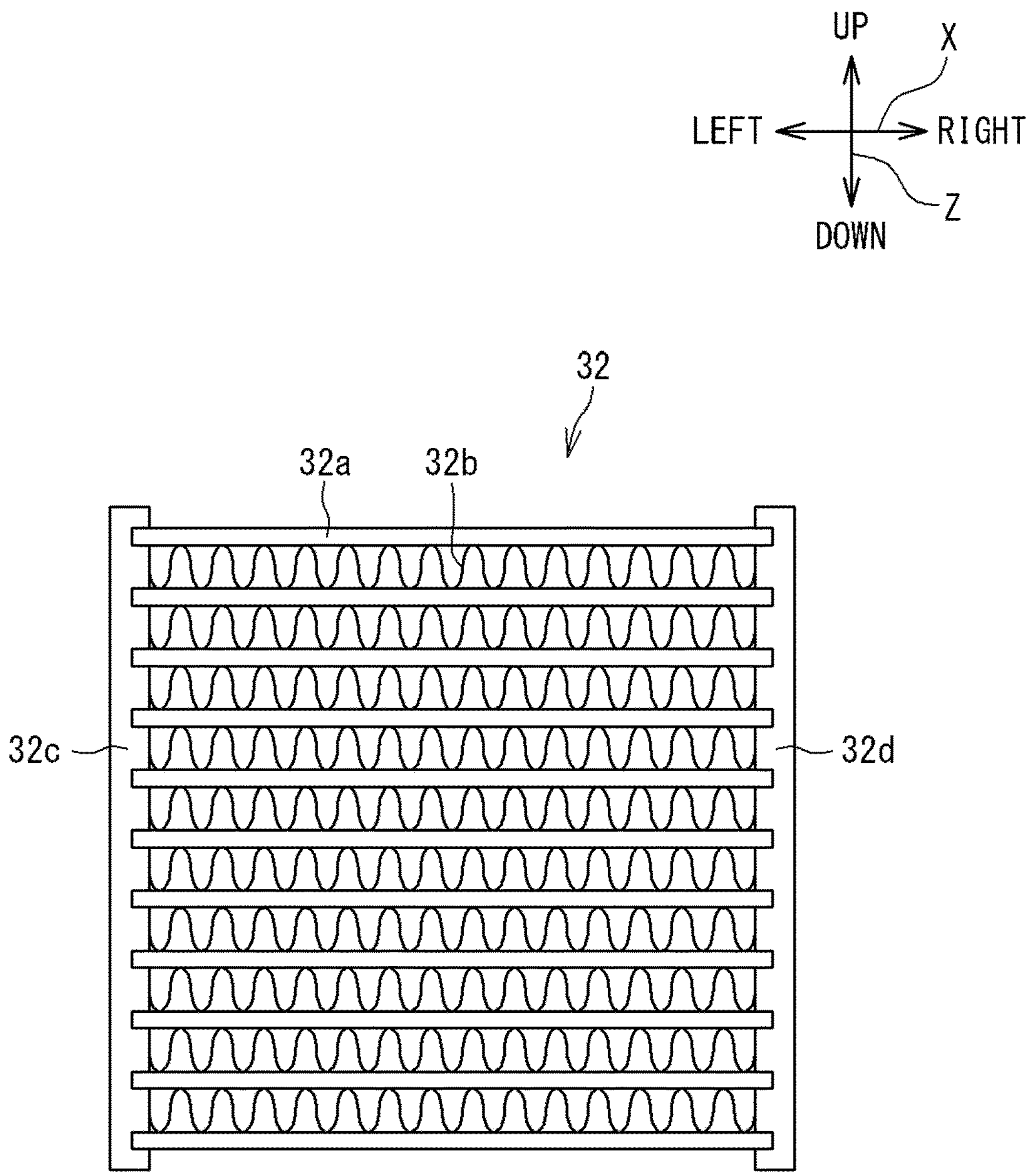
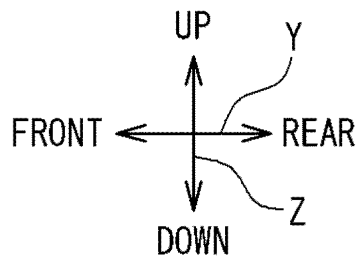


FIG. 9


UP
Y
FRONT
REAR
Z
DOWN

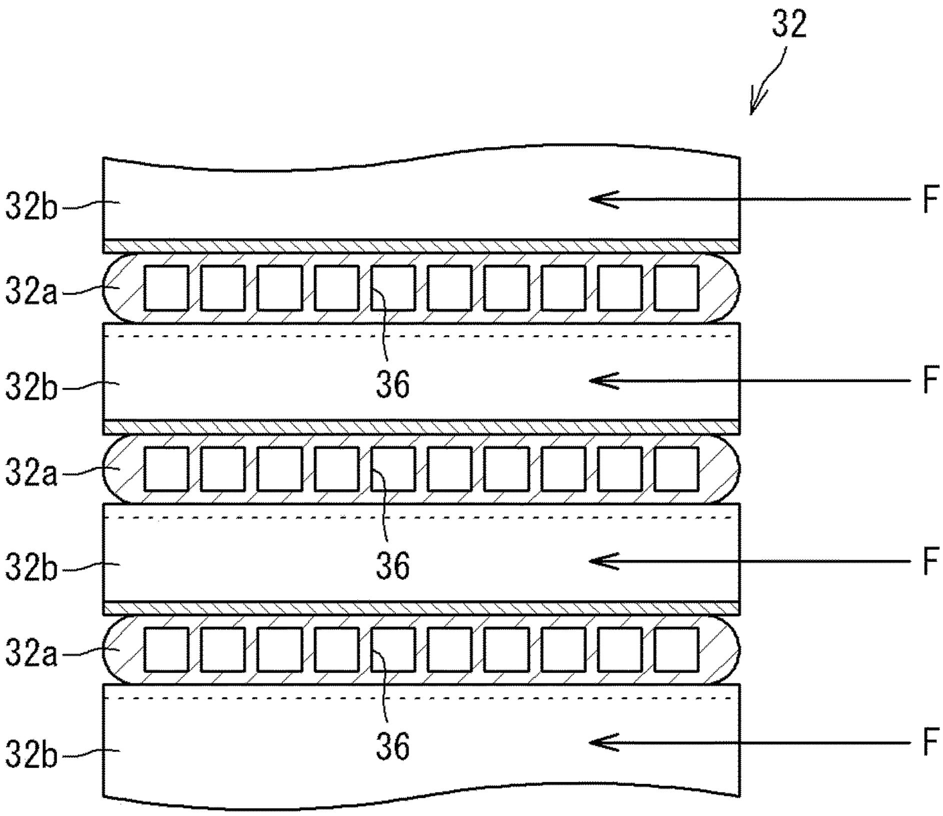

32
32b
F
32a
32b
36
F
32a
32b
36
F
32a
32b
36
F

FIG. 10A

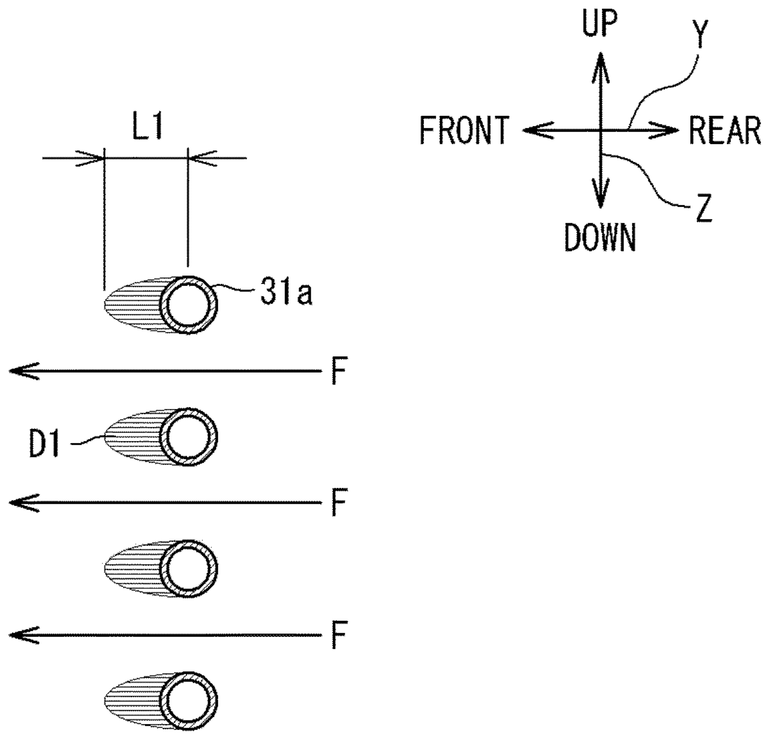


FIG. 10B

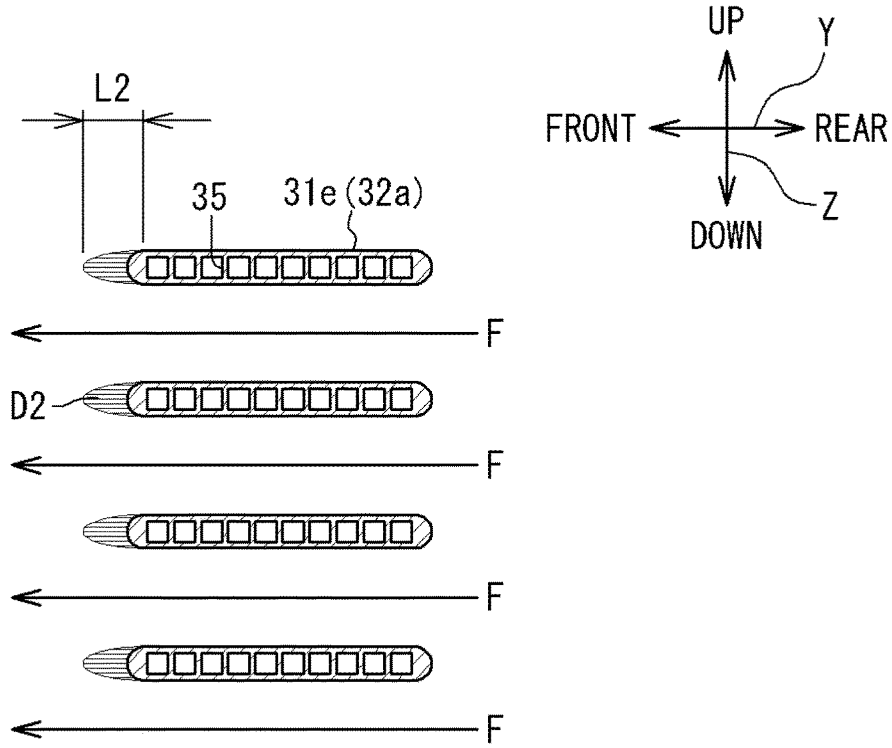


FIG. 11

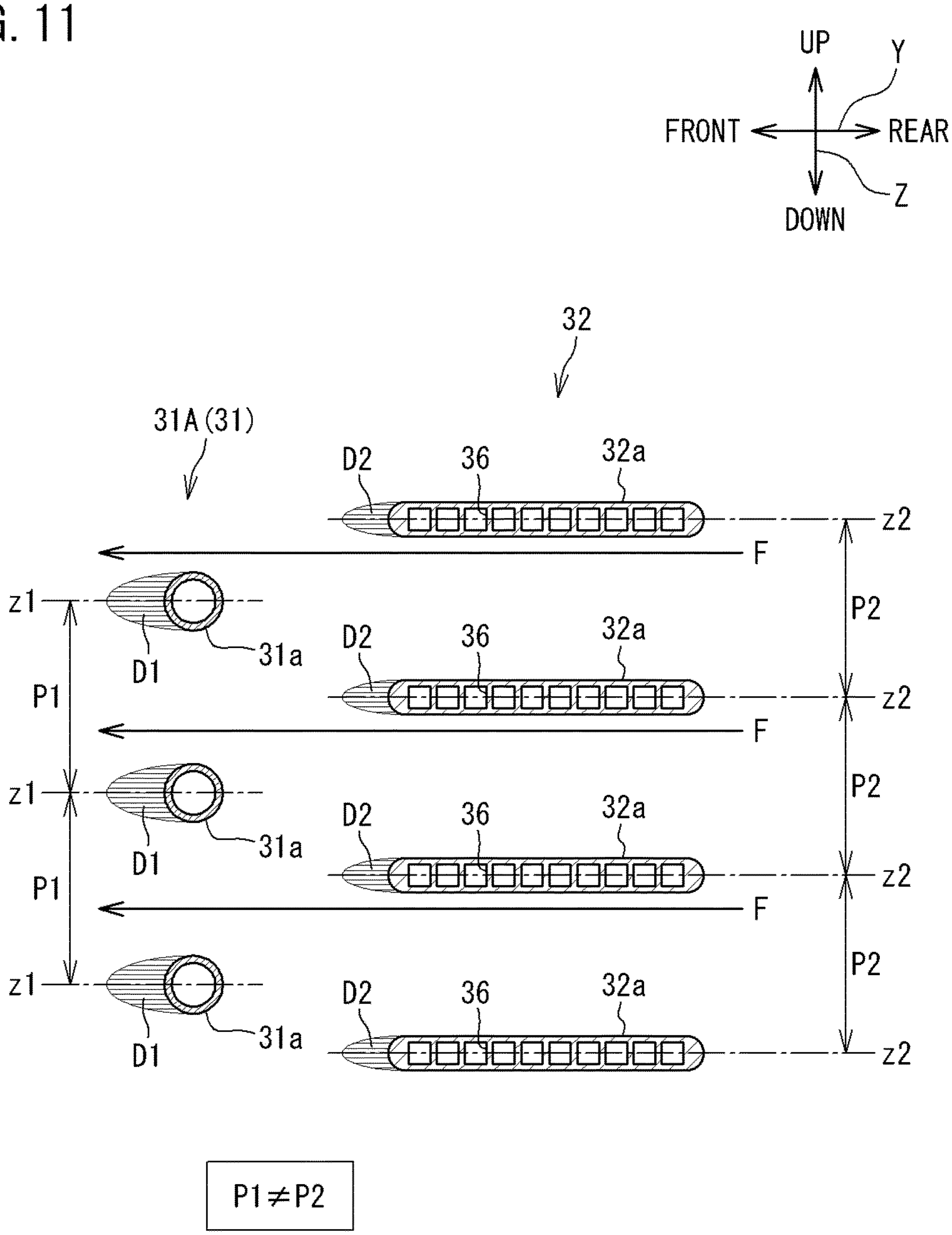


FIG. 12

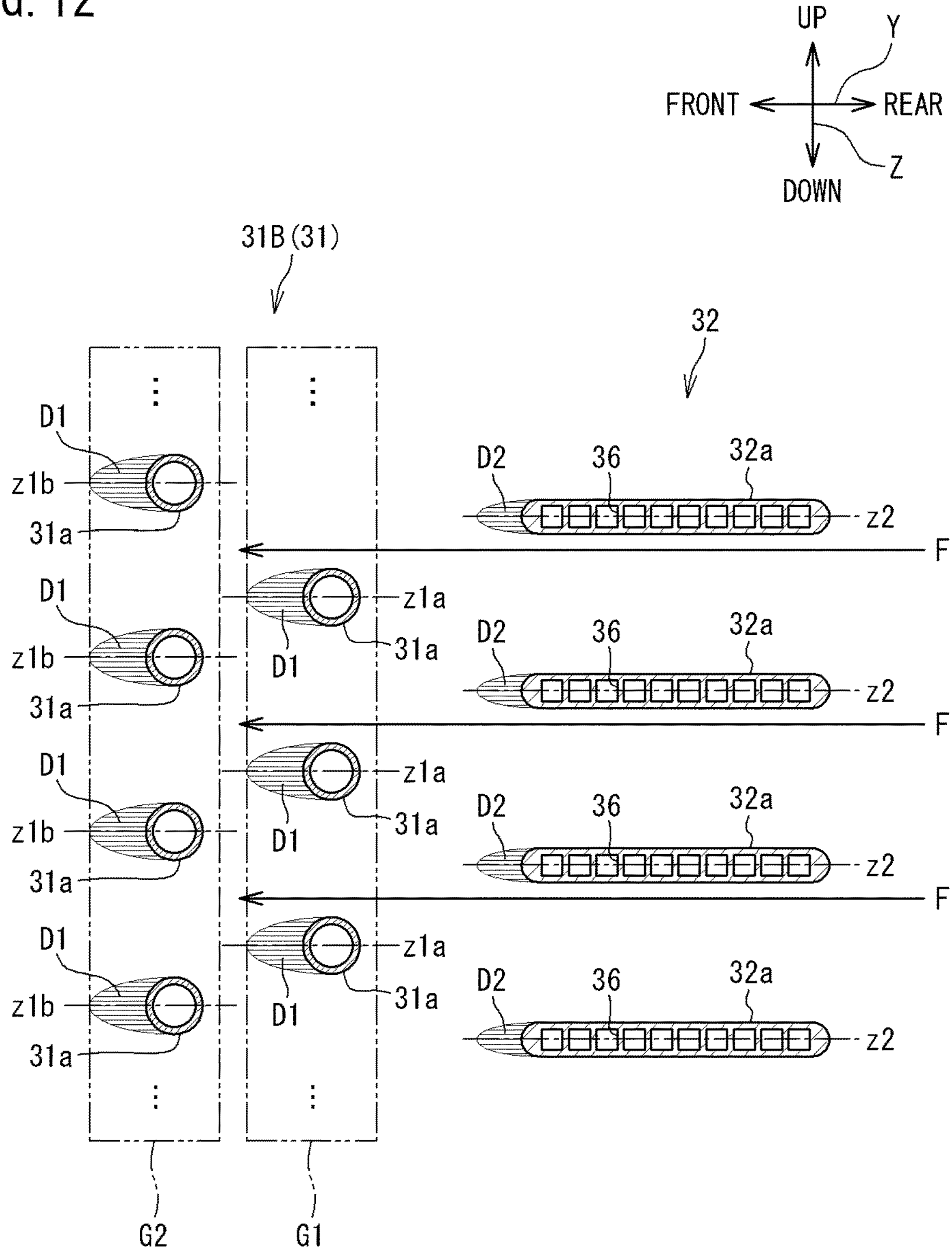
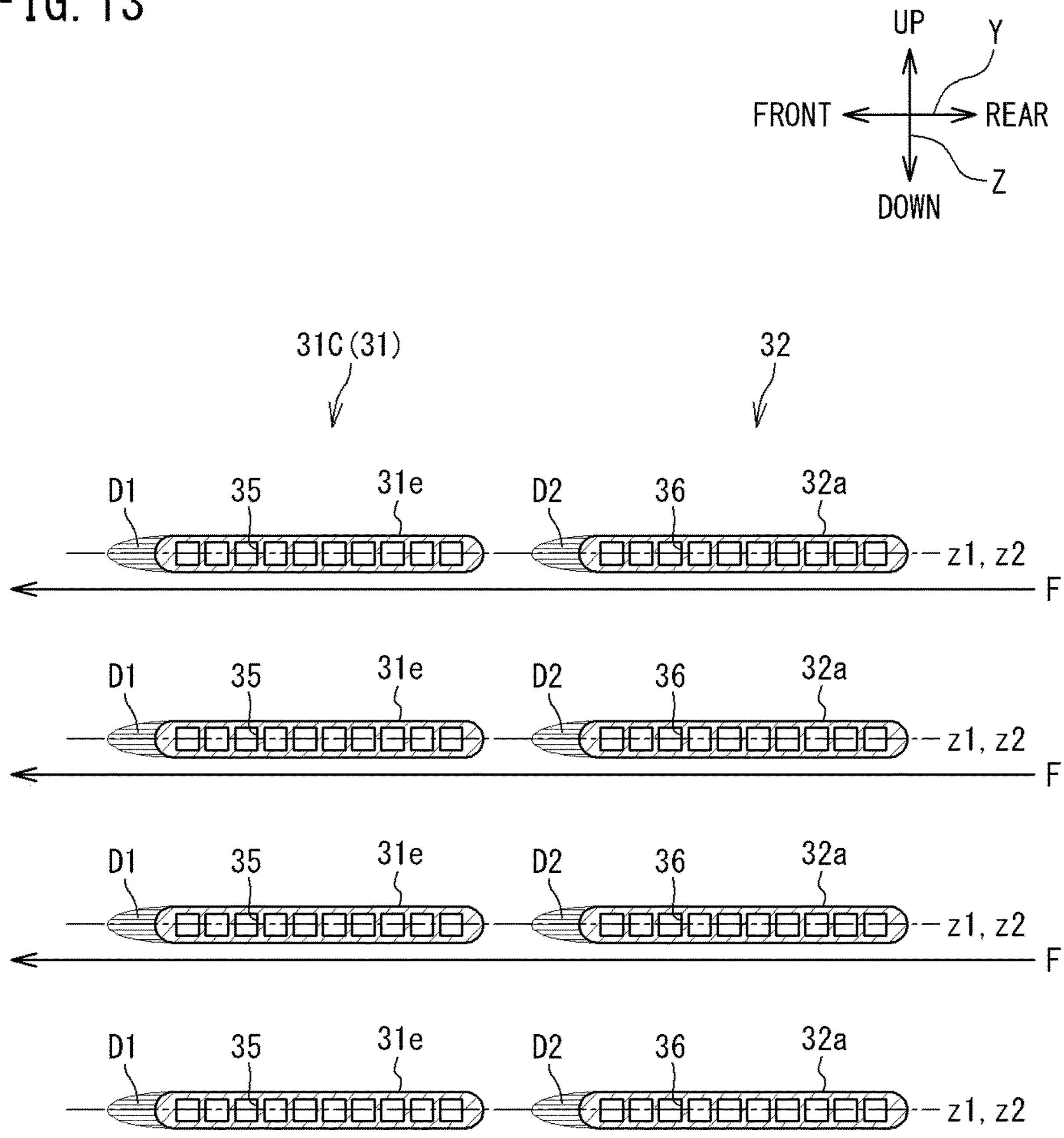

UP
Y
FRONT
REAR
Z
DOWN
31B (31)
32
D1
z1b
31a
D2
36
32a
z2
F
z1a
D1
G2
G1

FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2024/020197

A. CLASSIFICATION OF SUBJECT MATTER

F25B 7/00(2006.01)i; ***F25B 1/00***(2006.01)i; ***F25B 39/04***(2006.01)i; ***F28F 1/02***(2006.01)i
FI: F25B7/00 D; F25B1/00 397A; F25B39/04 C; F28F1/02 B

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)

F25B7/00; F25B1/00; F25B39/04; F28F1/02

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 1971-2024
Registered utility model specifications of Japan 1996-2024
Published registered utility model applications of Japan 1994-2024

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 A	WO 2022/013976 A1 (MITSUBISHI ELECTRIC CORPORATION) 20 January 2022 (2022-01-20) paragraphs [0012]-[0055], fig. 1-8	1-2, 4, 6-7 3, 5
Y A	JP 2022-115320 A (HITACHI-JOHNSON CONTROLS AIR CONDITIONING, INC.) 09 August 2022 (2022-08-09) paragraph [0036], fig. 6	1-2, 4, 6-7 3, 5
Y	JP 2008-261517 A (MITSUBISHI ELECTRIC CORPORATION) 30 October 2008 (2008-10-30) fig. 2	2, 4
Y	JP 2013-252560 A (SHANGHAI JIAO TONG UNIVERSITY) 19 December 2013 (2013-12-19) paragraph [0065]	4

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

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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
05 August 2024	**20 August 2024**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2024/020197

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 60-78258 A (HITACHI, LTD.) 02 May 1985 (1985-05-02) entire text, all drawings	1-7
A	JP 2022-159197 A (DAIKIN INDUSTRIES, LTD.) 17 October 2022 (2022-10-17) entire text, all drawings	1-7
A	WO 2019/077744 A1 (MITSUBISHI ELECTRIC CORPORATION) 25 April 2019 (2019-04-25) entire text, all drawings	1-7

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/020197

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
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		paragraphs [0012]-[0055], fig. 1-8	
		CN 115769032 A	
JP 2022-115320 A	09 August 2022	CN 114811768 A	
		paragraph [0049], fig. 6	
		JP 6918257 B1	
JP 2008-261517 A	30 October 2008	(Family: none)	
JP 2013-252560 A	19 December 2013	CN 102699155 A	
		paragraph [0079]	
JP 60-78258 A	02 May 1985	(Family: none)	
JP 2022-159197 A	17 October 2022	US 2024/0027104 A1	
		entire text, all drawings	
		US 2024/0027105 A1	
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		CN 117157496 A	
WO 2019/077744 A1	25 April 2019	US 2020/0224891 A1	
		entire text, all drawings	
		EP 3699502 A1	
		CN 111213010 A	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2014181399 A **[0003]**