(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 128 263 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
08.02.2017 Bulletin 2017/06

(21) Application number: **15757924.4**

(22) Date of filing: **06.03.2015**

(51) Int Cl.:
F25B 39/04 *(2006.01)* ***F25B 39/02*** *(2006.01)*
F28D 1/047 *(2006.01)*

(86) International application number:
PCT/JP2015/056724

(87) International publication number:
WO 2015/133626 (11.09.2015 Gazette 2015/36)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(30) Priority: **07.03.2014 PCT/JP2014/056018**

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(54) HEAT EXCHANGER AND AIR CONDITIONER

(57) A heat exchanger includes a primary heat exchange portion and a secondary heat exchange portion. The primary heat exchange portion includes first primary fins provided parallel to a direction in which a fan sends air, first primary pipes that are inserted into the first primary fins and through which refrigerant flows, second primary fins positioned windward of the first primary fins and provided parallel to the direction in which the fan sends air, second primary pipes that are inserted into the second primary fins and through which the refrigerant flows, and a primary-pipe connecting component extending in a direction parallel to the direction in which the fan sends air, and connecting one of the first primary pipes and one of the second primary pipes. The secondary heat exchange portion includes first secondary fins provided parallel to the direction in which the fan sends air, first secondary pipes that are inserted into the first secondary fins and through which the refrigerant flows, second secondary fins positioned windward of the first secondary fins and provided parallel to the direction in which the fan sends air, second secondary pipes that are inserted into the second secondary fins and through which the refrigerant flows, and a secondary-pipe connecting component extending in the direction parallel to the direction in which the fan sends air, and connecting one of the first secondary pipes and one of the second secondary pipes. When the heat exchanger acts as an evaporator, the refrigerant flows through the primary heat exchange portion from the first primary pipes toward the second primary pipes and the refrigerant flows through the secondary heat exchange portion from the second secondary pipes toward the first secondary pipes. When the heat exchanger acts as a condenser, the refrigerant flows through the primary heat exchange portion from the second primary pipes toward the first primary pipes and the refrigerant flows through the secondary heat exchange portion from the first secondary pipes toward the second secondary pipes.

Printed by Jouve, 75001 PARIS (FR)

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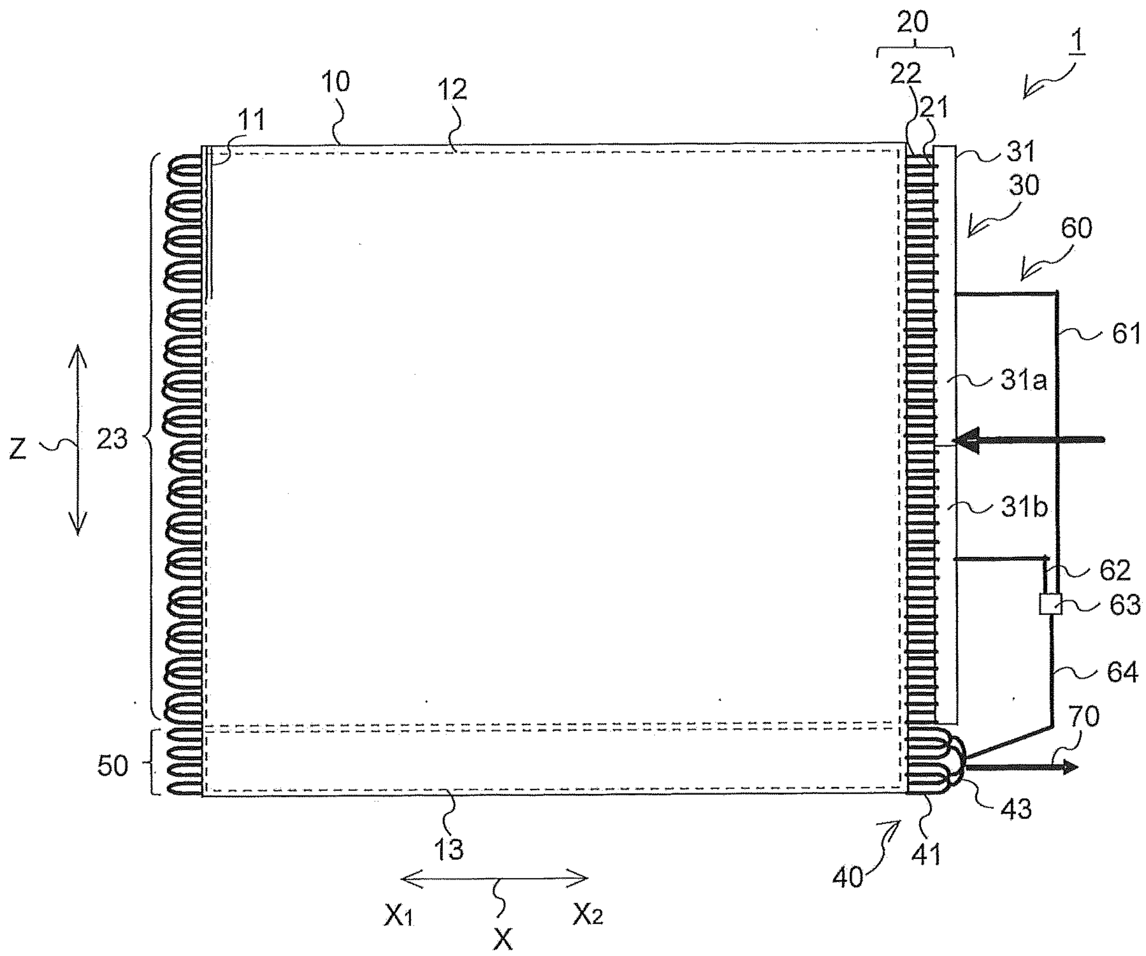
FIG. 1


20
22
21
1
10
12
11
31
30
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31a
Z
23
31b
62
63
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70
50
43
13
41
40
X1
X
X2

Description

Technical Field

[0001] The present invention relates to a heat exchanger and an air-conditioning apparatus including the heat exchanger.

Background Art

[0002] A finned tube heat exchanger is presented as a heat exchanger for use in an air-conditioning apparatus or another related apparatus. In the finned tube heat exchanger, tubes through which refrigerant flows are inserted into plate-shaped fins spaced apart from one another. In the finned tube heat exchanger, air flows through a space between the plate-shaped fins, and heat is exchanged between the air and the refrigerant flowing through the tubes.

[0003] As such a finned tube heat exchanger, Patent Literature 1 discloses a heat exchanger in which a first header collecting pipe is connected to one end of each of flat pipes, a second header collecting pipe is connected to the other end of each of the flat pipes, and fins are provided between the first header collecting pipe and the second header collecting pipe. The heat exchanger in Patent Literature 1 is separated into an upper heat exchange region and a lower heat exchange region, and the upper heat exchange region and the lower heat exchange region are separated in the direction of gravity. When the heat exchanger acts as a condenser, refrigerant flowing through the upper portion of the upper heat exchange region flows into the lower portion of the lower heat exchange region, and refrigerant flowing through the lower portion of the upper heat exchange region flows into the upper portion of the lower heat exchange region. Thus, the conventional technique aims to improve heat exchange efficiency by reducing heat loss due to heat exchange between gas state refrigerant and saturated liquid state refrigerant.

[0004] In addition to Patent Literature 1, Patent Literature 2 discloses a heat exchanger separated into an upper heat exchange region (main heat exchange portion) and a lower heat exchange region (auxiliary heat exchange portion). Patent Literature 2 aims to improve the condensing capacity and evaporating capacity of the heat exchanger by optimizing the degree of subcooling of refrigerant and the heating surface area of a flat pipe.

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2012-163328 (Page 2)
Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2013-83419 (Pages 2 to 4)

Summary of Invention

Technical Problem

[0006] However, in the heat exchangers disclosed in Patent Literatures 1 and 2, a direction in which air flows through a space between fins is perpendicular to a direction in which refrigerant flows through a flat pipe. Thus, the heat exchangers disclosed in Patent Literatures 1 and 2 are not able to sufficiently demonstrate their heat exchange performance.

[0007] In view of the problems, the present invention provides a heat exchanger in which heat exchange performance can be improved and an air-conditioning apparatus including the heat exchanger.

Solution to Problem

[0008] A heat exchanger according to an embodiment of the present invention includes a primary heat exchange portion and a secondary heat exchange portion. The primary heat exchange portion includes first primary fins provided parallel to a direction in which a fan sends air, first primary pipes that are inserted into the first primary fins and through which refrigerant flows, second primary fins positioned windward of the first primary fins and provided parallel to the direction in which the fan sends air, second primary pipes that are inserted into the second primary fins and through which the refrigerant flows, and a primary-pipe connecting component extending in a direction parallel to the direction in which the fan sends air, and connecting one of the first primary pipes and one of the second primary pipes. The secondary heat exchange portion includes first secondary fins provided parallel to the direction in which the fan sends air, first secondary pipes that are inserted into the first secondary fins and through which the refrigerant flows, second secondary fins positioned windward of the first secondary fins and provided parallel to the direction in which the fan sends air, second secondary pipes that are inserted into the second secondary fins and through which the refrigerant flows, and a secondary-pipe connecting component extending in the direction parallel to the direction in which the fan sends air, and connecting one of the first secondary pipes and one of the second secondary pipes. When the heat exchanger acts as an evaporator, the refrigerant flows through the primary heat exchange portion from the first primary pipes toward the second primary pipes and the refrigerant flows through the secondary heat exchange portion from the second secondary pipes toward the first secondary pipes. When the heat exchanger acts as a condenser, the refrigerant flows through the primary heat exchange portion from the second primary pipes toward the first primary pipes and the refrigerant flows through the secondary heat exchange portion from the first secondary pipes toward the second secondary pipes.

Advantageous Effects of Invention

[0009] According to an embodiment of the present invention, the primary-pipe connecting component and the secondary-pipe connecting component extend in the directions parallel to the direction in which air is sent. Thus, when the heat exchanger acts as either a condenser or an evaporator, a direction in which the refrigerant flows through the primary-pipe connecting component or the secondary-pipe connecting component is opposite to the direction in which air is sent. Consequently, heat exchange performance can be improved.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a front view of a heat exchanger 1 according to Embodiment 1.
[Fig. 2] Fig. 2 is a side view of the heat exchanger 1 according to Embodiment 1.
[Fig. 3] Fig. 3 is a cross-sectional view of the side of the heat exchanger 1 according to Embodiment 1.
[Fig. 4] Fig. 4 is another side view of the heat exchanger 1 according to Embodiment 1.
[Fig. 5] Fig. 5 is a circuit diagram of an air-conditioning apparatus 2 according to Embodiment 1.
[Fig. 6] Fig. 6 is a side view of a heat exchanger 100 according to Embodiment 2.
[Fig. 7] Fig. 7 is a top view of a secondary heat exchange portion 13 according to Embodiment 1.
[Fig. 8] Fig. 8 is a side view of the secondary heat exchange portion 13 according to Embodiment 1.
[Fig. 9] Fig. 9 is a cross-sectional view of the side of the secondary heat exchange portion 13 according to Embodiment 1.

Description of Embodiments

[0011] The following describes embodiments of a heat exchanger and an air-conditioning apparatus according to the present invention with reference to the drawings. Note that the present invention is not limited to the embodiments described below. Moreover, in the following drawings including Fig. 1, the size ratios of structural components may be different from the actual size ratios.

Embodiment 1

[0012] Fig. 1 is a front view of a heat exchanger 1 according to Embodiment 1. The following describes the heat exchanger 1 with reference to Fig. 1. As Fig. 1 illustrates, the heat exchanger 1 includes a fin portion 10, primary pipes 20, hairpin pipes 23, a header 30, secondary pipes 40, and connecting components (secondary-pipe connecting components) 50.

[0013] In the fin portion 10 having one end and the other end, plate-shaped fins 11 are spaced apart from one another in a direction (arrow X direction) perpendicular to a direction in which a heat medium such as air sent from a fan flows. The upper portion in the direction of gravity (arrow Z direction) of the fin portion 10 is a primary heat exchange portion 12 that exchanges heat between air and refrigerant. The lower portion in the direction of gravity (arrow Z direction) of the fin portion 10 is a secondary heat exchange portion 13. A part of the fin portion 10 occupied by the secondary heat exchange portion 13 is smaller than a part of the fin portion 10 occupied by the primary heat exchange portion 12. That is, the heat exchange area of the secondary heat exchange portion 13 is smaller than that of the primary heat exchange portion 12. Thus, the fin portion 10 includes the primary heat exchange portion 12 and the secondary heat exchange portion 13. The plate-shaped fins 11 are shared between the primary heat exchange portion 12 and the secondary heat exchange portion 13. However, the flow paths of installed heat transfer pipes, that is, the flow path of the primary pipes 20 and the flow path of the secondary pipes 40 are different.

[0014] Note that the plate-shaped fins 11 may include primary fins that are provided at the primary heat exchange portion 12 and into which the primary pipes 20 are inserted and secondary fins that are provided at the secondary heat exchange portion 13 and into which the secondary pipes 40 are inserted. The primary fins are arranged in two rows and parallel to the direction in which air flows. Likewise, the secondary fins are arranged in two rows and parallel to the direction in which air flows. The primary fin provided on the leeward side is a first primary fin, and the primary fin provided on the windward side is a second primary fin. The secondary fin provided on the leeward side is a first secondary fin, and the secondary fin provided on the windward side is a second secondary fin. Moreover, the primary fins and the secondary fins may be arranged in more than two rows.

[0015] The primary pipes 20, through which refrigerant flows, penetrate the plate-shaped fins 11 at the primary heat exchange portion 12 in an arrangement direction (arrow X direction). The primary pipes 20 include first primary pipes 21 each having one end and the other end inserted into the first primary fins and second primary pipes 22 each having one end and the other end inserted into the second primary fins. The first primary pipes 21 and the second primary pipes 22 are spaced apart from one another in the direction (arrow Z direction) parallel to the direction of gravity. In Embodiment 1, the number of the first primary pipes 21 is 16, and the number of the second primary pipes 22 is 16. Note that, in the direction in which the fan sends air, the first primary fins and the first primary pipes 21 are provided on the leeward side, and the second primary fins and the second primary pipes 22 are provided on the windward side. Moreover, the hairpin pipes 23 are provided at the other end of the fin portion 10 (on the X_1 side of the arrow X direction). The hairpin pipes 23 connect the other end of each of adjacent ones of the first primary pipes 21, and connect the other end of each of adjacent ones of the second primary pipes 22. Note that the first primary pipes 21, the second primary pipes 22, and the hairpin pipes 23 are flat pipes having flattened cross sections, for example.

[0016] Fig. 2 is a side view of the heat exchanger 1 according to Embodiment 1. As Fig. 2 illustrates, the header 30 includes a liquid-side header 31 and a gas-side header 32. When the heat exchanger 1 acts as a condenser, refrigerant flows from the gas-side header 32 toward the liquid-side header 31. When the heat exchanger 1 acts as an evaporator, the refrigerant flows from the liquid-side header 31 toward the gas-side header 32. The liquid-side header 31 is provided at the one end of the fin portion 10 (on the X_2 side of the arrow X direction in Fig. 1), and connects the one end of each of the first primary pipes 21 and the other end of a liquid pipe 60 having one end and the other end. Refrigerant in a substantially saturated liquid state flows through the liquid-side header 31.

[0017] Moreover, the liquid-side header 31 is divided at the center of the liquid-side header 31 in the direction of gravity (arrow Z direction). The liquid-side header 31 includes an upper header 31 a serving as the upper portion of the liquid-side header 31 and a lower header 31 b serving as the lower portion of the liquid-side header 31. Eight pipes of the first primary pipes 21 are connected to the upper header 31 a, and the other eight pipes of the first primary pipes 21 are connected to the lower header 31 b. That is, the refrigerant does not flow between the upper header 31 a and the lower header 31 b.

[0018] The one end of the liquid pipe 60 is connected to the secondary heat exchange portion 13. The liquid pipe 60 includes an upper capillary pipe 61, a lower capillary pipe 62, a distributor 63, and a junction pipe 64. The upper capillary pipe 61 extends from the upper header 31 a, and the lower capillary pipe 62 extends from the lower header 31 b. The upper capillary pipe 61 and the lower capillary pipe 62 join at the distributor 63. The junction pipe 64 connects the distributor 63 and the secondary heat exchange portion 13.

[0019] Moreover, the gas-side header 32 is connected to the one end of each of the second primary pipes 22, and is provided at the one end of the fin portion 10 (on the X_2 side of the arrow X direction in Fig. 1). That is, the gas-side header 32 and the liquid-side header 31 are adjacent in the direction (arrow Y direction) parallel to the direction in which air flows. Refrigerant in a substantially gas state flows through the gas-side header 32.

[0020] Fig. 3 is a cross-sectional view of the side of the heat exchanger 1 according to Embodiment 1. As Fig. 3 illustrates, in the primary heat exchange portion 12, the second primary pipe 22 extends from the gas-side header 32, curves upward in the direction of gravity (in the Z_1 direction) at the hairpin pipe 23 at the other end of the fin portion 10, is connected to a U bend pipe 24 provided in a direction (arrow Y direction) parallel to the direction in which air flows, via a joint 44, is again connected to the hairpin pipe 23, and is connected to the first primary pipe 21 extending up to the liquid-side header 31. That is, the U bend pipe 24 extends in a direction parallel to the direction in which the heat medium flows, and connects the other end of the first primary pipe 21 to the other end of the second primary pipe 22 at the other end of the fin portion 10. Note that the U bend pipe 24 corresponds to the primary-pipe connecting component of the present invention. However, the primary-pipe connecting component is not limited to the U bend pipe 24 having a U shape, but may be a curved rectangular pipe.

[0021] Moreover, the second primary pipe 22 adjacent to the second primary pipe 22 described above extends from the gas-side header 32, curves downward in the direction of gravity (in the arrow Z_2 direction) at the hairpin pipe 23 at the other end of the fin portion 10, is connected to the U bend pipe 24 provided in the direction (arrow Y direction) parallel to the direction in which air flows, is again connected to the hairpin pipe 23, and is connected to the first primary pipe 21 extending up to the liquid-side header 31. Thus, in the primary heat exchange portion 12, the second primary pipes 22 are adjacent to each other in the vicinity of the gas-side header 32, that is, at a portion in which the refrigerant is in a superheated state. Moreover, the first primary pipes 21 are adjacent to each other in the vicinity of the liquid-side header 31, that is, at a portion in which the refrigerant is in a saturated liquid state.

[0022] The secondary pipes 40, through which the refrigerant flows, penetrate the plate-shaped fins 11 at the secondary heat exchange portion 13 in the arrangement direction (arrow X direction). The secondary pipes 40 include first secondary pipes 41 inserted into the first secondary fins and second secondary pipes 42 inserted into the second secondary fins. Note that, in the direction in which the fan sends air, the first secondary fins and the first secondary pipes 41 are provided on the leeward side, and the second secondary fins and the second secondary pipes 42 are provided on the windward side.

[0023] As Fig. 2 illustrates, one end of the first secondary pipe 41 is connected to the one end of the liquid pipe 60, and four first secondary pipes 41 are spaced apart from one another in the direction (arrow Z direction) parallel to the direction of gravity. The upper two pipes of the four first secondary pipes 41 are connected to two ends of a branch pipe such as a three-way pipe 43. One end of the junction pipe 64 of the liquid pipe 60 is connected to the other end of the three-way pipe 43. Moreover, the lower two pipes of the four first secondary pipes 41 are connected to two ends of a branch pipe such as the three-way pipe 43. Another end of the junction pipe 64 of the liquid pipe 60 is connected to the other end of the three-way pipe 43.

[0024] Note that, as described above, the junction pipe 64 connects the distributor 63 and the secondary heat exchange portion 13 to one another, and is divided into two paths on the side where the secondary heat exchange portion 13 is provided. The divided paths are each connected to one end of a different one of the three-way pipes 43. Note that the one end of each of the first secondary pipes 41 is below the liquid-side header 31. Moreover, the first secondary pipes 41 are, for example, flat pipes having flattened cross sections. The three-way pipes 43 are circular pipes having circular cross sections. Thus, the first secondary pipe 41 and the three-way pipe 43 are joined by the joint 44 whose one end is flat and whose other end is circular.

[0025] One end of the second secondary pipe 42 serves as the inlet or outlet of the refrigerant, and four second secondary pipes 42 are spaced apart from one another in the direction (arrow Z direction) parallel to the direction of gravity. The upper two pipes of the four second secondary pipes 42 are connected to two ends of a branch pipe such as the three-way pipe 43. One end of a liquid inlet-outlet pipe 70 serving as the inlet or outlet of the refrigerant is connected to the other end of the three-way pipe 43. Moreover, the lower two pipes of the four second secondary pipes 42 are connected to two ends of a branch pipe such as the three-way pipe 43. Another end of the liquid inlet-outlet pipe 70 is connected to the other end of the three-way pipe 43.

[0026] Note that the liquid inlet-outlet pipe 70 is divided into two paths at the other ends of the three-way pipes 43 and the two paths join later. Note that the one end of each of the second secondary pipes 42 is below the gas-side header 32. Moreover, the second secondary pipes 42 are, for example, flat pipes having flattened cross sections. The three-way pipes 43 are circular pipes having circular cross sections. Thus, the second secondary pipe 42 and the three-way pipe 43 are joined by the joint 44 whose one end is flat and whose other end is circular.

[0027] Note that, in the direction in which the fan sends air, the first secondary pipes 41 are provided on the leeward side, and the second secondary pipes 42 are provided on the windward side. Moreover, the first secondary pipe 41 and the second secondary pipe 42 adjacent to each other are not horizontal in the direction in which air flows (arrow Y direction) and are at different positions in the direction of gravity (arrow Z direction).

[0028] Fig. 4 is another side view of the heat exchanger 1 according to Embodiment 1. As Fig. 4 illustrates, the connecting component 50 extends in the direction (arrow Y direction) parallel to the direction in which air flows, and connects the other end of the first secondary pipe 41 and the other end of the second secondary pipe 42 at the other end of the fin portion 10. Fig. 7 is a top view of the secondary heat exchange portion 13 according to Embodiment 1. As Fig. 7 illustrates, the connecting component 50 connects the first secondary pipe 41 and the second secondary pipe 42 in top view. Note that, as described above, the first secondary pipe 41 and the second secondary pipe 42 adjacent to each other are not horizontal in the direction in which air flows (arrow Y direction) and are at different positions in the direction of gravity (arrow Z direction). Thus, the connecting component 50 is inclined by an amount corresponding to a difference in the positions of the first secondary pipe 41 and the second secondary pipe 42 in the direction of gravity (arrow Z direction).

[0029] Fig. 8 is a side view of the secondary heat exchange portion 13 according to Embodiment 1. As Fig. 8 illustrates, as described above, in the secondary heat exchange portion 13, a pipe connecting adjacent pipes such as the connecting component 50 is not used in a longitudinal direction that is the direction of gravity (arrow Z direction). A pipe extending from one column to another column such as the connecting component 50 is used only in a row direction that is a direction (arrow Y direction) parallel to the direction in which air flows. Thus, the direction in which refrigerant flows is the same in the first secondary pipes 41 adjacent to each other in the longitudinal direction and in the second secondary pipes 42 adjacent to each other in the longitudinal direction.

[0030] The following describes operations of the heat exchanger 1 according to Embodiment 1.

[0031] The following describes a case in which the heat exchanger 1 acts as a condenser. Refrigerant flows into the gas-side header 32, and flows through the 16 second primary pipes 22. Heat is exchanged between air and the refrigerant flowing through the second primary pipes 22 at the fin portion 10, and the refrigerant is condensed. The refrigerant turns around at the hairpin pipes 23 at the other end of the fin portion 10 (on the X_1 side of the arrow X direction in Fig. 1), and heat is again exchanged between the refrigerant and air at the fin portion 10. The refrigerant is further condensed and enters a saturated liquid state. The saturated liquefied refrigerant flows into the U bend pipes 24, and flows from the second primary pipes 22 to the first primary pipes 21. A portion of the saturated liquefied refrigerant flows into the upper eight pipes of the first primary pipes 21 in the direction of gravity (arrow Z direction), and then flows into the upper header 31 a of the liquid-side header 31. The other portion of the saturated liquefied refrigerant flows into the lower eight pipes of the first primary pipes 21 in the direction of gravity (arrow Z direction), and then flows into the lower header 31 b of the liquid-side header 31.

[0032] The refrigerant flowing through the upper header 31 a flows into the upper capillary pipe 61. The refrigerant flowing through the lower header 31 b flows into the lower capillary pipe 62. The divided refrigerant joins at the distributor 63, flows through the junction pipe 64, is again divided into two, flows through the three-way pipes 43, and then flows into the four first secondary pipes 41. Heat is exchanged between air and the refrigerant flowing through the first secondary pipes 41 at the fin portion 10. Thus, the refrigerant is further condensed and enters a subcooled state. The refrigerant flows into the connecting components 50 at the other end of the fin portion 10 (on the X_1 side of the arrow X direction in Fig. 1), and flows from the first secondary pipes 41 to the second secondary pipes 42. Note that, in Embodiment 1, when the heat exchanger 1 acts as the condenser, the refrigerant flowing through the connecting components 50 flows in a direction opposite to the direction in which air flows. The refrigerant then flows into the second secondary pipes 42. Heat is exchanged between air and the refrigerant at the fin portion 10, further condensing the refrigerant. The refrigerant flows into the three-way pipes 43, and the subcooled refrigerant is discharged from the liquid inlet-outlet pipe 70.

[0033] The following describes a case in which the heat exchanger 1 acts as an evaporator. Two-phase state refrigerant flows into the three-way pipes 43 from the liquid inlet-outlet pipe 70, and flows through the second secondary pipes 42. Then, heat is exchanged between the refrigerant and air at the fin portion 10. The refrigerant is evaporated and flows into the connecting components 50 at the other end of the fin portion 10 (on the X_1 side of the arrow X direction in Fig. 1). The refrigerant flows from the second secondary pipes 42 to the first secondary pipes 41. Heat is exchanged between air and the refrigerant flowing through the first secondary pipes 41 at the fin portion 10. The refrigerant enters a saturated liquid state, flows into the three-way pipes 43, and then flows into the junction pipe 64. The saturated liquid state refrigerant is divided into two at the distributor 63. A portion of the refrigerant flows into the upper capillary pipe 61, and then flows into the upper header 31 a of the liquid-side header 31. The other portion of the refrigerant flows into the lower capillary pipe 62, and then flows into the lower header 31 b of the liquid-side header 31.

[0034] The refrigerant flowing into the upper header 31 a flows into eight pipes of the first primary pipes 21 on the upper side in the direction of gravity (arrow Z direction). The other refrigerant flowing into the lower header 31 b flows into eight pipes of the first primary pipes 21 on the lower side in the direction of gravity (arrow Z direction). Heat is further exchanged between the refrigerant and air at the fin portion 10, and the refrigerant is evaporated. The refrigerant turns around at the hairpin pipes 23 at the other end of the fin portion 10 (on the X_1 side of the arrow X direction in Fig. 1), and heat is again exchanged between the refrigerant and air at the fin portion 10. The refrigerant is further evaporated and enters a gas state. The gasified refrigerant flows into the U bend pipes 24, and flows from the first primary pipes 21 to the second primary pipes 22. The gas state refrigerant flows into the gas-side header 32, and is then discharged from the heat exchanger 1 to the outside.

[0035] The following describes effects of the heat exchanger 1 according to Embodiment 1. As described above, the connecting components 50 of the heat exchanger 1 extend in the direction parallel to the direction in which a heat medium such as air flows. Thus, either when the heat exchanger 1 acts as a condenser or when the heat exchanger 1 acts as an evaporator, a direction in which refrigerant flows through the connecting components 50 is opposite to the direction in which air flows. Consequently, the heat exchange performance of the heat exchanger 1 improves.

[0036] Fig. 9 is a cross-sectional view of the side of the secondary heat exchange portion 13 according to Embodiment 1. As Fig. 9 illustrates, in Embodiment 1, when the secondary heat exchange portion 13 of the heat exchanger 1 acts as a condenser, the refrigerant flows through the connecting components 50 in a direction opposite to the direction in which air flows. Consequently, the subcooling performance of the secondary heat exchange portion 13 improves. Note that the connecting components 50 may be U bend pipes that are U-shaped or curved rectangular pipes. Thus, when the heat exchanger 1 acts as the condenser, at the outlet of the secondary heat exchange portion 13 or the outlet of the heat exchanger 1, a direction in which the refrigerant flows is opposite to the direction in which air flows.

[0037] When the primary heat exchange portion 12 of the heat exchanger 1 acts as an evaporator, refrigerant flows through the U bend pipes 24 (primary-pipe connecting components) in a direction opposite to the direction in which air flows. Thus, when the heat exchanger 1 acts as the evaporator, at the outlet of the primary heat exchange portion 12 or the outlet of the heat exchanger 1, a direction in which the refrigerant flows is opposite to the direction in which air flows. A temperature difference between superheated gas and air can be sufficiently obtained at the outlet of the primary heat exchange portion 12. Consequently, the heat exchange performance of the heat exchanger 1 improves.

[0038] In Embodiment 1, when the heat exchanger 1 acts as either the condenser or evaporator, at the outlet of the heat exchanger 1, refrigerant flows in the direction opposite to the direction in which air flows. Thus, when the heat exchanger 1 acts as either the condenser or evaporator, the heat exchange performance of the heat exchanger 1 improves.

[0039] Note that heat exchange performance is more effectively demonstrated in a case where the subcooling performance is improved by the heat exchanger 1 acting as the condenser than in a case where the heat exchange performance is improved by the heat exchanger 1 acting as the evaporator. In a conventional heat exchanger, a direction in which refrigerant flows through the primary-pipe connecting components of a primary heat exchange portion is the same as a direction in which refrigerant flows through the secondary-pipe connecting components of a secondary heat exchange portion. By the heat exchanger acting as a condenser, the direction in which the refrigerant flows through the secondary-pipe connecting components of the secondary heat exchange portion is opposite to a direction in which air flows. This configuration can improve heat exchange performance (subcooling performance). However, when the heat exchanger acts as an evaporator, the direction in which the refrigerant flows through the primary-pipe connecting components of the primary heat exchange portion is parallel to the direction in which air flows. Thus, a temperature difference between superheated gas and air at the outlet of the primary heat exchange portion cannot be sufficiently obtained. Consequently, the heat exchange performance of the heat exchanger cannot be improved.

[0040] At the secondary heat exchange portion 13, a pipe connecting adjacent pipes such as the connecting component 50 is not used in a longitudinal direction that is the direction of gravity (arrow Z direction). A pipe extending from one column to another column such as the connecting component 50 is used only in a row direction (arrow Y direction) parallel to the direction in which air flows. Thus, when the secondary heat exchange portion 13 of the heat exchanger 1 acts as the condenser, a direction in which refrigerant flows is the same in the first secondary pipes 41 adjacent to each other in the longitudinal direction and in the second secondary pipes 42 adjacent to each other in the longitudinal direction. Thus, the temperature of the refrigerant is substantially the same in the first secondary pipes 41 adjacent to each other in the longitudinal direction and in the second secondary pipes 42 adjacent to each other in the longitudinal direction. This configuration reduces heat loss caused in the plate-shaped fins 11 between the first secondary pipes 41 and in the plate-shaped fins 11 between the second secondary pipes 42. Consequently, the heat exchange performance of the heat exchanger 1 improves.

[0041] Moreover, in the primary heat exchange portion 12 of the heat exchanger 1, the second primary pipes 22 are adjacent at a portion in which the refrigerant is in a superheated state, and the first primary pipes 21 are adjacent at a portion in which the refrigerant is in a saturated liquid state. This configuration can reduce heat loss between a superheated region and a saturation region. Consequently, the heat exchange performance of the heat exchanger 1 improves.

[0042] Moreover, unlike the primary heat exchange portion 12, the secondary heat exchange portion 13 of the heat exchanger 1 does not include the header 30. Thus, when the heat exchanger 1 acts as a condenser, no heat is lost during transition from the saturation region to a subcooled region. Furthermore, in the secondary heat exchange portion 13, the first secondary pipes 41 and the second secondary pipes 42 are connected to the three-way pipes 43, which are branch pipes. Thus, the number of branches increases to decrease pressure loss in the pipes.

[0043] The following describes an air-conditioning apparatus 2 according to Embodiment 1. Fig. 5 is a circuit diagram of the air-conditioning apparatus 2 according to Embodiment 1. The air-conditioning apparatus 2 includes a refrigerant circuit 3 in which a compressor 80, a first heat exchanger 81, an expansion unit 82, and a second heat exchanger 83 are connected by pipes. The compressor 80 compresses refrigerant. The first heat exchanger 81 exchanges heat between the refrigerant and air, and acts as a condenser. A first fan 84 and a first motor 84a provided in the refrigerant circuit 3 are to send air toward the first heat exchanger 81.

[0044] The expansion unit 82 expands the refrigerant. The second heat exchanger 83 exchanges heat between the refrigerant and air, and acts as an evaporator. A second fan 85 and a second motor 85a provided in the refrigerant circuit 3 are to send air toward the second heat exchanger 83. Note that, although not illustrated in Fig. 5, a four-way valve is included in the refrigerant circuit 3 to change a direction in which the refrigerant flows through the refrigerant circuit 3. Thus, the first heat exchanger 81 can act as the evaporator and the second heat exchanger 83 can act as the condenser.

[0045] The heat exchanger 1 according to Embodiment 1 is used as at least one of the first heat exchanger 81 and the second heat exchanger 83 of the air-conditioning apparatus 2 according to Embodiment 1. Moreover, as the refrigerant flowing through the refrigerant circuit 3 of the air-conditioning apparatus 2, for example, an R410A refrigerant, an R32 refrigerant, an HFO1234yf refrigerant, or an HFO1123 refrigerant is used.

[0046] The following describes operations of the air-conditioning apparatus 2 according to Embodiment 1. The compressor 80 suctions and compresses refrigerant, and discharges the refrigerant in a high-temperature and high-pressure gas state. The discharged refrigerant flows into the first heat exchanger 81. The first heat exchanger 81 exchanges heat between the refrigerant and air supplied from the first fan 84, thereby condensing the refrigerant. The condensed refrigerant flows into the expansion unit 82, and the expansion unit 82 decompresses the condensed refrigerant. The decompressed refrigerant flows into the second heat exchanger 83. The second heat exchanger 83 exchanges heat between the refrigerant and air supplied from the second fan 85, thereby evaporating the refrigerant. The evaporated refrigerant is suctioned by the compressor 80.

[0047] The following describes effects of the air-conditioning apparatus 2 according to Embodiment 1. The heat exchanger 1 according to Embodiment 1 is used as at least one of the first heat exchanger 81 and the second heat exchanger 83 of the air-conditioning apparatus 2. Thus, the heat exchange performance of the first heat exchanger 81 or the second heat exchanger 83 in which the heat exchanger 1 according to Embodiment 1 is used improves. The following describes cooling energy efficiency in cooling operation and heating energy efficiency in heating operation. The cooling energy efficiency is calculated by the following expression (1).

$$\text{Cooling energy efficiency} = \text{capacity of evaporator (indoor heat exchanger)} / \text{total input} \quad (1)$$

[0048] Moreover, the heating energy efficiency is calculated by the following expression (2).

$$\text{Heating energy efficiency} = \text{capacity of condenser (indoor heat exchanger)} / \text{total input} \quad (2)$$

[0049] The heat exchanger 1 according to Embodiment 1 is used as at least one of the first heat exchanger 81 and the second heat exchanger 83 of the air-conditioning apparatus 2. Thus, the cooling energy efficiency and the heating energy efficiency of the air-conditioning apparatus 2 are high according to the above expressions (1) and (2). Consequently, in Embodiment 1, the air-conditioning apparatus 2 having high energy efficiency can be achieved.

[0050] Moreover, when a refrigerant including the HFO1123 refrigerant, which has a low critical temperature, is used as the refrigerant flowing through the refrigerant circuit 3 of the air-conditioning apparatus 2, an enthalpy difference needs to be ensured on a high-pressure side. The subcooling performance or total heat exchange performance of the heat exchanger 1 according to Embodiment 1 improves, thereby increasing a difference between a superheated region and a subcooled region. This configuration can sufficiently ensure the enthalpy difference on the high-pressure side. Thus, even when the refrigerant including the HFO1123 refrigerant is used, the air-conditioning apparatus 2 can sufficiently demonstrate its performance.

[0051] Note that, in Embodiment 1, air and refrigerant are used as examples of a heat medium. However, a gas, a liquid, and a gas-liquid mixed fluid other than these examples may be used. Moreover, the heat exchanger 1 according to Embodiment 1 may be used in an indoor unit or an outdoor unit of the air-conditioning apparatus 2. Furthermore, as a refrigerating machine oil flowing through the air-conditioning apparatus 2, for example, a mineral oil, an alkylbenzene oil, an ester oil, an ether oil, or a fluorine oil can be used irrespective of whether or not such a refrigerating machine oil is dissolved in the refrigerant.

Embodiment 2

[0052] The following describes a heat exchanger 100 according to Embodiment 2. Fig. 6 is a side view of the heat exchanger 100 according to Embodiment 2. Embodiment 2 is different from Embodiment 1 in that a liquid pipe 160 includes a first liquid pipe 161 and a second liquid pipe 162. In Embodiment 2, identical reference signs are used to designate common components in Embodiments 1 and 2, and explanations for these components are omitted. Differences from Embodiment 1 are mainly described below.

[0053] As Fig. 6 illustrates, one end of the liquid pipe 160, which includes the first liquid pipe 161 and the second liquid pipe 162, is connected to a secondary heat exchange portion 13. The first liquid pipe 161 connects one end of a first secondary pipe 41 on the lower side of the secondary heat exchange portion 13 and the upper portion of a liquid-side header 31, that is, an upper header 31 a. Moreover, the second liquid pipe 162 connects one end of the first secondary pipe 41 on the upper side of the secondary heat exchange portion 13 and the lower portion of the liquid-side header 31, that is, a lower header 31 b.

[0054] Liquid state refrigerant concentrates at the first secondary pipe 41 on the lower side of the secondary heat exchange portion 13 by gravity. Thus, the first secondary pipe 41 on the lower side of the secondary heat exchange portion 13 and the upper header 31 a that is far from the first secondary pipe 41 are connected. Moreover, the first secondary pipe 41 on the upper side of the secondary heat exchange portion 13 and the lower header 31 b that is close to the first secondary pipe 41 are connected. This configuration reduces the concentration of the refrigerant and balances distribution of the refrigerant. This configuration enables efficient heat exchange by the heat exchanger 100 according to Embodiment 2. Note that the heat exchanger 100 according to Embodiment 2 can be also used in the air-conditioning apparatus 2 according to Embodiment 1.

[0055] Note that the present invention is applicable to a power saving heat pump apparatus that can be easily manufactured and has excellent heat exchange performance.

Reference Signs List

[0056] 1 heat exchanger 2 air-conditioning apparatus 3 refrigerant circuit 10 fin portion 11 plate-shaped fin 12 primary heat exchange portion 13 secondary heat exchange portion 20 primary pipe 21 first primary pipe 22 second primary pipe 23 hairpin pipe 24 U bend pipe (primary-pipe connecting component) 30 header 31 liquid-side header 31 a upper header 31 b lower header 32 gas-side header 40 secondary pipe 41 first secondary pipe 42 second secondary pipe 43 three-way pipe 44 joint 50 connecting component (secondary-pipe connecting component) 60 liquid pipe 61 upper capillary pipe 62 lower capillary pipe 63 distributor 64 junction pipe70 liquid inlet-outlet pipe 80 compressor 81 first heat exchanger 82 expansion unit 83 second heat exchanger 84 first fan 84a first motor 85 second fan 85a second motor 100 heat exchanger 160 liquid pipe 161 first liquid pipe 162 second liquid pipe

Claims

1. A heat exchanger comprising a primary heat exchange portion and a secondary heat exchange portion,
the primary heat exchange portion including
first primary fins provided parallel to a direction in which a fan sends air,
first primary pipes that are inserted into the first primary fins and through which refrigerant flows,
second primary fins positioned windward of the first primary fins and provided parallel to the direction in which the fan sends air,
second primary pipes that are inserted into the second primary fins and through which the refrigerant flows, and
a primary-pipe connecting component extending in a direction parallel to the direction in which the fan sends air, and connecting one of the first primary pipes and one of the second primary pipes,
the secondary heat exchange portion including
first secondary fins provided parallel to the direction in which the fan sends air, first secondary pipes that are inserted into the first secondary fins and through which the refrigerant flows,
second secondary fins positioned windward of the first secondary fins and provided parallel to the direction in which the fan sends air,
second secondary pipes that are inserted into the second secondary fins and through which the refrigerant flows, and
a secondary-pipe connecting component extending in the direction parallel to the direction in which the fan sends air, and connecting one of the first secondary pipes and one of the second secondary pipes,
when the heat exchanger acts as an evaporator, the refrigerant flowing through the primary heat exchange portion from the first primary pipes toward the second primary pipes and the refrigerant flowing through the secondary heat exchange portion from the second secondary pipes toward the first secondary pipes,
when the heat exchanger acts as a condenser, the refrigerant flowing through the primary heat exchange portion from the second primary pipes toward the first primary pipes and the refrigerant flowing through the secondary heat exchange portion from the first secondary pipes toward the second secondary pipes.

2. The heat exchanger of claim 1, wherein, when the secondary heat exchange portion acts as a condenser, the refrigerant flowing through the secondary-pipe connecting component flows in a direction opposite to the direction in which the fan sends air.

3. The heat exchanger of claim 1 or claim 2, wherein, when the primary heat exchange portion acts as an evaporator, the refrigerant flowing through the primary-pipe connecting component flows in a direction opposite to the direction in which the fan sends air.

4. The heat exchanger of any one of claims 1 to 3, wherein
the secondary heat exchange portion is below the primary heat exchange portion in a direction of gravity, and
the heat exchanger further comprises:

    a first liquid pipe connecting an upper portion of a liquid-side header and one end of one of the first secondary pipes positioned on a lower side of the secondary heat exchange portion in the direction of gravity; and
    a second liquid pipe connecting a lower portion of the liquid-side header and one end of one of the first secondary pipes positioned on an upper side of the secondary heat exchange portion in the direction of gravity.

5. The heat exchanger of any one of claims 1 to 4, wherein the first primary pipes and the second primary pipes are

spaced apart from one another in a direction parallel to a direction of gravity.

6. The heat exchanger of any one of claims 1 to 5, wherein
the first secondary pipes are spaced apart from one another in a direction parallel to a direction of gravity, and the heat exchanger further comprises a branch pipe connecting one end of a liquid pipe and the first secondary pipes.

7. The heat exchanger of any one of claims 1 to 6, wherein the refrigerant includes an HFO1123 refrigerant.

8. An air-conditioning apparatus comprising:

a compressor for compressing the refrigerant; and
the heat exchanger of any one of claims 1 to 7.

FIG. 1

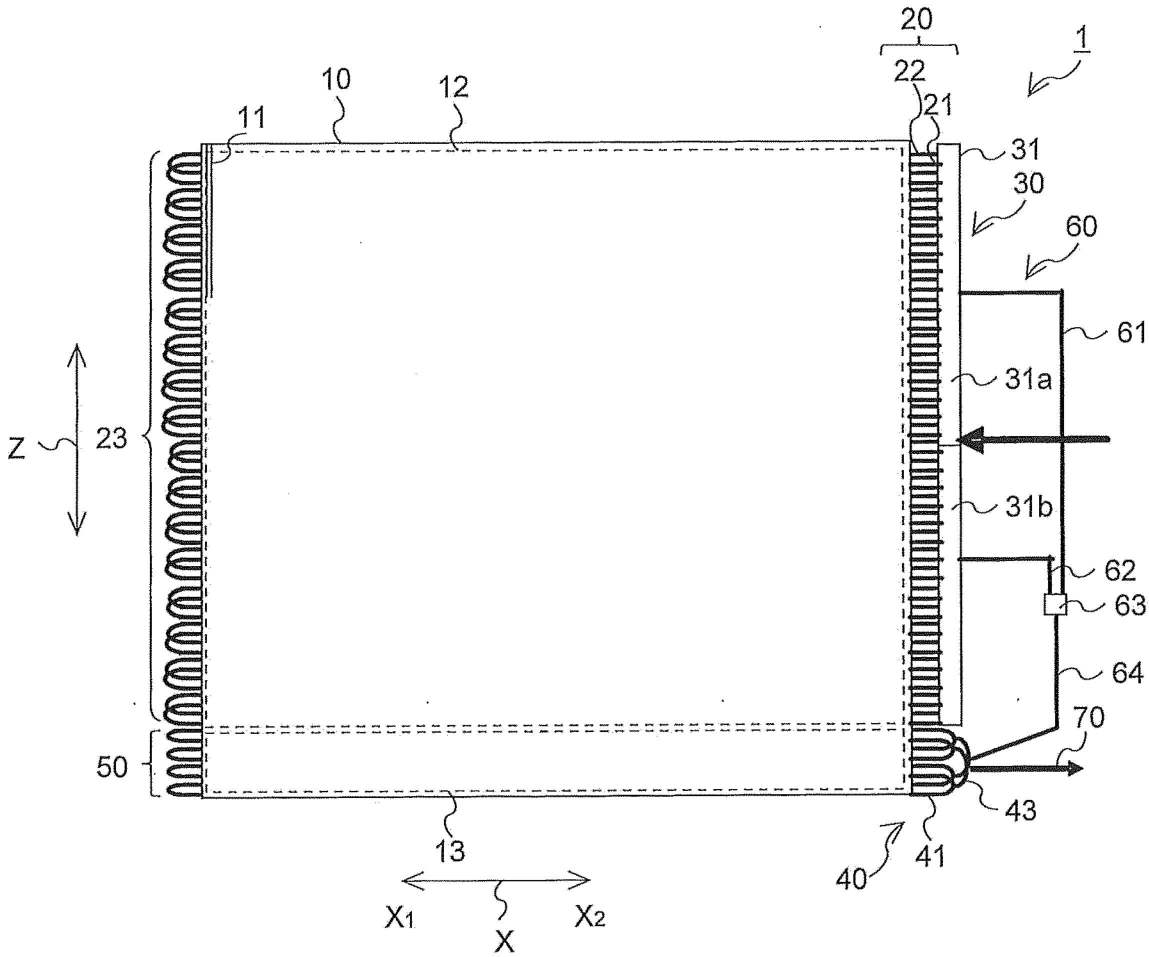

20
1
22
21
10
12
11
31
30
60
61
31a
Z
23
31b
62
63
64
70
50
43
13
41
40
X1
X2
X

FIG. 2

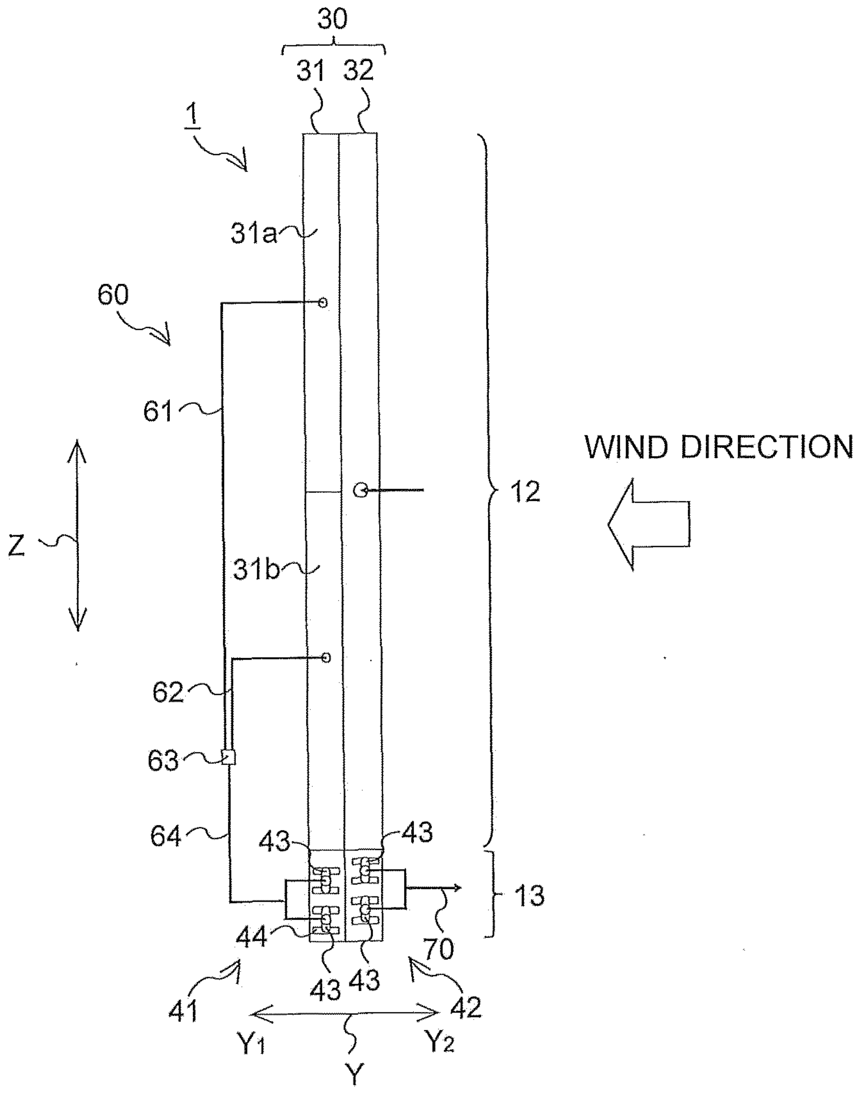

30
31
32
1
31a
60
61
62
63
64
43
43
44
43
43
70
13
12
31b
Z
WIND DIRECTION
41
42
Y1
Y2
Y

FIG. 3

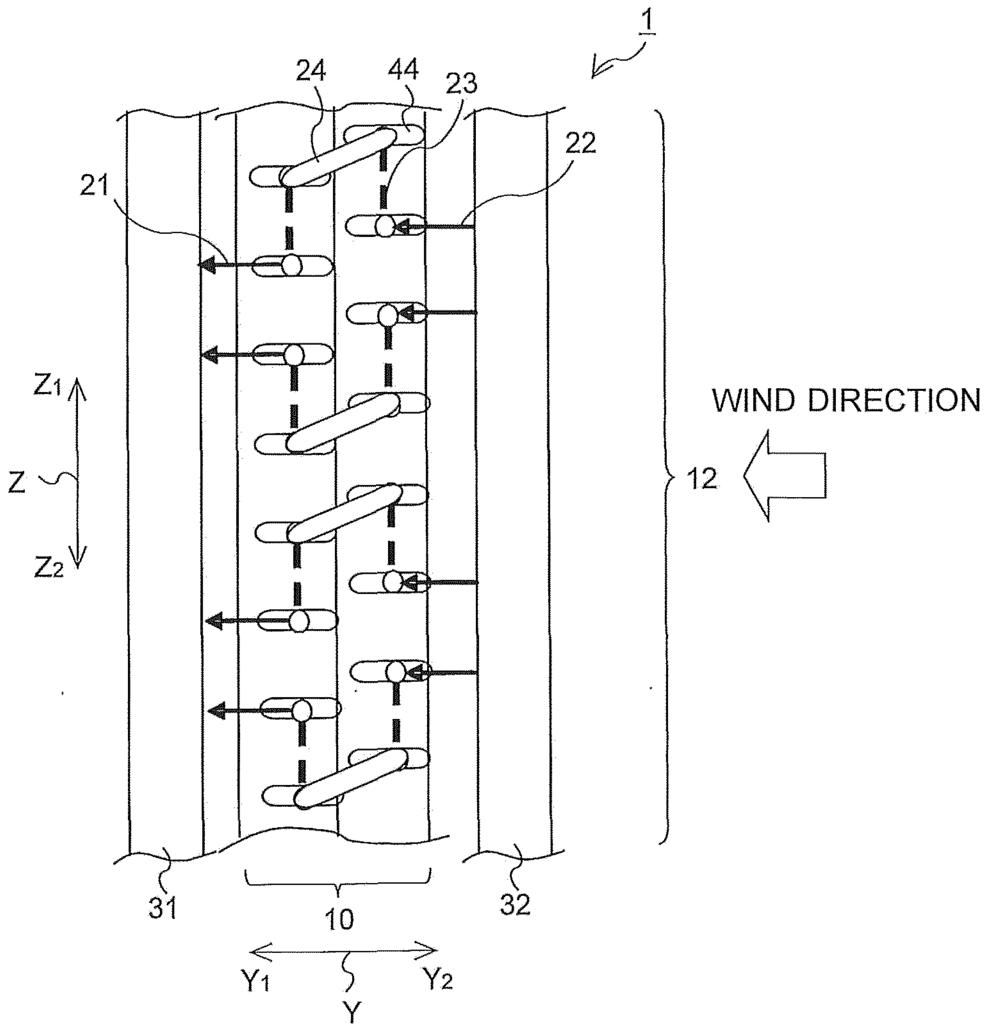


FIG. 4

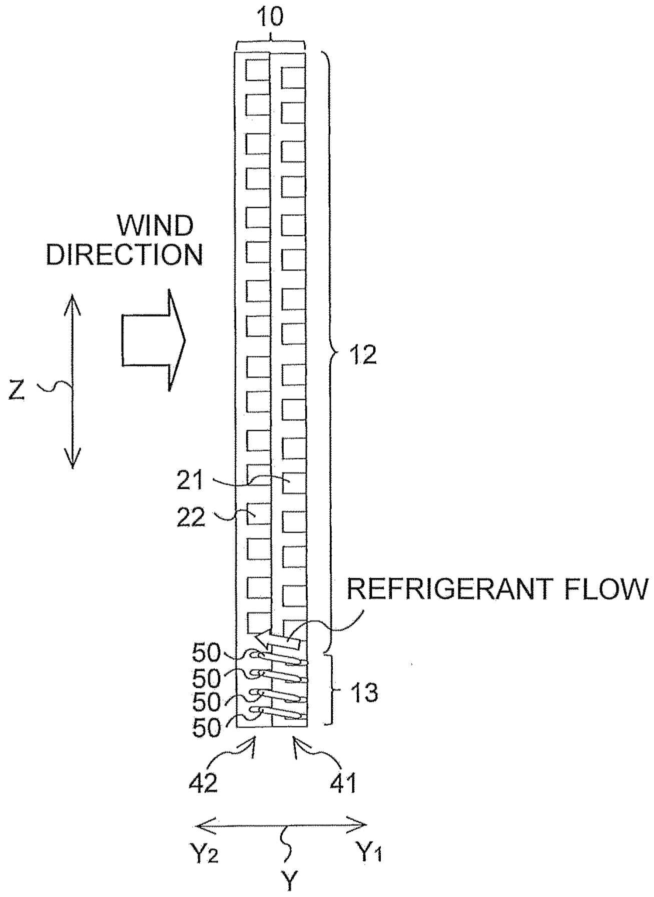

10
WIND
DIRECTION
12
Z
21
22
REFRIGERANT FLOW
50
50
50
50
13
42
41
Y2
Y
Y1

FIG. 5

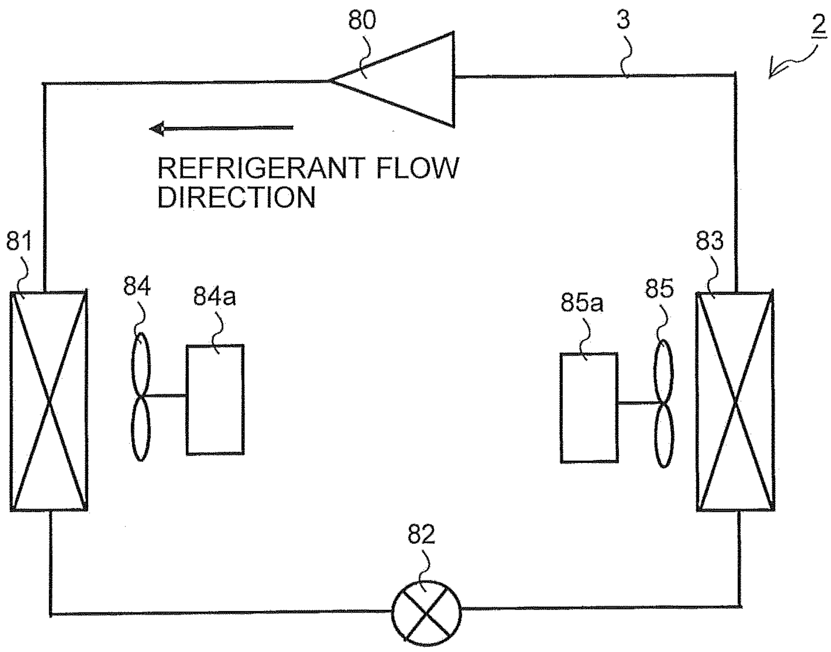

80
3
2
REFRIGERANT FLOW
DIRECTION
81
84
84a
85a
85
83
82

FIG. 6

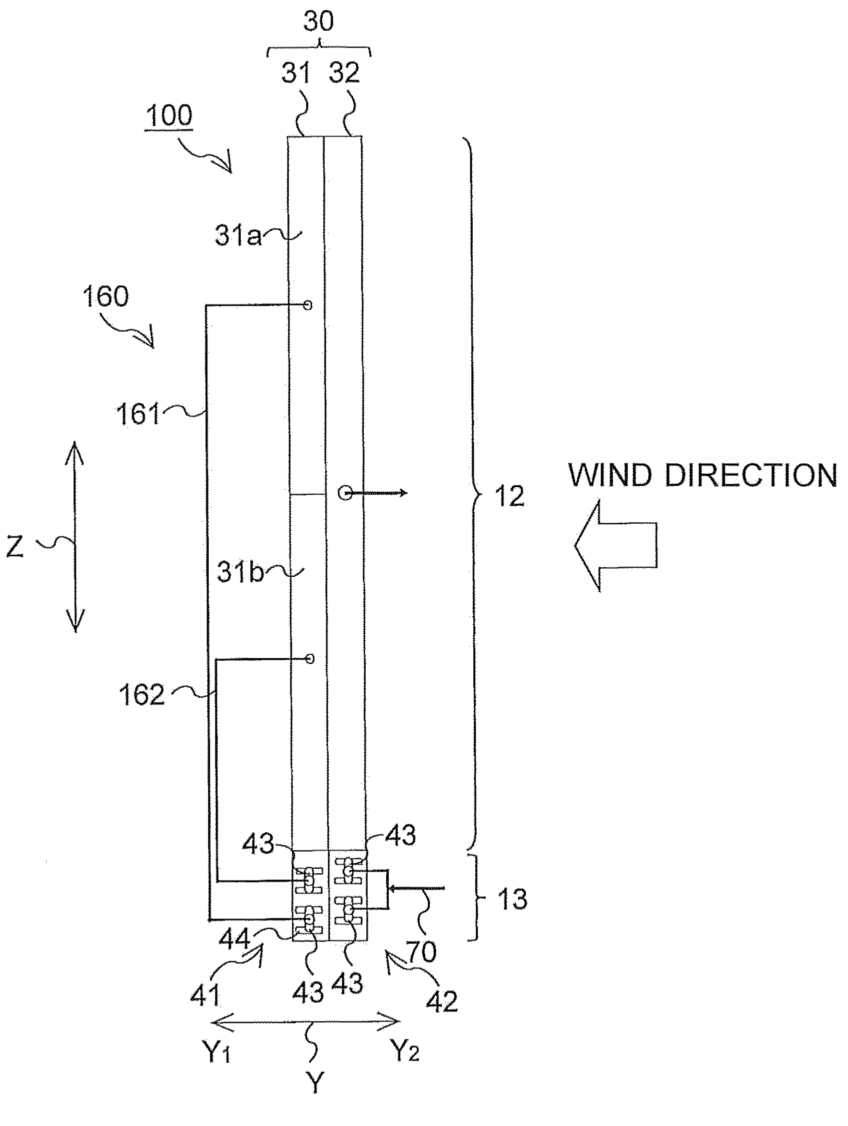

30
31
32
100
31a
160
161
Z
31b
162
12
WIND DIRECTION
43
43
13
44
70
41
43
43
42
Y1
Y
Y2

FIG. 7

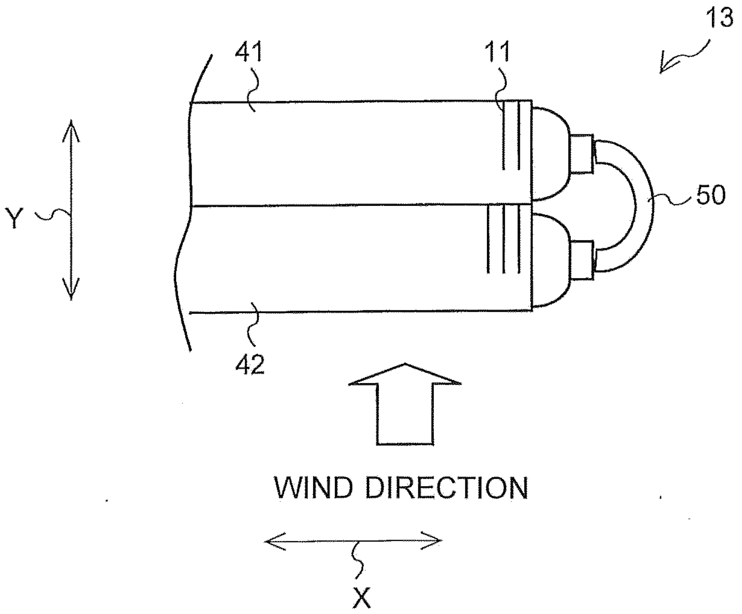

13
41
11
50
Y
42
WIND DIRECTION
X

FIG. 8

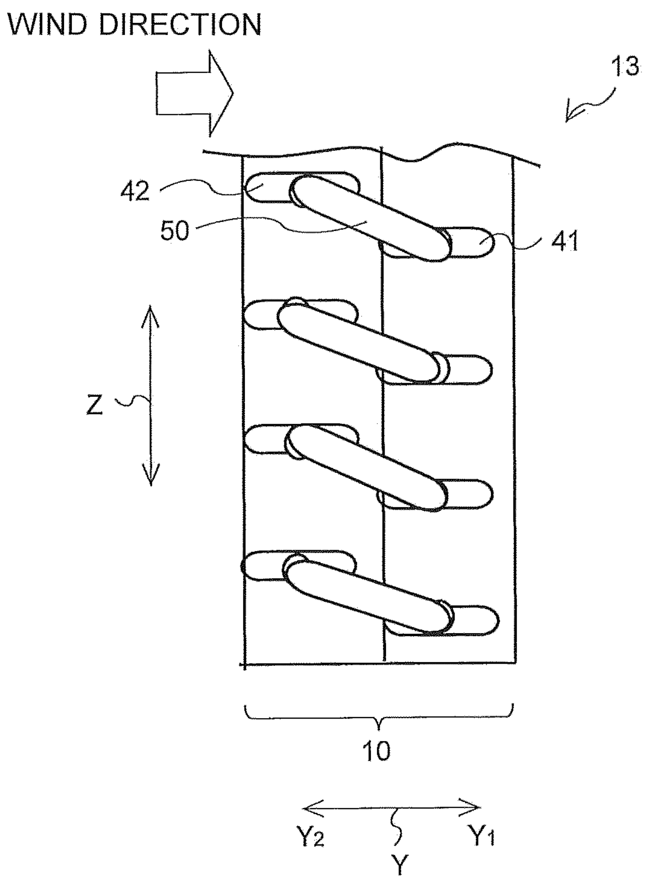
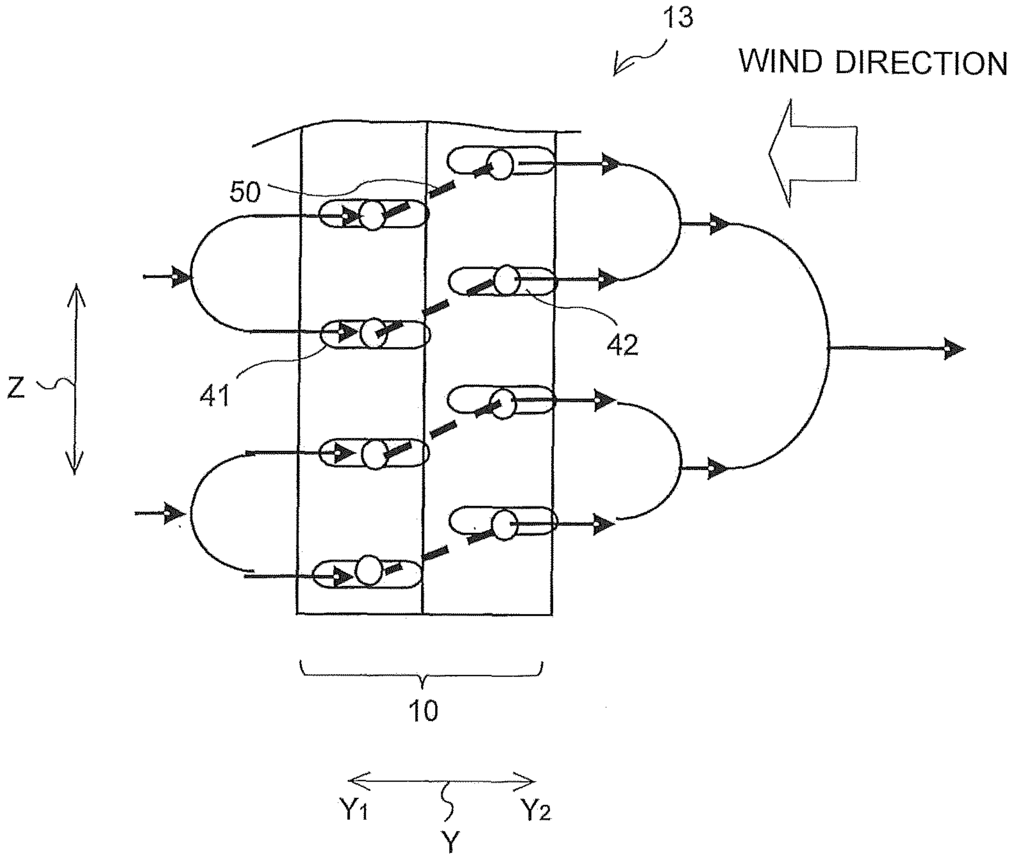

WIND DIRECTION
13
42
50
41
Z
10
Y2
Y
Y1

FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/056724

A. CLASSIFICATION OF SUBJECT MATTER
F25B39/04(2006.01)i, *F25B39/02*(2006.01)i, *F28D1/047*(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)
F25B39/04, F25B39/02, F28D1/047

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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 2002-195675 A (Toshiba Carrier Corp.), 10 July 2002 (10.07.2002), paragraphs [0007], [0019] to [0047]; fig. 3 to 4 (Family: none)	1-8
Y	JP 2001-66017 A (Hitachi, Ltd.), 16 March 2001 (16.03.2001), paragraph [0012]; fig. 1 (Family: none)	1-8
Y	JP 2011-80638 A (Daikin Industries, Ltd.), 21 April 2011 (21.04.2011), paragraphs [0046] to [0048]; fig. 2(c) (Family: none)	1-8

☒ 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
12 May 2015 (12.05.15)	19 May 2015 (19.05.15)

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

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2015/056724

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-14389 A (Mitsubishi Heavy Industries, Ltd.), 15 January 2003 (15.01.2003), paragraph [0016]; fig. 1 (Family: none)	1-8
Y	JP 2014-20696 A (Hitachi Appliances, Inc.), 03 February 2014 (03.02.2014), paragraphs [0009] to [0014], [0058] to [0076]; fig. 7 (Family: none)	4-8
Y	JP 2003-287390 A (Mitsubishi Electric Corp.), 10 October 2003 (10.10.2003), paragraphs [0019] to [0021]; fig. 1 to 5 (Family: none)	4-8
Y	JP 2012-163328 A (Daikin Industries, Ltd.), 30 August 2012 (30.08.2012), paragraph [0060]; fig. 1 to 3 & JP 2012-163319 A & US 2013/0306285 A1 & WO 2012/098917 A1 & EP 2660550 A1 & CN 103348212 A & KR 10-2013-0114249 A	6-8
Y	JP 2013-83419 A (Daikin Industries, Ltd.), 09 May 2013 (09.05.2013), paragraph [0086]; fig. 8 to 9 & WO 2013/046729 A1	6-8
Y	WO 2012/157764 A1 (Asahi Glass Co., Ltd.), 22 November 2012 (22.11.2012), paragraph [0010] & JP 2014-98166 A & JP 2015-7257 A & US 2014/0070132 A1 & WO 2012/157764 A1 & EP 2711405 A1 & DE 112012002154 T & CN 103562338 A	7-8
A	JP 2012-172938 A (Daikin Industries, Ltd.), 10 September 2012 (10.09.2012), paragraphs [0034] to [0039]; fig. 4 to 5 & US 2013/0327509 A1 & WO 2012/114719 A1 & EP 2674717 A1 & CN 103392109 A & KR 10-2013-0129272 A	1-8
A	JP 2010-78287 A (Mitsubishi Electric Corp.), 08 April 2010 (08.04.2010), paragraphs [0035] to [0038]; fig. 6 (Family: none)	1-8

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- JP 2012163328 A **[0005]**
- JP 2013083419 A **[0005]**