



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

(43) Date of publication:
07.09.2016 Bulletin 2016/36

(21) Application number: **13896742.7**

(22) Date of filing: **29.10.2013**

(51) Int Cl.:
F16L 21/00 ^(2006.01) **F16L 25/00** ^(2006.01)
F24F 1/00 ^(2011.01) **F24F 1/14** ^(2011.01)
F28F 9/26 ^(2006.01)

(86) International application number:
PCT/JP2013/079248

(87) International publication number:
WO 2015/063858 (07.05.2015 Gazette 2015/18)

(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

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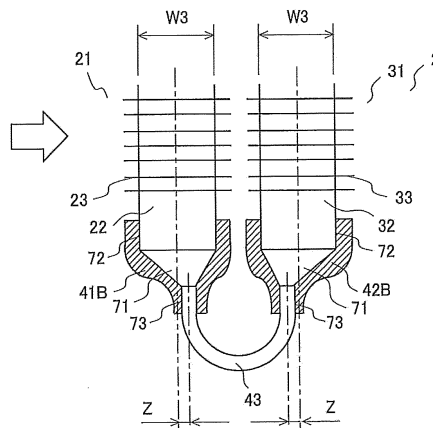
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(54) **PIPE JOINT, HEAT EXCHANGER, AND AIR CONDITIONER**

(57) A tube fitting includes a through portion 71. A flat tube is connected to the first end portion 72 of the through portion 71, and another tube different in cross-sectional shape from the flat tube is connected to

the second end portion 73 of the through portion 71. The central axis of the first end portion 72 and the central axis of the second end portion 73 are deviated from each other.

FIG. 11



Description

Technical Field

[0001] The present invention relates to a tube fitting, a heat exchanger, and an air-conditioning apparatus.

Background Art

[0002] Tube fittings thus far developed include a type having a through portion formed therethrough, to a first end portion of which a flat tube is connected and to a second end portion of which a tube different in cross-sectional shape from the flat tube, for example a round tube, is connected. The flat tube includes a plurality of flow paths aligned in the direction of the major axis (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2013-142454 (Paragraph [0009], Fig. 1, Fig. 2)

Summary of Invention

Technical Problem

[0004] In such conventional tube fittings, a fluid flowing through the tube different in cross-sectional shape from the flat tube may be subjected to inertial force acting in a direction parallel to the major axis of the flat tube, in which case the balance among the flows of fluid flowing into each of the flow paths formed in the flat tube may fluctuate. In particular, when the fluid flowing through the tube different in cross-sectional shape from the flat tube is refrigerant in a two-phase gas-liquid, the fluctuation of the balance becomes more prominent. However, in such tube fittings, the central axis of the first end portion to which the flat tube is connected and the central axis of the second end portion, to which the tube different in cross-sectional shape from the flat tube is connected, coincide with each other, and therefore there is no way to cope with the fluctuation of the balance among the flows of fluid flowing into each of the flow paths formed in the flat tube. In other words, with the conventional tube fitting the balance among the flows of fluid flowing into the plurality of flow paths in the flat tube is unable to be optimized.

[0005] The present invention has been accomplished in view of the foregoing problem, and provides a tube fitting capable of optimizing the balance among the flows of fluid flowing into the plurality of flow paths in the flat tube. The present invention also provides a heat exchanger including the mentioned tube fitting. Further, the present invention provides an air-conditioning apparatus

including the mentioned heat exchanger.

Solution to Problem

[0006] In an aspect, the present invention provides a tube fitting that includes a through portion to a first end portion of which a flat tube is connected and to a second end portion of which another tube different in cross-sectional shape from the flat tube is connected, in which the central axis of the first end portion and the central axis of the second end portion are deviated from each other. Advantageous Effects of Invention

[0007] With the tube fitting according to the present invention, even when a fluid flowing through the tube different in cross-sectional shape from the flat tube is subjected to inertial force acting in a direction parallel to the major axis of the flat tube, the balance among the flows of fluid flowing into each of the flow paths formed in the flat tube can be optimized, since the central axis of the first end portion of the through portion and the central axis of the second end portion of the through portion are deviated from each other.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a perspective view of a heat exchanger according to Embodiment 1.

[Fig. 2] Fig. 2 is an exploded perspective view of a stacked header of the heat exchanger according to Embodiment 1.

[Fig. 3] Fig. 3 is a perspective view of a cylindrical header of the heat exchanger according to Embodiment 1.

[Fig. 4] Fig. 4 is a schematic drawing illustrating connection between a heat exchange unit and a branch/junction section of the heat exchanger according to Embodiment 1.

[Fig. 5] Fig. 5 is another schematic drawing illustrating connection between the heat exchange unit and the branch/junction section of the heat exchanger according to Embodiment 1.

[Fig. 6] Fig. 6 is a schematic drawing illustrating connection between the heat exchange unit and the branch/junction section of the heat exchanger according to a variation of Embodiment 1.

[Fig. 7] Fig. 7 is a schematic drawing illustrating connection between the heat exchange unit and the branch/junction section of the heat exchanger according to another variation of Embodiment 1.

[Fig. 8] Fig. 8 is a schematic drawing illustrating connection between the heat exchange unit and the branch/junction section of the heat exchanger according to still another variation of Embodiment 1.

[Fig. 9] Fig. 9 is a schematic drawing showing a configuration of a windward concentric tube fitting and a leeward concentric tube fitting of the heat exchanger.

er according to Embodiment 1.

[Fig. 10] Fig. 10 is a schematic drawing showing a configuration of a windward concentric tube fitting and a leeward concentric tube fitting of the heat exchanger according to a comparative example.

[Fig. 11] Fig. 11 is a schematic drawing showing a configuration of a windward eccentric tube fitting and a leeward eccentric tube fitting of the heat exchanger according to Embodiment 1.

[Fig. 12] Fig. 12 is a block diagram showing a configuration of an air-conditioning apparatus including the heat exchanger according to Embodiment 1.

[Fig. 13] Fig. 13 is another block diagram showing the configuration of the air-conditioning apparatus including the heat exchanger according to Embodiment 1.

[Fig. 14] Fig. 14 is a schematic drawing illustrating liquid distribution of refrigerant flowing into a leeward heat transfer tube, realized when the heat exchanger according to Embodiment 1 acts as evaporator.

[Fig. 15] Fig. 15 is a graph illustrating the liquid distribution of the refrigerant flowing into the leeward heat transfer tube, realized when the heat exchanger according to Embodiment 1 acts as evaporator.

[Fig. 16] Fig. 16 is a schematic drawing illustrating gas distribution of refrigerant flowing into a windward heat transfer tube, realized when the heat exchanger according to Embodiment 1 acts as condenser.

[Fig. 17] Fig. 17 is a graph illustrating the gas distribution of the refrigerant flowing into the windward heat transfer tube, realized when the heat exchanger according to Embodiment 1 acts as condenser.

[Fig. 18] Fig. 18 is a perspective view of a heat exchanger according to Embodiment 2.

[Fig. 19] Fig. 19 is a schematic drawing illustrating connection between a heat exchange unit and a branch/junction section of the heat exchanger according to Embodiment 2.

[Fig. 20] Fig. 20 is another schematic drawing illustrating connection between the heat exchange unit and the branch/junction section of the heat exchanger according to Embodiment 2.

[Fig. 21] Fig. 21 is a schematic drawing illustrating connection between the heat exchange unit and the branch/junction section of the heat exchanger according to a variation of Embodiment 2.

[Fig. 22] Fig. 22 is a block diagram showing a configuration of an air-conditioning apparatus including the heat exchanger according to Embodiment 2.

[Fig. 23] Fig. 23 is another block diagram showing the configuration of the air-conditioning apparatus including the heat exchanger according to Embodiment 2.

Description of Embodiments

[0009] Hereafter, a tube fitting according to the present invention will be described with reference to the draw-

ings.

[0010] Configurations and operations described hereunder are merely exemplary, and the configurations and operations of the tube fitting according to the present invention are not limited to the description given hereunder. In the drawings, the same or similar constituents will be given the same reference numeral, or may be cited without the numeral. Minor details of the configuration may be simplified or omitted, as the case may be. Descriptions of the same or similar configurations may be simplified or omitted, as the case may be.

[0011] Although the tube fitting according to the present invention is employed in a heat exchanger in the following description, the tube fitting according to the present invention may be incorporated in an apparatus other than the heat exchanger. Although the heat exchanger including the tube fitting according to the present invention is employed in an air-conditioning apparatus in the following description, the heat exchanger may be incorporated in another refrigeration cycle apparatus having a refrigerant circuit. Further, although the heat exchanger including the tube fitting according to the present invention is exemplified by an outdoor heat exchanger of the air-conditioning apparatus in the description given hereunder, the heat exchanger may be an indoor heat exchanger of the air-conditioning apparatus. In addition, although the air-conditioning apparatus cited hereunder is configured to be switched between a heating operation and a cooling operation, the air-conditioning apparatus may be configured to perform only either of the heating operation and the cooling operation.

Embodiment 1

[0012] The heat exchanger according to Embodiment 1 will be described.

< Configuration of Heat Exchanger >

[0013] Hereunder, a configuration of the heat exchanger according to Embodiment 1 will be described.

(General Configuration of Heat Exchanger)

[0014] Hereunder, a general configuration of the heat exchanger according to Embodiment 1 will be described.

[0015] Fig. 1 is a perspective view of the heat exchanger according to Embodiment 1.

[0016] As shown in Fig. 1, the heat exchanger 1 includes a heat exchange unit 2 and a branch/junction section 3.

[0017] The heat exchange unit 2 includes a windward heat exchange unit 21 located windward in the flow direction of air passing through the heat exchange unit 2 (blank arrow in Fig. 1), and a leeward heat exchange unit 31 located leeward in the air flow direction. The windward heat exchange unit 21 includes a plurality of windward heat transfer tubes 22, and a plurality of windward fins

23 respectively joined to the windward heat transfer tubes 22, for example by brazing. The leeward heat exchange unit 31 includes a plurality of leeward heat transfer tubes 32, and a plurality of leeward fins 33 respectively joined to the leeward heat transfer tubes 32, for example by brazing. The heat exchange unit 2 may be constituted of two rows, namely a row of the windward heat exchange unit 21 and a row of the leeward heat exchange unit 31, or three or more rows.

[0018] The windward heat transfer tubes 22 and the leeward heat transfer tubes 32 are flat tubes, each including a plurality of flow paths aligned in the direction of the major axis. Each of the plurality of windward heat transfer tubes 22 and the plurality of leeward heat transfer tubes 32 is bent in a hair-pin shape between a first end portion and a second end portion, so as to form a turnback section 22a, 32a. The windward heat transfer tubes 22 and the leeward heat transfer tubes 32 are arranged in a plurality of columns stacked in a direction intersecting the flow of air passing through the heat exchange unit 2 (blank arrow in Fig. 1). The first end portion and the second end portion of each of the windward heat transfer tubes 22 and the leeward heat transfer tubes 32 are aligned so as to oppose the branch/junction section 3.

[0019] The branch/junction section 3 includes a stacked header 51 and a cylindrical header 61. The stacked header 51 and the cylindrical header 61 are aligned in the flow direction of air passing through the heat exchange unit 2 (blank arrow in Fig. 1). A non-illustrated refrigerant tube is connected to the stacked header 51, via a joint tube 52. A non-illustrated refrigerant tube is also connected to the cylindrical header 61, via a joint tube 62. The joint tube 52 and the joint tube 62 are, for example, round tubes.

[0020] The stacked header 51 includes therein a branch/junction flow path 51 a, and is connected to the windward heat exchange unit 21. When the heat exchange unit 2 acts as evaporator, the branch/junction flow path 51 a serves as branch flow path for distributing the refrigerant received through the non-illustrated refrigerant tube to the plurality of windward heat transfer tubes 22 in the windward heat exchange unit 21. When the heat exchange unit 2 acts as condenser, the branch/junction flow path 51 a serves as junction flow path for merging the refrigerant received from each of the windward heat transfer tubes 22 in the windward heat exchange unit 21 and passing the merged flow to the non-illustrated refrigerant tube. The stacked header 51 corresponds to the "header located on a windward side" in the present invention.

[0021] The cylindrical header 61 includes therein a branch/junction flow path 61a, and is connected to the leeward heat exchange unit 31. When the heat exchange unit 2 acts as condenser, the branch/junction flow path 61 a serves as branch flow path for distributing the refrigerant received through the non-illustrated refrigerant tube to the plurality of leeward heat transfer tubes 32 in the leeward heat exchange unit 31. When the heat ex-

change unit 2 acts as evaporator, the branch/junction flow path 61 a serves as junction flow path for merging the refrigerant received from each of the leeward heat transfer tubes 32 in the leeward heat exchange unit 31 and passing the merged flow to the non-illustrated refrigerant tube. The cylindrical header 61 corresponds to the "header located on a leeward side" in the present invention.

10 (Configuration of Stacked Header)

[0022] Hereunder, a configuration of the stacked header of the heat exchanger according to Embodiment 1 will be described.

15 **[0023]** Fig. 2 is an exploded perspective view of the stacked header of the heat exchanger according to Embodiment 1. Arrows in Fig. 2 indicate the flow of the refrigerant realized when the branch/junction flow path 51 a of the stacked header 51 serves as branch flow path.

20 **[0024]** As shown in Fig. 2, the stacked header 51 includes a first plate member 53 including a flow path segment 53a, a plurality of second plate members 54_1 to 54_3 respectively including flow path segments 54a_1 to 54a_3, and a third plate member 55 including a plurality of flow path segments 55a, the first, second, and third plate members being stacked via clad members 56_1 to 56_4 each including one or more flow path segments 56a, sequentially interposed between the plate members. A braze material is applied to one or both surfaces of the clad members 56_1 to 56_4. In the description given hereunder, the first plate member 53, the plurality of second plate members 54_1 to 54_3, the third plate member 55, and the plurality of clad members 56_1 to 56_4 may be collectively referred to as "plate member".

35 **[0025]** The flow path segments 53a, 55a, 56a are circular through holes. Each of the flow path segments 54a_1 to 54a_3 is a linear through slot in which a first end portion and a second end portion are located at different heights in the gravity direction (for example, Z-shape or S-shape). The non-illustrated refrigerant tube is connected to the flow path segment 53a, via the joint tube 52. The windward heat transfer tubes 22 are respectively connected to the flow path segments 55a, via a joint tube 57. The joint tube 57 is, for example, a round tube or an elliptical tube.

40 **[0026]** The flow path segment 56a of the clad member 56_1 is formed so as to oppose the flow path segment 53a. The flow path segments 56a of the clad member 56_4 are formed so as to oppose the respective flow path segments 55a. The first end portion and the second end portion of the flow path segments 54a_1 to 54a_3 are located so as to oppose the flow path segment 56a of one of the clad members 56_2 to 56_4 stacked on the side of the windward heat exchange unit 21. A section of each of the flow path segments 54a_1 to 54a_3 between the first end portion and the second end portion is located so as to oppose the flow path segment 56a of one of the clad member 56_1 to 56_3 stacked on the

opposite side of the windward heat exchange unit 21.

[0027] When the plate members are stacked together, the flow path segments 53a, 54a_1 to 54a_3, 55a, 56a are allowed to communicate with each other, so as to form the branch/junction flow path 51 a. The branch/junction flow path 51 a serves as branch flow path when the refrigerant flows in the direction of the arrows in Fig. 2, and serves as junction flow path when the refrigerant flows in the direction opposite to the arrows.

[0028] When the branch/junction flow path 51 a serves as branch flow path, the refrigerant which has entered the flow path segment 53a through the joint tube 52 flows into the section between the first end portion and the second end portion of the flow path segment 54a_1 through the flow path segment 56a, thereby colliding with the surface of the clad member 56_2 and being branched in two directions. The refrigerant thus branched flows out through the first end portion and the second end portion of the flow path segment 54a_1 and flows into the section between the first end portion and the second end portion of the flow path segment 54a_2 through the flow path segments 56a, thereby colliding with the surface of the clad member 56_3 and being branched in two directions. The refrigerant thus branched flows out through the first end portion and the second end portion of the flow path segment 54a_2 and flows into the section between the first end portion and the second end portion of the flow path segment 54a_3 through the flow path segments 56a, thereby colliding with the surface of the clad member 56_4 and being branched in two directions. The refrigerant branched as above flows out through the first end portion and the second end portion of the flow path segment 54a_3, and flows into each of the joint tubes 57 through the corresponding flow path segment 56a and the flow path segment 55a.

[0029] When the branch/junction flow path 51 a serves as junction flow path, the refrigerant which has entered the flow path segment 55a through the joint tube 57 passes through the flow path segment 56a and flows into the first end portion and the second end portion of the flow path segment 54a_3, and then into the flow path segment 56a communicating with the section between the first end portion and the second end portion of the flow path segment 54a_3, thus to be merged together. The refrigerant thus merged flows into the first end portion and the second end portion of the flow path segment 54a_2, and then into the flow path segment 56a communicating with the section between the first end portion and the second end portion of the flow path segment 54a_2, thus to be merged together. The refrigerant thus merged flows into the first end portion and the second end portion of the flow path segment 54a_1, and then into the flow path segment 56a communicating with the section between the first end portion and the second end portion of the flow path segment 54a_1, thus to be merged together. The refrigerant merged as above flows into the joint tube 52 through the flow path segment 53a.

[0030] Here, the first plate member 53, the second

plate members 54_1 to 54_3, and the third plate member 55 may be directly stacked on each other without the clad members 56_1 to 56_4 being interposed. When the clad members 56_1 to 56_4 are interposed, the flow path segments 56a serve as a refrigerant isolation flow path, and assures the isolation of the refrigerant flows passing through the flow path segments 53a, 54a_1 to 54a_3, and 55a. Alternatively, each of the first plate member 53, the second plate member 54_1 to 54_3, and the third plate member 55 may be coupled with the corresponding clad member 56_1 to 56_4, and such plate members may be directly stacked on each other.

(Configuration of Cylindrical Header)

[0031] Hereunder, a configuration of the cylindrical header of the heat exchanger according to Embodiment 1 will be described.

[0032] Fig. 3 is a perspective view of the cylindrical header of the heat exchanger according to Embodiment 1. Arrows in Fig. 3 indicate the flow of the refrigerant realized when the branch/junction flow path 61 a of the cylindrical header 61 serves as junction flow path.

[0033] As shown in Fig. 3, the cylindrical header 61 includes a cylindrical portion 63 having the both end portions closed, and aligned such that the axial direction is parallel to the gravity direction. Here, it is not mandatory that the axial direction of the cylindrical portion 63 is parallel to the gravity direction. Arranging the cylindrical header 61 so as to make the axial direction of the cylindrical portion 63 parallel to the longitudinal direction of the stacked header 51 allows reduction of the footprint of the branch/junction section 3. Here, the cylindrical portion 63 may be an oval tube having an elliptical cross-section.

[0034] The non-illustrated refrigerant tube is connected to the sidewall of the cylindrical portion 63, via the joint tube 62. To the sidewall of the cylindrical portion 63, also a plurality of joint tubes 64, respectively connected to the leeward heat transfer tubes 32, are connected. The joint tube 64 is, for example, a round tube or an elliptical tube. The cylindrical portion 63 includes therein the branch/junction flow path 61 a. The branch/junction flow path 61 a serves as junction flow path when the refrigerant flows in the direction of the arrows in Fig. 3, and serves as branch flow path when the refrigerant flows in the direction opposite to the arrows.

[0035] When the branch/junction flow path 61 a serves as junction flow path, the refrigerant which has entered the plurality of joint tubes 64 flows through inside the cylindrical portion 63 and then flows into the joint tube 62, thus to be merged. When the branch/junction flow path 61 a serves as branch flow path, the refrigerant flowing in through the joint tube 62 passes through inside the cylindrical portion 63 and then flows into each of the joint tubes 64, thus to be branched.

[0036] It is preferable that a circumferential position of the cylindrical portion 63 where the joint tube 62 is con-

nected and circumferential positions where the joint tubes 64 are connected are not opposed across the center of the cylindrical portion 63. Such a configuration facilitates the refrigerant to evenly flow into the plurality of joint tubes 64, when the branch/junction flow path 61 a serves as branch flow path.

(Connection between Heat Exchange Unit and Branch/Junction Section)

[0037] Hereunder, connection between the heat exchange unit and the branch/junction section of the heat exchanger according to Embodiment 1 will be described.

[0038] Fig. 4 and Fig. 5 are schematic drawings illustrating the connection between the heat exchange unit and the branch/junction section of the heat exchanger according to Embodiment 1. Fig. 5 is a cross-sectional view taken along a line A-A in Fig. 4.

[0039] As shown in Fig. 4 and Fig. 5, a windward concentric tube fitting 41 A is joined to the first end portion 22b of the windward heat transfer tube 22. A windward eccentric tube fitting 41 B is joined to the second end portion 22c of the windward heat transfer tube 22. A leeward concentric tube fitting 42A is joined to the second end portion 32c of the leeward heat transfer tube 32. A leeward eccentric tube fitting 42B is joined to the first end portion 32b of the leeward heat transfer tube 32.

[0040] The joint tube 57 of the stacked header 51 is connected to the windward concentric tube fitting 41A. To the leeward concentric tube fitting 42A, the joint tube 64 of the cylindrical header 61 is connected. The windward eccentric tube fitting 41 B and the leeward eccentric tube fitting 42B are connected to each other via a row joint tube 43. The row joint tube 43 is, for example, a round tube or an elliptical tube, bent in an arcuate shape.

[0041] Fig. 6 is a schematic drawing illustrating the connection between the heat exchange unit and the branch/junction section of the heat exchanger according to a variation of Embodiment 1. Here, Fig. 6 is a cross-sectional view from a position corresponding to the line A-A in Fig. 4.

[0042] The windward heat transfer tubes 22 and the leeward heat transfer tubes 32 may be arranged such that, when viewed from a lateral position of the heat exchanger 1, the first end portion 22b and the second end portion 22c of the windward heat transfer tube 22 and the first end portion 32b and the second end portion 32c of the leeward heat transfer tube 32 are formed in a staggered manner as shown in Fig. 5, or form a checker pattern as shown in Fig. 6.

[0043] Fig. 7 and Fig. 8 are schematic drawings illustrating the connection between the heat exchange unit and the branch/junction section of the heat exchanger according to another variation of Embodiment 1. Here, Fig. 7 and Fig. 8 are cross-sectional views from a position corresponding to the line A-A in Fig. 4.

[0044] As shown in Fig. 7 and Fig. 8, the second end portion 22c of the windward heat transfer tube 22 and

the first end portion 22b of the windward heat transfer tube 22 of the adjacent column may be connected to each other via a windward column joint tube 44 and the windward concentric tube fitting 41A, and the second end portion 32c of the leeward heat transfer tube 32 and the first end portion 32b of the leeward heat transfer tube 32 of the adjacent column may be connected via a leeward column joint tube 45 and the leeward concentric tube fitting 42A. The windward column joint tube 44 and the leeward column joint tube 45 are, for example, round tubes or elliptical tubes bent in an arcuate shape.

[0045] In addition, instead of bending the section between the first end portion and the second end portion of the windward heat transfer tube 22 and the leeward heat transfer tube 32 in the hair-pin shape, to form the turnback sections 22a, 32a, the first end portion of the windward heat transfer tube 22 and the first end portion of the adjacent windward heat transfer tube 22 may be connected via the windward column joint tube 44 and the windward concentric tube fitting 41 A, and the first end portion of the leeward heat transfer tube 32 and the first end portion of the adjacent leeward heat transfer tube 32 may be connected via the leeward column joint tube 45 and the leeward concentric tube fitting 42A, so as to allow the refrigerant to turn the flow direction.

(Detailed Configuration of Windward Concentric Tube Fitting and Leeward Concentric Tube Fitting)

[0046] Hereunder, the detailed configuration of the windward concentric tube fitting and the leeward concentric tube fitting of the heat exchanger according to Embodiment 1 will be described.

[0047] Fig. 9 is a schematic drawing showing the configuration of the windward concentric tube fitting and the leeward concentric tube fitting of the heat exchanger according to Embodiment 1. Fig. 9 includes a front cross-sectional view of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A, a side cross-sectional view thereof, and an upper plan view and a bottom view thereof. In Fig. 9, further, the tubes respectively connected to a first end portion 72 and a second end portion 73 of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A are indicated by broken lines. As shown in Fig. 9, round tubes are employed as joint tube 57 of the stacked header 51 and joint tube 64 of the cylindrical header 61.

[0048] As shown in Fig. 9, the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A each include a through portion 71. The first end portion 72 of the through portion 71 has a cross-sectional shape that matches the cross-sectional shape of the windward heat transfer tube 22 or the leeward heat transfer tube 32. The second end portion 73 of the through portion 71 has a cross-sectional shape that matches the cross-sectional shape of the joint tube 57 of the stacked header 51 or the joint tube 64 of the cylindrical header 61. The central axis of the first end portion 72 and the

central axis of the second end portion 73 coincide with each other.

[0049] In the front view of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A, the inner diameter D1 of the second end portion 73 is smaller than or equal to the inner diameter W1 of the first end portion 72 taken along the major axis. In the side view of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A, the inner diameter D2 of the second end portion 73 is larger than or equal to the inner diameter W2 of the first end portion 72 taken along the minor axis. Accordingly, the inner diameter D (D1, D2) of the cross-section of the second end portion 73 with respect to the entire circumference thereof may be expressed as $W2 \leq D \leq W1$. In addition, the flow path cross-sectional area ($d1^2 \times \pi/4$) of the joint tube 57 of the stacked header 51 and the joint tube 64 of the cylindrical header 61 is larger than the flow path cross-sectional area ($w1 \times w2 \times \text{number of flow paths}$) of the windward heat transfer tube 22 and the leeward heat transfer tube 32. Here, when the joint tube 57 of the stacked header 51 and the joint tube 64 of the cylindrical header 61 are elliptical tubes, D1 may be either larger or smaller than D2.

[0050] The foregoing configuration not only enables reduction in size of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A by making D1 smaller, but also suppresses pressure loss of the refrigerant flowing through the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A by increasing D2 so as to allow a tube having a larger flow path cross-sectional area to be connected. In addition, the configuration that can be expressed as $W2 \leq D \leq W1$ contributes to improving the degree of freedom in bending work of the joint tube 57 of the stacked header 51 and the joint tube 64 of the cylindrical header 61.

[0051] Fig. 10 is a schematic drawing showing a configuration of the windward concentric tube fitting and the leeward concentric tube fitting of the heat exchanger according to a comparative example. Fig. 10 is a front cross-sectional view of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A. In Fig. 10, the tubes respectively connected to the first end portion 72 and the second end portion 73 of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A are indicated by broken lines.

[0052] The through portion 71 includes a shape transition section 74 located between the first end portion 72 and the second end portion 73. Through the shape transition section 74, the cross-sectional shape of the inner circumferential surface of the first end portion 72 is gradually translated into the cross-sectional shape of the inner circumferential surface of the second end portion 73. When the shape transition section 74 is not provided in the through portion 71, in other words when the first end portion 72 and the second end portion 73 directly communicate with each other as shown in Fig. 10, a vortex flow is generated at corner portions of the first end portion

72, which incurs pressure loss of the refrigerant flowing through the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A. However, forming the shape transition section 74 in the region between the first end portion 72 and the second end portion 73 of the through portion 71 suppresses such a phenomenon.

[0053] Further, the joint tube 57 of the stacked header 51 and the joint tube 64 of the cylindrical header 61 are inserted to the boundary between the second end portion 73 and the shape transition section 74, when joined to the tube fitting 41 A, 42A. In other words, the region in the inner circumferential surface of the second end portion 73 where the outer circumferential surface of the joint tube 57 of the stacked header 51 or the joint tube 64 of the cylindrical header 61 is joined is closely adjacent to the shape transition section 74. Therefore, the refrigerant flowing in through the joint tube 57 of the stacked header 51 or the joint tube 64 of the cylindrical header 61 can flow into the windward heat transfer tube 22 or the leeward heat transfer tube 32 without passing over a stepped portion, thereby being more effectively exempted from suffering pressure loss. Further, the second end portion 73 can be formed in a reduced axial length, which leads to reduction in size of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A.

(Detailed Configuration of Windward Eccentric Tube fitting and Leeward Eccentric Tube fitting)

[0054] Hereunder, the detailed configuration of the windward eccentric tube fitting and the leeward eccentric tube fitting of the heat exchanger according to Embodiment 1.

[0055] Fig. 11 is a schematic drawing showing the configuration of the windward eccentric tube fitting and the leeward eccentric tube fitting of the heat exchanger according to Embodiment 1. Fig. 11 includes a front cross-sectional view of the windward eccentric tube fitting 41 B and the leeward eccentric tube fitting 42B, and associated components.

[0056] The windward eccentric tube fitting 41 B and the leeward eccentric tube fitting 42B basically have the same configuration as that of the windward concentric tube fitting 41 A and the leeward concentric tube fitting 42A, however are different therefrom in that the central axis of the first end portion 72 and the central axis of the second end portion 73 are deviated from each other, as shown in Fig. 11. The eccentricity Z may be expressed as $0 < Z < W3/2$, where W3 represents the outer diameter taken along the major axis of the windward heat transfer tube 22 and the leeward heat exchanger 32

[0057] The central axes are deviated such that the distance between the central axis of the second end portion 73 of the through portion 71 of the windward eccentric tube fitting 41 B and the central axis of the leeward heat transfer tube 32 becomes shorter than the distance between the central axis of the first end portion 72 of the through portion 71 of the windward eccentric tube fitting

41 B and the central axis of the leeward heat transfer tube 32. Likewise, the central axes are deviated such that the distance between the central axis of the second end portion 73 of the through portion 71 of the leeward eccentric tube fitting 42B and the central axis of the windward heat transfer tube 22 becomes shorter than the distance between the central axis of the first end portion 72 of the through portion 71 of the leeward eccentric tube fitting 42B and the central axis of the windward heat transfer tube 22.

< Configuration of Air-Conditioning Apparatus Including Heat Exchanger >

[0058] Hereunder, a configuration of an air-conditioning apparatus that includes the heat exchanger according to Embodiment 1 will be described.

[0059] Fig. 12 and Fig. 13 are block diagrams showing the configuration of the air-conditioning apparatus including the heat exchanger according to Embodiment 1. Fig. 12 represents the case where the air-conditioning apparatus 91 performs a heating operation. Fig. 13 represents the case where the air-conditioning apparatus 91 performs a cooling operation.

[0060] As shown in Fig. 12 and Fig. 13, the air-conditioning apparatus 91 includes a compressor 92, a four-way valve 93, an outdoor heat exchanger (heat source-side heat exchanger) 94, an expansion device 95, an indoor heat exchanger (load-side heat exchanger) 96, an outdoor fan (heat source-side fan) 97, an indoor fan (load-side fan) 98, and a controller 99. The compressor 92, the four-way valve 93, the outdoor heat exchanger 94, the expansion device 95, and the indoor heat exchanger 96 are connected via a refrigerant pipe, so as to form a refrigerant circuit. The four-way valve 93 may be another type of flow switching device.

[0061] The outdoor heat exchanger 94 corresponds to the heat exchanger 1. In the heat exchanger 1, the stacked header 51 is located on the windward side and the cylindrical header 61 is located on the leeward side, in the airflow generated when the outdoor fan 97 is driven. The outdoor fan 97 may be provided either windward or leeward of the heat exchanger 1.

[0062] To the controller 99, for example the compressor 92, the four-way valve 93, the expansion device 95, the outdoor fan 97, the indoor fan 98, and various sensors are connected. The controller 99 switches the flow path in the four-way valve 93, thereby switching between the heating operation and the cooling operation.

< Operation of Heat Exchanger and Air-Conditioning Apparatus >

[0063] Hereunder, an operation of the heat exchanger according to Embodiment 1 and the air-conditioning apparatus including the heat exchanger will be described.

(Operation of Heat Exchanger and Air-Conditioning Apparatus in Heating Operation)

[0064] Referring to Fig. 12, the flow of the refrigerant in the heating operation will be described hereunder.

[0065] The high-pressure and high-temperature gas refrigerant discharged from the compressor 92 flows into the indoor heat exchanger 96 through the four-way valve 93, and is condensed through heat exchange with air supplied by the indoor fan 98, thereby heating the indoor air. The condensed refrigerant turns into high-pressure subcooled liquid refrigerant and flows out of the indoor heat exchanger 96, and then turns into low-pressure two-phase gas-liquid refrigerant in the expansion device 95. The low-pressure two-phase gas-liquid refrigerant flows into the outdoor heat exchanger 94, and is evaporated through heat exchange with air supplied by the outdoor fan 97. The evaporated refrigerant turns into low-pressure superheated gas refrigerant and flows out of the outdoor heat exchanger 94, and is then sucked into the compressor 92 through the four-way valve 93. Thus, the outdoor heat exchanger 94 acts as evaporator in the heating operation.

[0066] In the outdoor heat exchanger 94, the refrigerant flows into the branch/junction flow path 51 a of the stacked header 51 thus to be branched, and flows into the windward heat transfer tube 22 of the windward heat exchange unit 21, through the windward concentric tube fitting 41 A. The refrigerant which has entered the windward heat transfer tube 22 sequentially passes through the windward eccentric tube fitting 41 B, the row joint tube 43, and the leeward eccentric tube fitting 42B, and flows into the leeward heat transfer tube 32 of the leeward heat exchange unit 31. The refrigerant which has entered the leeward heat transfer tube 32 passes through the leeward concentric tube fitting 42A and flows into the branch/junction flow path 61 a of the cylindrical header 61, thus to be merged.

(Operation of Heat Exchanger and Air-Conditioning Apparatus in Cooling Operation)

[0067] Referring to Fig. 13, the flow of the refrigerant in the cooling operation will be described hereunder.

[0068] The high-pressure and high-temperature gas refrigerant discharged from the compressor 92 flows into the outdoor heat exchanger 94 through the four-way valve 93, and is condensed through heat exchange with air supplied by the outdoor fan 97. The condensed refrigerant turns into high-pressure subcooled liquid refrigerant or low-quality refrigerant, and flows out of the outdoor heat exchanger 94 and then turns into low-pressure two-phase gas-liquid refrigerant in the expansion device 95. The low-pressure two-phase gas-liquid refrigerant flows into the indoor heat exchanger 96, and is evaporated through heat exchange with air supplied by the indoor fan 98, thereby cooling the indoor air. The evaporated refrigerant turns into low-pressure superheated gas

refrigerant and flows out of the indoor heat exchanger 96, and is then sucked into the compressor 92 through the four-way valve 93. Thus, the outdoor heat exchanger 94 acts as condenser in the cooling operation.

[0069] In the outdoor heat exchanger 94, the refrigerant flows into the branch/junction flow path 61 a of the cylindrical header 61 thus to be branched, and flows into the leeward heat transfer tube 32 of the leeward heat exchange unit 31, through the leeward concentric tube fitting 42A. The refrigerant which has entered the leeward heat transfer tube 32 sequentially passes through the leeward eccentric tube fitting 42B, the row joint tube 43, and the windward eccentric tube fitting 41 B, and flows into the windward heat transfer tube 22 of the windward heat exchange unit 21. The refrigerant which has entered the windward heat transfer tube 22 passes through the windward concentric tube fitting 41 A and flows into the branch/junction flow path 51 a of the stacked header 51, thus to be merged.

< Effects of Heat Exchanger >

[0070] Hereunder, the effects of the heat exchanger according to Embodiment 1 will be described.

[0071] In the heat exchanger 1, the central axis of the first end portion 72 and the central axis of the second end portion 73 are deviated from each other, in the windward eccentric tube fitting 41 B and the leeward eccentric tube fitting 42B. Therefore, the balance among the flows of flows of the fluid flowing into the windward heat transfer tube 22 and the leeward heat transfer tube 32 can be optimized.

[0072] Fig. 14 and Fig. 15 are a schematic drawing and a graph respectively, illustrating liquid distribution of the refrigerant flowing into the leeward heat transfer tube, realized when the heat exchanger according to Embodiment 1 acts as evaporator. In Fig. 14, the flow direction of the refrigerant is indicated by solid arrows.

[0073] When the heat exchange unit 2 acts as evaporator, the refrigerant flows parallel to the airflow generated by driving the outdoor fan 97 as shown in Fig. 14 and Fig. 15, in other words flows from the windward heat transfer tube 22 to the leeward heat transfer tube 32, and then flows into the leeward eccentric tube fitting 42B through the row joint tube 43 in the two-phase gas-liquid state. The two-phase gas-liquid refrigerant flowing through the row joint tube 43 is subjected to centrifugal force, so that a high-density portion of the refrigerant flows along the outer side and a low-density portion of the refrigerant flows along the inner side. In the leeward eccentric tube fitting 42B, therefore, if the eccentricity Z between the central axis of the first end portion 72 and the central axis of the second end portion 73 were 0, a larger portion of the liquid refrigerant flowing into the leeward eccentric tube fitting 42B would flow toward a point L in the leeward heat transfer tube 32, than a portion flowing toward a point S.

[0074] In the heat exchanger 1, in contrast, the eccen-

tricity Z between the central axis of the first end portion 72 and the central axis of the second end portion 73 is larger than 0 in the leeward eccentric tube fitting 42B, and therefore a major portion of the liquid refrigerant flowing into the leeward eccentric tube fitting 42B flows toward the point S in the leeward heat transfer tube 32. When the heat exchanger 1 acts as evaporator, the thermal load (heat exchange amount) of the airflow generated by driving the outdoor fan 97 is larger on the windward side, and therefore distributing the liquid refrigerant to the flow path openings of the flat tube such that a major portion thereof flows toward the point S of the leeward heat transfer tube 32, in other words into the flow path on the windward side, allows the liquid refrigerant to be more efficiently evaporated, thereby improving the heat exchange efficiency. Further, the row joint tube 43 can be formed with a smaller curvature radius so as to increase the capacity of the heat exchange unit 2, and therefore the heat exchange efficiency can be further improved. The improvement in heat exchange efficiency leads to improved operation efficiency of the refrigeration cycle, thereby upgrading the energy saving performance. Further, the footprint of the heat exchanger 1 can be reduced without compromising the performance level of the refrigeration cycle.

[0075] Fig. 16 and Fig. 17 are a schematic drawing and a graph respectively, illustrating gas distribution of the refrigerant flowing into the windward heat transfer tube, realized when the heat exchanger according to Embodiment 1 acts as condenser. In Fig. 16, the flow direction of the refrigerant is indicated by solid arrows.

[0076] When the heat exchange unit 2 acts as condenser, the refrigerant flows against the airflow generated by driving the outdoor fan 97 as shown in Fig. 16 and Fig. 17, in other words the refrigerant flows from the leeward heat transfer tube 32 to the windward heat transfer tube 22, and then flows into the windward eccentric tube fitting 41 B through the row joint tube 43 in the two-phase gas-liquid state. The two-phase gas-liquid refrigerant flowing through the row joint tube 43 is subjected to centrifugal force, so that a high-density portion of the refrigerant flows along the outer side and a low-density portion of the refrigerant flows along the inner side. In the windward eccentric tube fitting 41 B, therefore, if the eccentricity Z between the central axis of the first end portion 72 and the central axis of the second end portion 73 were 0, a larger portion of the liquid refrigerant flowing into the windward eccentric tube fitting 41 B would flow toward a point L in the windward heat transfer tube 22, than a portion flowing toward a point S.

[0077] In the heat exchanger 1, in contrast, the eccentricity Z between the central axis of the first end portion 72 and the central axis of the second end portion 73 is larger than 0 in the windward eccentric tube fitting 41 B, and therefore a major portion of the gas refrigerant flowing into the windward eccentric tube fitting 41 B flows toward the point L in the windward heat transfer tube 22, since a major portion of liquid refrigerant flows toward

the point S. When the heat exchanger 1 acts as condenser, the thermal load (heat exchange amount) of the airflow generated by driving the outdoor fan 97 is larger on the windward side, and therefore distributing the gas refrigerant to the flow path openings of the flat tube such that a major portion thereof flows toward the point L of the windward heat transfer tube 22, in other words into the flow path on the windward side, allows the gas refrigerant to be more efficiently condensed, thereby improving the heat exchange efficiency. Further, the row joint tube 43 can be formed with a smaller curvature radius and the capacity of the heat exchange unit 2 can be increased, and therefore the heat exchange efficiency can be further improved. The improvement in heat exchange efficiency leads to improved operation efficiency of the refrigeration cycle, thereby upgrading the energy saving performance. Further, the footprint of the heat exchanger 1 can be reduced without compromising the performance level of the refrigeration cycle.

[0078] Further, in the windward concentric tube fitting 41 A, the leeward concentric tube fitting 42A, the windward eccentric tube fitting 41 B, and the leeward eccentric tube fitting 42B of the heat exchanger 1, since the inner diameter D (D1, D2) of the cross-section of the second end portion 73 with respect to the entire circumference thereof is set to $W2 \leq D \leq W1$, where W1 represents the inner diameter of the first end portion 72 taken along the major axis and W2 represents the inner diameter thereof taken along the minor axis, reduction in size and reduction in pressure loss can both be realized. Accordingly, the spacing between the heat exchange unit 2 and the branch/junction section 3 can be narrowed so as to increase the capacity of the heat exchange unit 2, and therefore the heat exchange efficiency can be improved. The improvement in heat exchange efficiency leads to improved operation efficiency of the refrigeration cycle, thereby upgrading the energy saving performance. Further, the footprint of the heat exchanger 1 can be reduced without compromising the performance level of the refrigeration cycle.

[0079] Still further, in the windward concentric tube fitting 41A, the leeward concentric tube fitting 42A, the windward eccentric tube fitting 41 B, and the leeward eccentric tube fitting 42B of the heat exchanger 1, the shape transition section 74 is provided in the region between the first end portion 72 and the second end portion 73 of the through portion 71, and the region in the inner circumferential surface of the second end portion 73 where the outer circumferential surface of the joint tube 57 of the stacked header 51, the joint tube 64 of the cylindrical header 61, or the row joint tube 43 is joined is closely adjacent to the shape transition section 74, and therefore reduction in size and reduction in pressure loss can both be realized. Accordingly, the spacing between the heat exchange unit 2 and the branch/junction section 3 can be narrowed so as to increase the capacity of the heat exchange unit 2, and therefore the heat exchange efficiency can be improved. The improvement in heat ex-

change efficiency leads to improved operation efficiency of the refrigeration cycle, thereby upgrading the energy saving performance. Further, the footprint of the heat exchanger 1 can be reduced without compromising the performance level of the refrigeration cycle.

Embodiment 2.

[0080] Hereafter, a heat exchanger according to Embodiment 2 will be described.

[0081] The description of the aspects same as or similar to those of Embodiment 1 will be simplified or omitted, as the case may be.

< Configuration of Heat Exchanger >

[0082] Hereunder, a configuration of the heat exchanger according to Embodiment 2 will be described.

(General Configuration of Heat Exchanger)

[0083] Hereunder, a general configuration of the heat exchanger according to Embodiment 2 will be described.

[0084] Fig. 18 is a perspective view of the heat exchanger according to Embodiment 2.

[0085] As shown in Fig. 18, the heat exchange unit 2 only includes the windward heat exchange unit 21. The windward heat transfer tubes 22 are arranged in a plurality of columns in a direction intersecting the flow direction of air passing through the heat exchange unit 2 (blank arrow in Fig. 18). Each of the windward heat transfer tubes 22 is bent in a hair-pin shape between the first end portion and the second end portion, so as to form a turn-back section 22a. The first end portion and the second end portion of each of the windward heat transfer tubes 22 are aligned so as to oppose the stacked header 51.

[0086] The stacked header 51 includes therein a branch/junction flow path 51a, and is connected to the windward heat exchange unit 21. When the heat exchange unit 2 acts as evaporator, the branch/junction flow path 51 a serves as branch flow path for distributing the refrigerant received through a non-illustrated refrigerant tube to the plurality of windward heat transfer tubes 22 in the windward heat exchange unit 21. When the heat exchange unit 2 acts as condenser, the branch/junction flow path 51 a serves as junction flow path for merging the refrigerant received from each of the windward heat transfer tubes 22 in the windward heat exchange unit 21 and passing the merged flow to the non-illustrated refrigerant tube.

[0087] The cylindrical header 61 includes therein a branch/junction flow path 61 a, and is connected to the windward heat exchange unit 21. When the heat exchange unit 2 acts as condenser, the branch/junction flow path 61 a serves as branch flow path for distributing the refrigerant received through a non-illustrated refrigerant tube to the plurality of windward heat transfer tubes 22 in the windward heat exchange unit 21. When the heat

exchange unit 2 acts as evaporator, the branch/junction flow path 61 a serves as junction flow path for merging the refrigerant received from each of the windward heat transfer tubes 22 in the windward heat exchange unit 21 and passing the merged flow to the non-illustrated refrigerant tube.

(Connection between Heat Exchange Unit and Branch/Junction Section)

[0088] Hereunder, connection between the heat exchange unit and the branch/junction section of the heat exchanger according to Embodiment 2 will be described.

[0089] Fig. 19 and Fig. 20 are schematic drawings illustrating the connection between the heat exchange unit and the branch/junction section of the heat exchanger according to Embodiment 2. Fig. 20 is a cross-sectional view taken along a line B-B in Fig. 19.

[0090] As shown in Fig. 19 and Fig. 20, each of the windward concentric tube fittings 41 A is joined to the first end portion 22b or the second end portion 22c of the windward heat transfer tube 22. The joint tube 57 of the stacked header 51 is connected to the windward concentric tube fitting 41 A joined to the first end portion 22b of the windward heat transfer tube 22. The joint tube 64 of the cylindrical header 61 is connected to the windward concentric tube fitting 41 A joined to the second end portion 22c of the windward heat transfer tube 22.

[0091] Fig. 21 is a schematic drawing illustrating the connection between the heat exchange unit and the branch/junction section of the heat exchanger according to a variation of Embodiment 2. Here, Fig. 21 is a cross-sectional view from a position corresponding to the line B-B in Fig. 19.

[0092] As shown in Fig. 21, the second end portion 22c of the windward heat transfer tube 22 and the first end portion 22b of the windward heat transfer tube 22 of the adjacent column may be connected to each other via the windward column joint tube 44 and the windward concentric tube fitting 41 A.

< Operation of Heat Exchanger and Air-Conditioning Apparatus >

[0093] Hereunder, an operation of the heat exchanger according to Embodiment 2 and the air-conditioning apparatus including the heat exchanger will be described.

(Operation of Heat Exchanger and Air-Conditioning Apparatus in Heating Operation)

[0094] Fig. 22 is a block diagram showing the configuration of the air-conditioning apparatus including the heat exchanger according to Embodiment 2. Fig. 22 represents the case where the air-conditioning apparatus 91 performs a heating operation.

[0095] Referring to Fig. 22, the flow of the refrigerant in the heating operation will be described hereunder.

[0096] In the outdoor heat exchanger 94, the refrigerant flows into the branch/junction flow path 51 a of the stacked header 51 thus to be branched, and flows into the windward heat transfer tube 22 of the windward heat exchange unit 21, through the windward concentric tube fitting 41 A. The refrigerant which has entered the windward heat transfer tube 22 passes through the windward concentric tube fitting 41 A and flows into the branch/junction flow path 61 a of the cylindrical header 61, thus to be merged.

(Operation of Heat Exchanger and Air-Conditioning Apparatus in Cooling Operation)

[0097] Fig. 23 is a block diagram showing the configuration of the air-conditioning apparatus including the heat exchanger according to Embodiment 2. Fig. 23 represents the case where the air-conditioning apparatus 91 performs a cooling operation.

[0098] Referring to Fig. 23, the flow of the refrigerant in the cooling operation will be described hereunder.

[0099] In the outdoor heat exchanger 94, the refrigerant flows into the branch/junction flow path 61 a of the cylindrical header 61 thus to be branched, and flows into the windward heat transfer tube 22 of the windward heat exchange unit 21, through the windward concentric tube fitting 41 A. The refrigerant which has entered the windward heat transfer tube 22 passes through the windward concentric tube fitting 41 A and flows into the branch/junction flow path 51 a of the stacked header 51, thus to be merged.

< Effects of Heat Exchanger >

[0100] Hereunder, the effects of the heat exchanger according to Embodiment 2 will be described.

[0101] In the windward concentric tube fitting 41 A of the heat exchanger 1, as in the heat exchanger 1 according to Embodiment 1, the inner diameter D (D1, D2) of the cross-section of the second end portion 73 with respect to the entire circumference thereof is set to $W2 \leq D \leq W1$, where W1 represents the inner diameter of the first end portion 72 taken along the major axis and W2 represents the inner diameter thereof taken along the minor axis, and therefore reduction in size and reduction in pressure loss can both be realized. Accordingly, the spacing between the heat exchange unit 2 and the branch/junction section 3 can be narrowed so as to increase the capacity of the heat exchange unit 2, and consequently the heat exchange efficiency can be improved. The improvement in heat exchange efficiency leads to improved operation efficiency of the refrigeration cycle, thereby upgrading the energy saving performance. Further, the footprint of the heat exchanger 1 can be reduced without compromising the performance level of the refrigeration cycle.

[0102] Further, in the windward concentric tube fitting 41 A of the heat exchanger 1, as in the heat exchanger

1 according to Embodiment 1, the shape transition section 74 is provided in the region between the first end portion 72 and the second end portion 73 of the through portion 71, and the region in the inner circumferential surface of the second end portion 73 where the outer circumferential surface of the joint tube 57 of the stacked header 51 or the joint tube 64 of the cylindrical header 61 is joined is closely adjacent to the shape transition section 74, and therefore reduction in size and reduction in pressure loss can both be realized. Accordingly, the spacing between the heat exchange unit 2 and the branch/junction section 3 can be narrowed so as to increase the capacity of the heat exchange unit 2, and therefore the heat exchange efficiency can be improved. The improvement in heat exchange efficiency leads to improved operation efficiency of the refrigeration cycle, thereby upgrading the energy saving performance. Further, the footprint of the heat exchanger 1 can be reduced without compromising the performance level of the refrigeration cycle.

[0103] Although Embodiment 1 and Embodiment 2 have been described as above, the present invention is in no way limited to the foregoing Embodiments. For example, the whole or a part of Embodiments may be combined as desired. Reference Signs List

[0104] 1: heat exchanger, 2: heat exchange unit, 3: branch/junction section, 21: windward heat exchange unit, 22: windward heat transfer tube, 22a: turnback section, 22b: the first end portion, 22c: the second end portion, 23: leeward fin, 31: leeward heat exchange unit, 32: leeward heat transfer tube, 32a: turnback section, 32b: the first end portion, 32c: the second end portion, 33: leeward fin, 41 A: windward concentric tube fitting, 41B: windward eccentric tube fitting, 42A: leeward concentric tube fitting, 42B: leeward eccentric tube fitting, 43: row joint tube 44: windward column joint tube 45: leeward column joint tube, 51: stacked header, 51 a: branch/junction flow path, 52, 57: joint tube, 53: first plate member, 54_1 to 54_3: second plate member, 55: third plate member, 56_1 to 56_4: clad member, 53a, 54a_1 to 54a_3, 55a, 56a: flow path segment, 61: cylindrical header, 61 a: branch/junction flow path, 62, 64: joint tube, 63: cylindrical portion, 71: through portion, 72: first end portion, 73: second end portion, 74: shape transition section, 91: air-conditioning apparatus, 92: compressor, 93: four-way valve, 94: outdoor heat exchanger, 95: expansion device, 96: indoor heat exchanger, 97: outdoor fan, 98: indoor fan, 99: controller

Claims

1. A tube fitting including a through portion, to a first end portion of which a flat tube is connected and to a second end portion of which an other tube different in cross-sectional shape from the flat tube is connected, wherein a central axis of the first end portion and a

central axis of the second end portion are deviated from each other.

2. The tube fitting of claim 1, wherein an inner diameter D of the second end portion in a cross-section perpendicular to the central axis with respect to an entire circumference is smaller than or equal to an inner diameter W1 of the first end portion in the major axis, and equal to or larger than an inner diameter W2 of the first end portion in the minor axis.
3. The tube fitting of claim 1 or 2, wherein an outer circumferential surface of the flat tube is joined to an inner circumferential surface of the first end portion, an outer circumferential surface of the other tube is joined to an inner circumferential surface of the second end portion, the through portion includes a shape transition section formed in a region between the first end portion and the second end portion, the shape transition section being configured so as to gradually translate a cross-sectional shape of the inner circumferential surface of the first end portion into a cross-sectional shape of the inner circumferential surface of the second end portion, and a region in the inner circumferential surface of the second end portion where the outer circumferential surface of the other tube is joined is adjacent to the shape transition section.
4. A tube fitting including a through portion, to a first end portion of which a flat tube is connected and to a second end portion of which an other tube different in cross-sectional shape from the flat tube is connected, wherein an outer circumferential surface of the flat tube is joined to an inner circumferential surface of the first end portion, an outer circumferential surface of the other tube is joined to an inner circumferential surface of the second end portion, the through portion includes a shape transition section formed in a region between the first end portion and the second end portion, the shape transition section being configured so as to gradually translate a cross-sectional shape of the inner circumferential surface of the first end portion into a cross-sectional shape of the inner circumferential surface of the second end portion, and a region in the inner circumferential surface of the second end portion where the outer circumferential surface of the other tube is joined is adjacent to the shape transition section.
5. A heat exchanger comprising:

the tube fitting of any one of claims 1 to 3; and
a heat exchange unit including the flat tube, at
least an end portion of which is connected to the
first end portion of the tube fitting, and an other
flat tube located on a windward side or a leeward
side of the flat tube,

wherein the second end portion of the tube fitting
connected to the flat tube and the other flat tube are
connected to each other via a row joint tube, and
a distance between the central axis of the second
end portion of the tube fitting connected to the flat
tube and the central axis of the other flat tube is short-
er than a distance between the central axis of the
first end portion of the tube fitting connected to the
flat tube and the central axis of the other flat tube.

6. The heat exchanger of claim 5,
wherein the heat exchange unit acts as evaporator
and the other flat tube is located windward of the flat
tube.

7. The heat exchanger of claim 5 or 6,
wherein the heat exchange unit acts as condenser
and the other flat tube is located leeward of the flat
tube.

8. A heat exchanger comprising:

a tube fitting including a through portion, to a
first end portion of which a flat tube is connected
and to a second end portion of which an other
tube different in cross-sectional shape from the
flat tube is connected;
a heat exchange unit including the flat tube, at
least an end portion of which is connected to the
first end portion of the tube fitting, the flat tube
being located on a windward side and a leeward
side; and
a header connected to the heat exchange unit
and located on the windward side and a header
connected to the heat exchange unit and located
on the leeward side,

wherein the second end portion of the tube fitting
connected to the flat tube located on the windward
side and the second end portion of the tube fitting
connected to the flat tube located on the leeward
side are connected to each other via a row joint tube,
the row joint tube is located between the heat ex-
change unit and the header located on the windward
side and the header located on the leeward side, and
the tube fitting is configured such that an inner di-
ameter D of the second end portion in a cross-section
perpendicular to the central axis with respect to an
entire circumference is smaller than or equal to an
inner diameter W1 of the first end portion in the major
axis, and equal to or larger than an inner diameter

W2 of the first end portion in the minor axis.

9. The heat exchanger of any one of claims 5 to 8,
wherein a flow path cross-sectional area of the row
joint tube is larger than a flow path cross-sectional
area of the flat tube.

10. A heat exchanger comprising:

the tube fitting of claim 4;
a heat exchange unit including the flat tube, at
least an end portion of which is connected to the
first end portion of the tube fitting; and
a header including a branch flow path for deliv-
ering refrigerant in branched flows or a junction
flow path for delivering a merged flow of the re-
frigerant, and a joint tube provided at an outlet
of the branch flow path and connected to the
second end portion of the tube fitting or a joint
tube provided at an inlet of the junction flow path
and connected to the second end portion of the
tube fitting.

11. A heat exchanger comprising:

a tube fitting including a through portion, to a
first end portion of which a flat tube is connected
and to a second end portion of which an other
tube different in cross-sectional shape from the
flat tube is connected;
a heat exchange unit including the flat tube, at
least an end portion of which is connected to the
first end portion of the tube fitting; and
a header including a branch flow path for deliv-
ering refrigerant in branched flows or a junction
flow path for delivering a merged flow of the re-
frigerant, and a joint tube provided at an outlet
of the branch flow path and connected to the
second end portion of the tube fitting or a joint
tube provided at an inlet of the junction flow path
and connected to the second end portion of the
tube fitting,

wherein the tube fitting is configured such that an
inner diameter D of the second end portion in a cross-
section perpendicular to the central axis with respect
to an entire circumference is smaller than or equal
to an inner diameter W1 of the first end portion in the
major axis, and equal to or larger than an inner di-
ameter W2 of the first end portion in the minor axis.

12. The heat exchanger of claim 10 or 11,
wherein a flow path cross-sectional area of the joint
tube is larger than a flow path cross-sectional area
of the flat tube.

13. An air-conditioning apparatus comprising the heat
exchanger of any one of claims 5 to 12.

FIG. 1

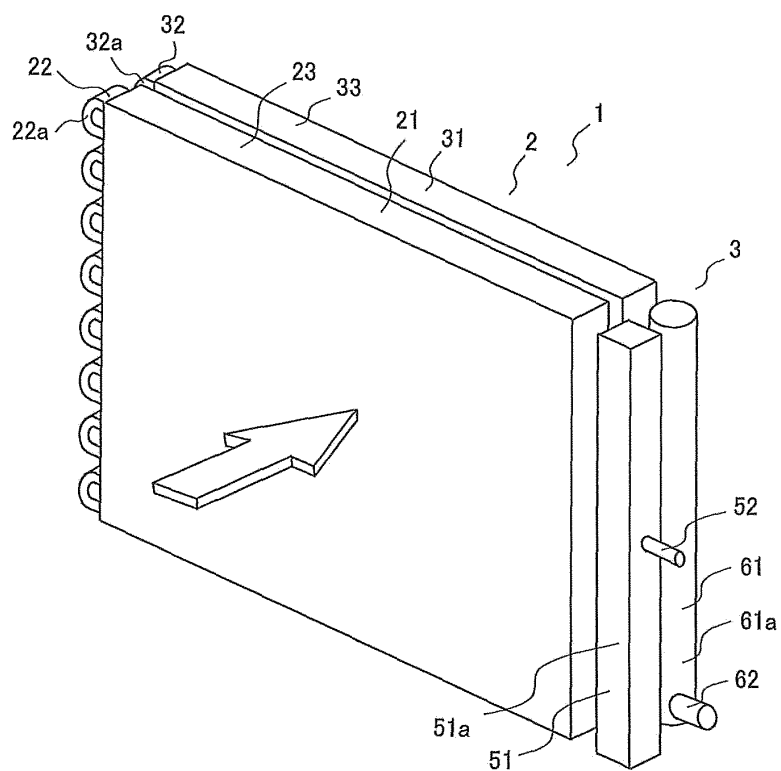


FIG. 2

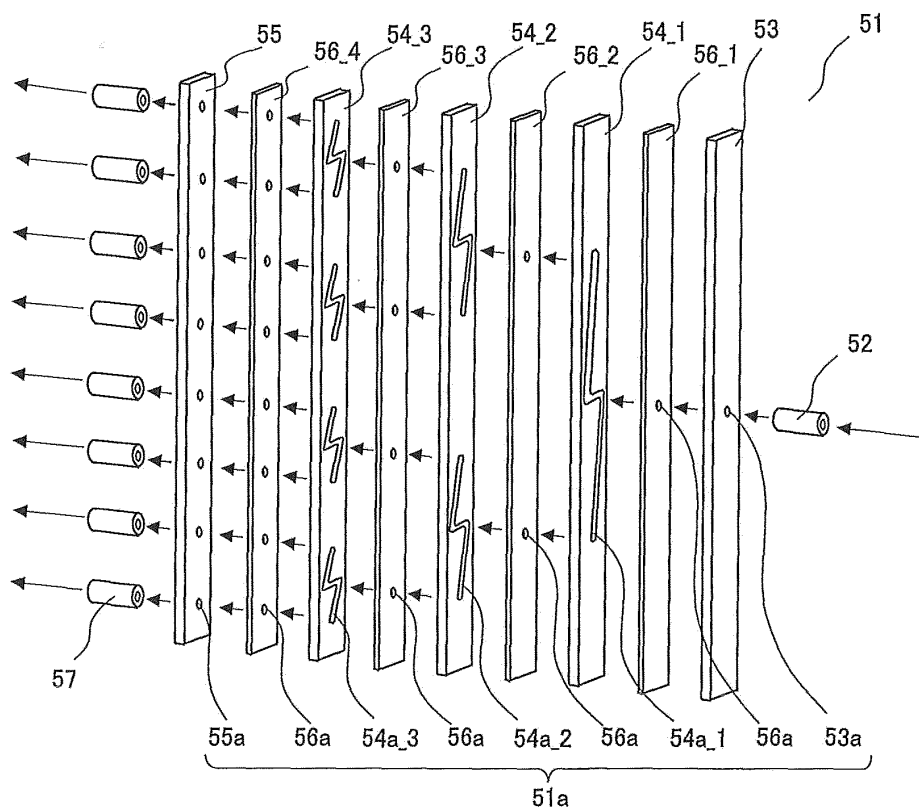


FIG. 3

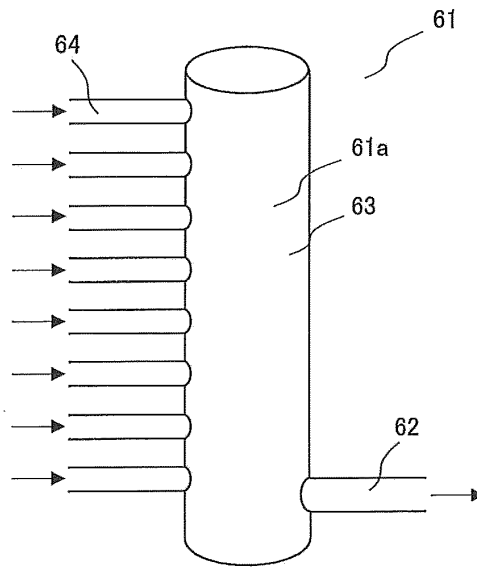


FIG. 4

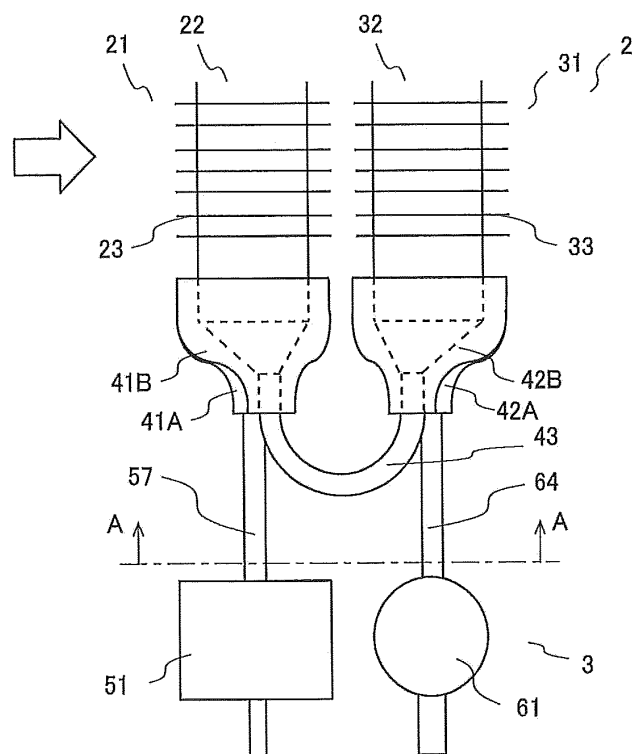


FIG. 5

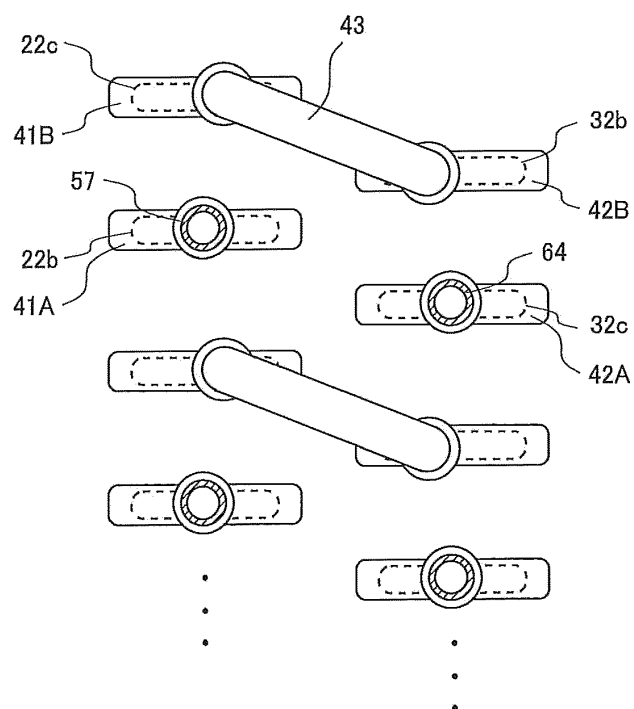


FIG. 6

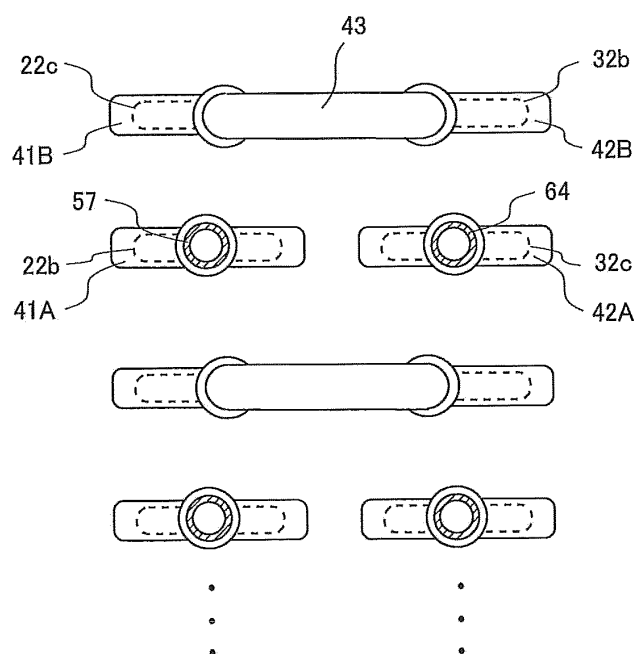


FIG. 7

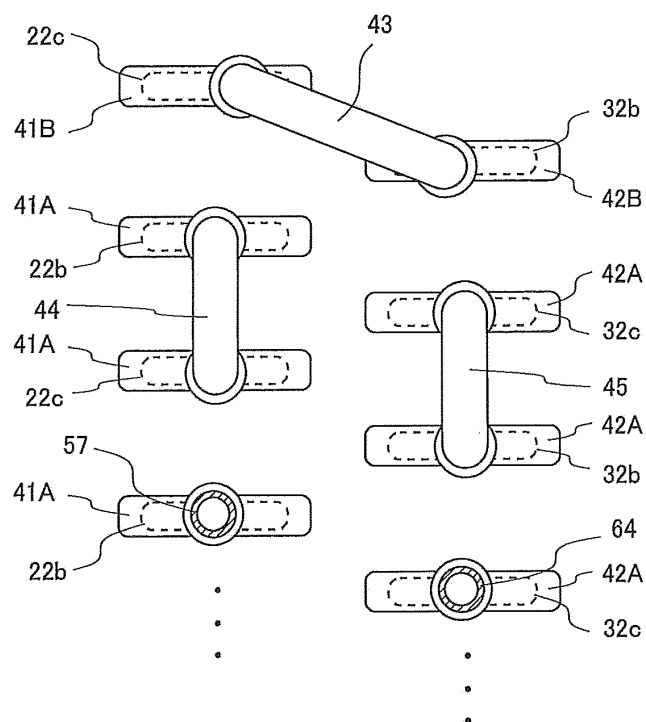


FIG. 8

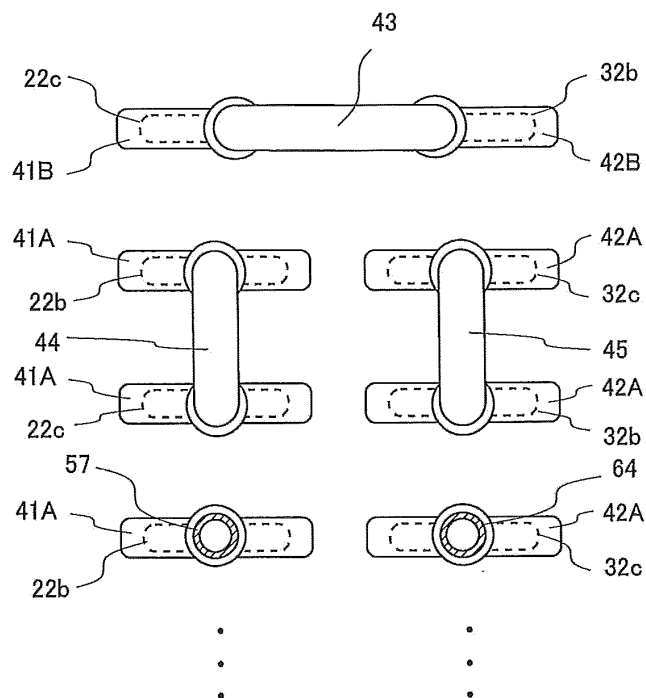


FIG. 9

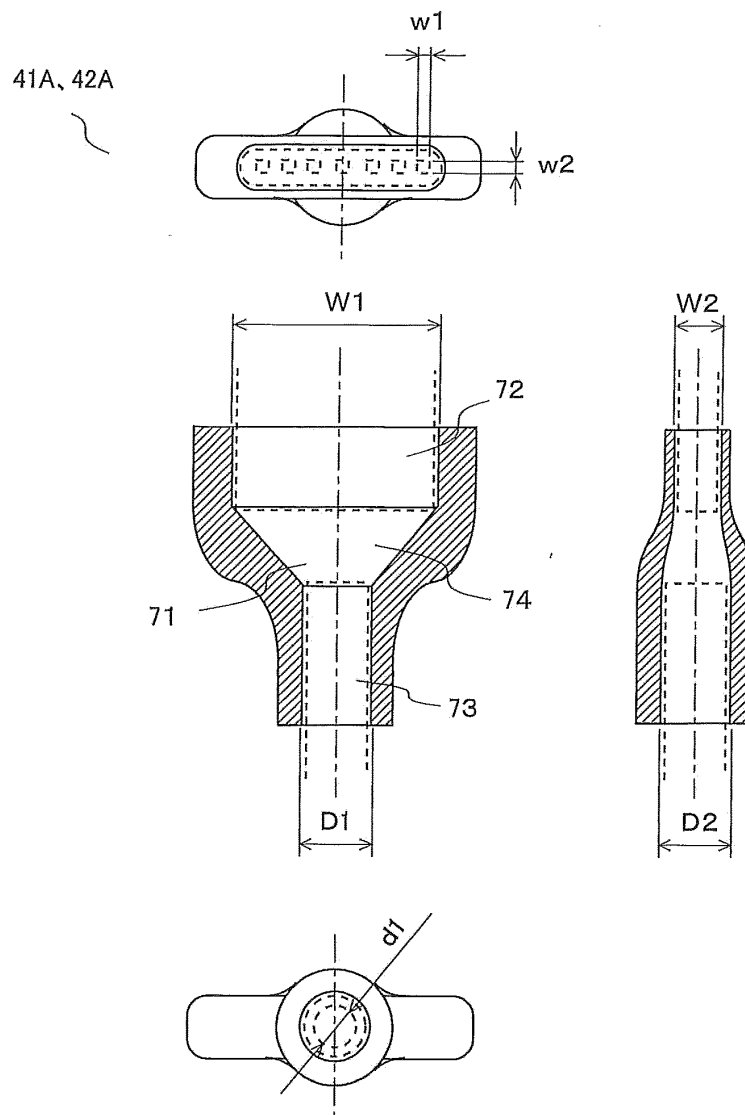


FIG. 10

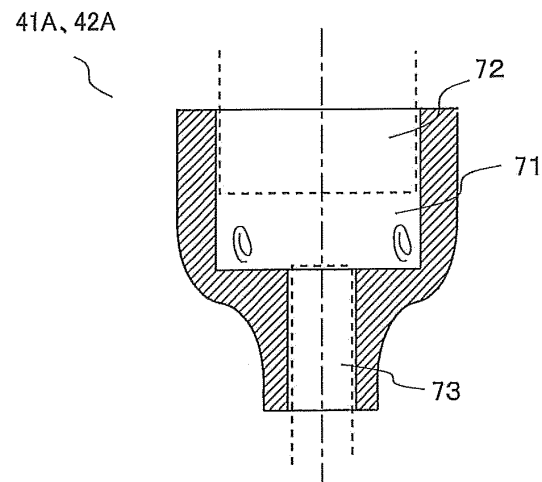


FIG. 11

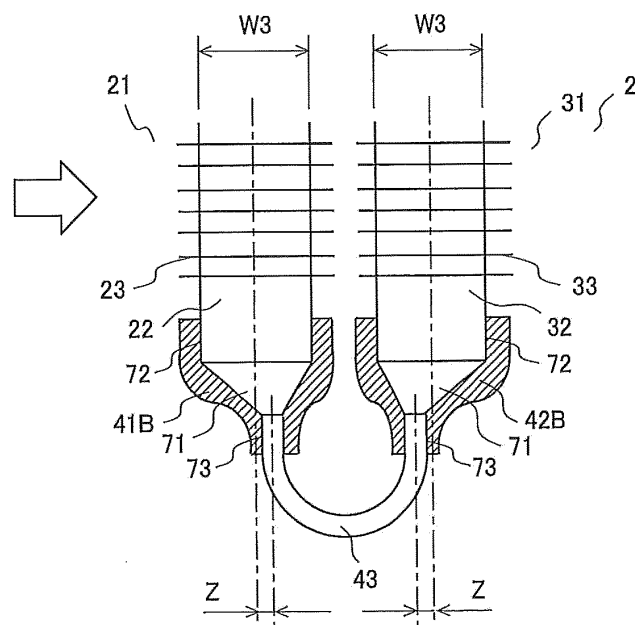


FIG. 12

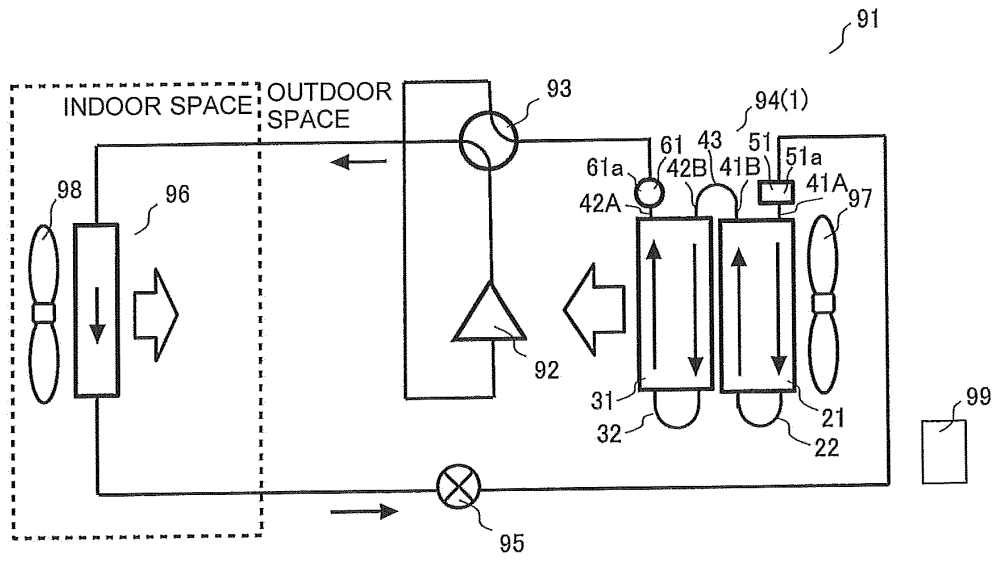


FIG. 13

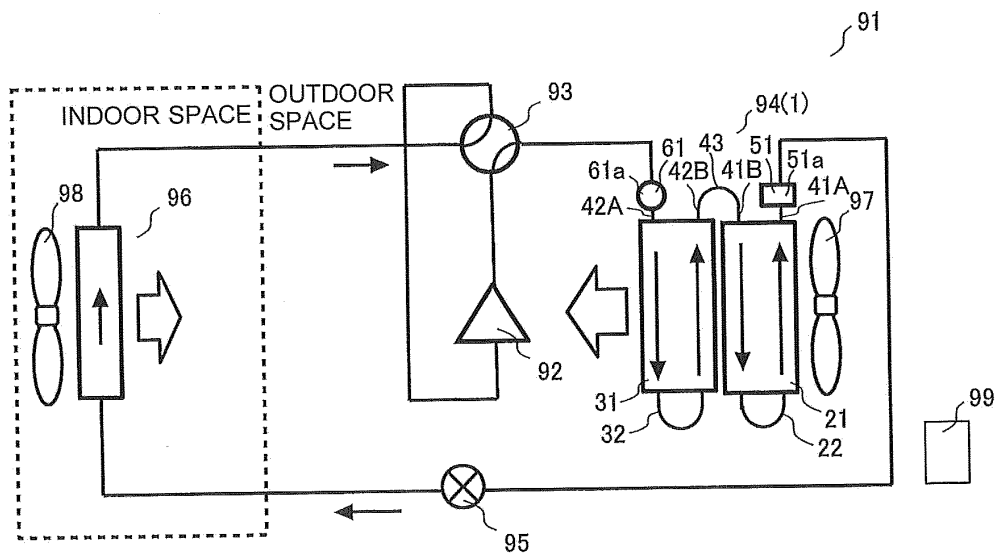


FIG. 14

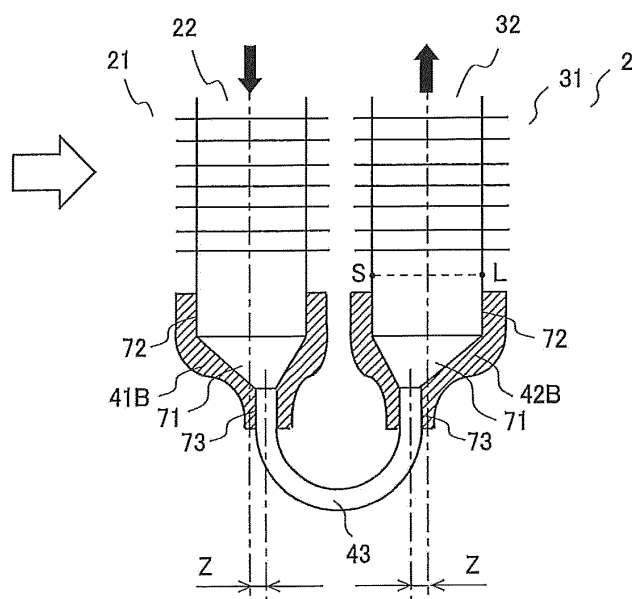


FIG. 15

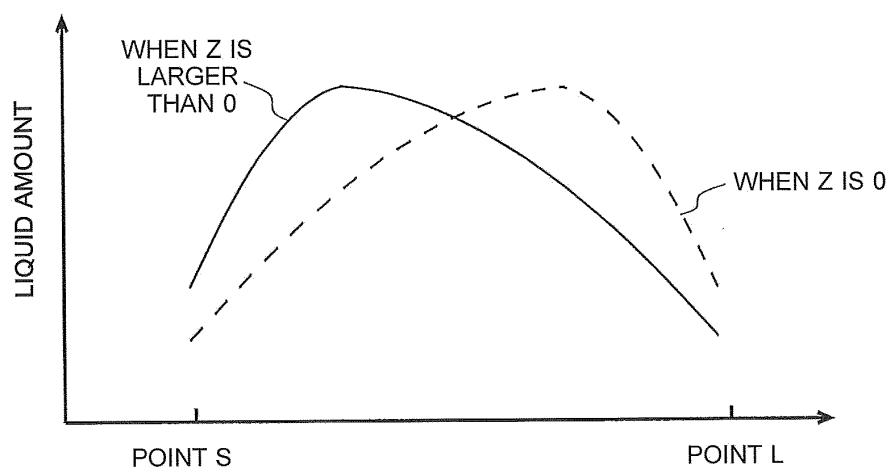


FIG. 16

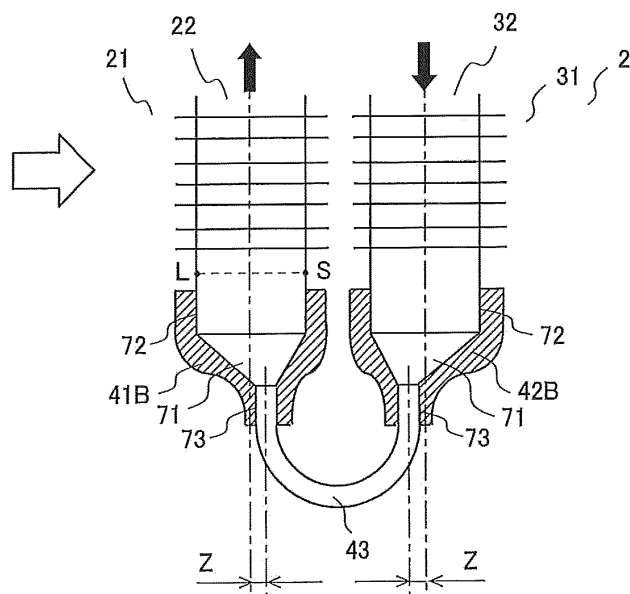


FIG. 17

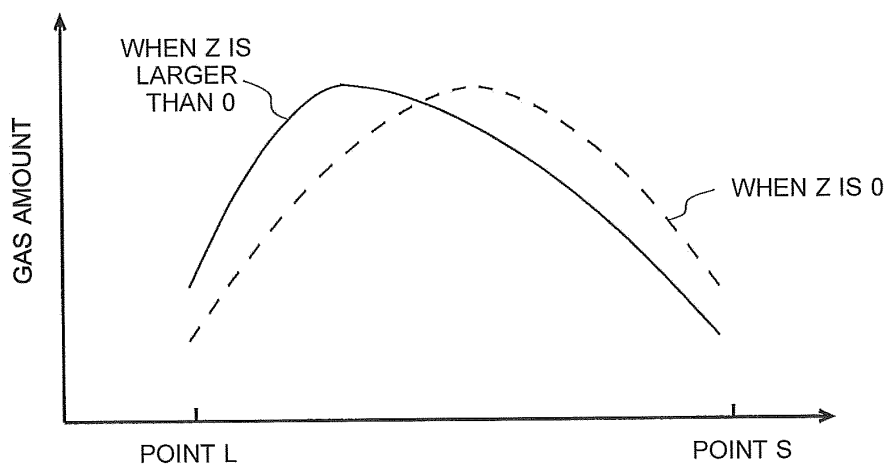


FIG. 18

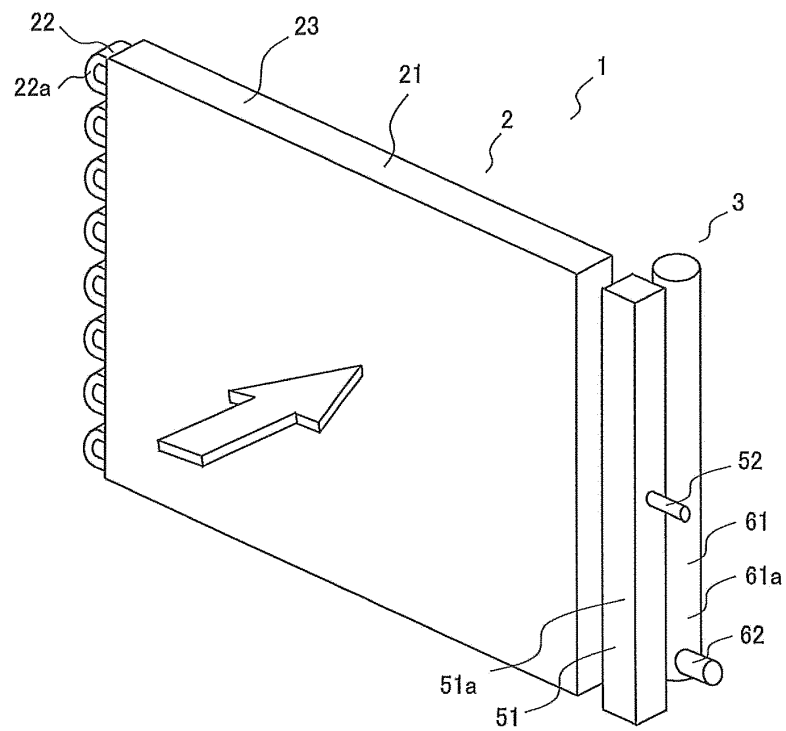


FIG. 19

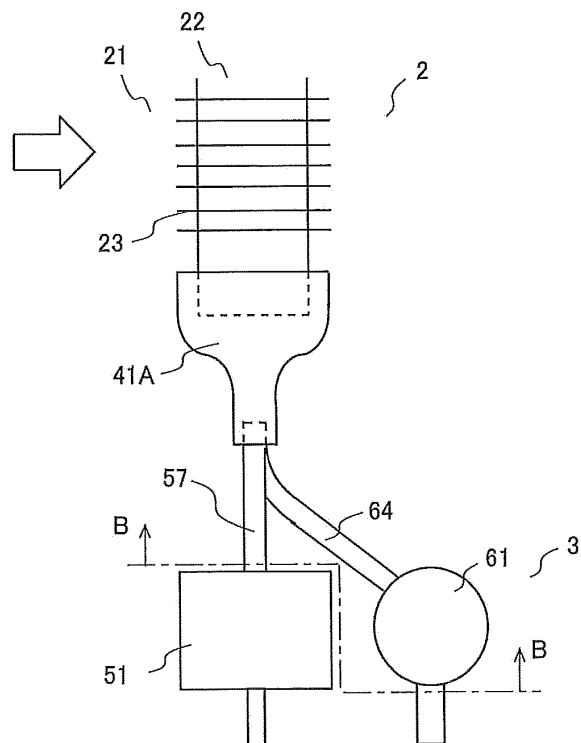


FIG. 20

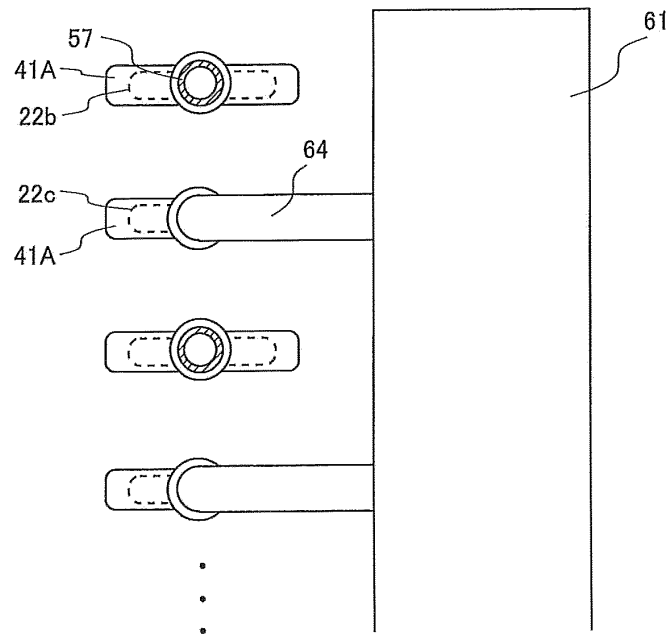


FIG. 21

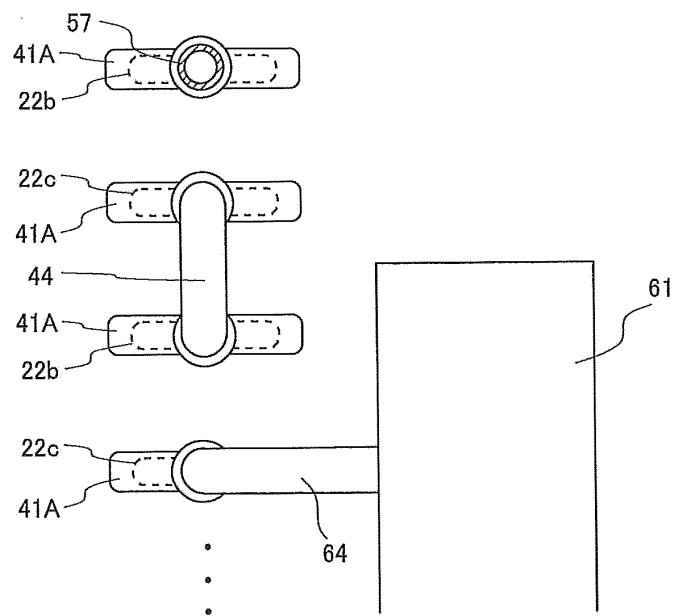


FIG. 22

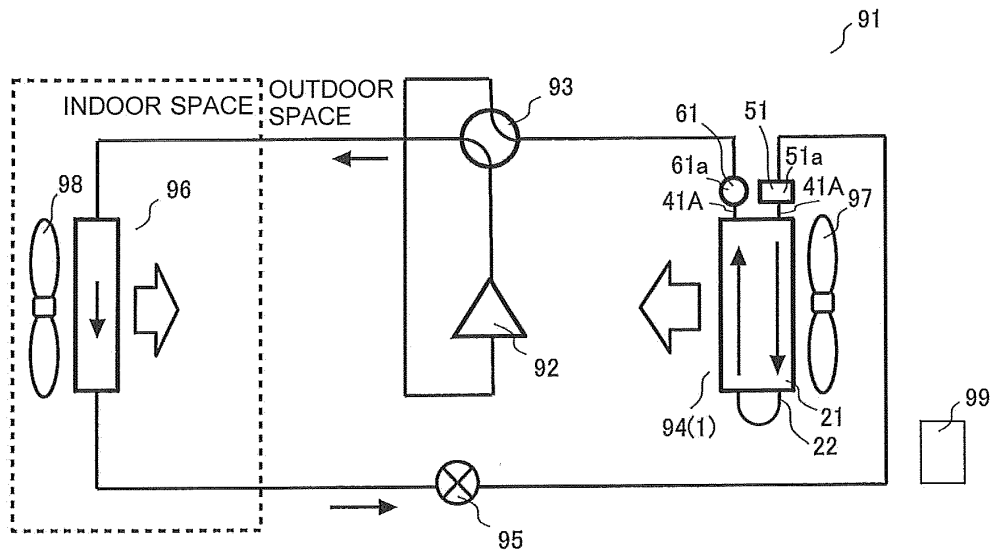
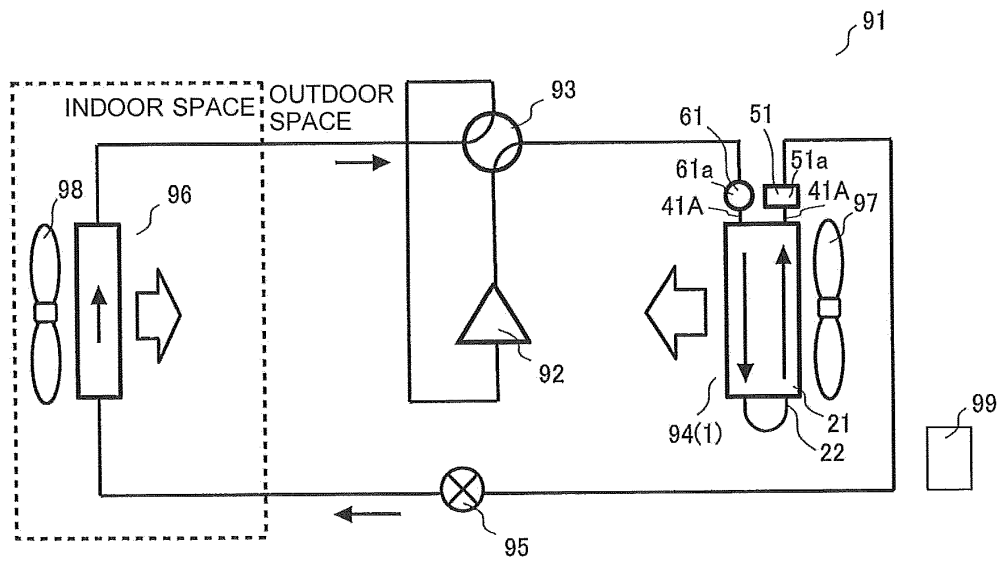


FIG. 23



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/079248

A. CLASSIFICATION OF SUBJECT MATTER

F16L21/00(2006.01)i, *F16L25/00*(2006.01)i, *F24F1/00*(2011.01)i, *F24F1/14*
(2011.01)i, *F28F9/26*(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)

F16L21/00, *F16L25/00*, *F24F1/00*, *F24F1/14*, *F28F9/26*

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 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2012-082986 A (Mitsubishi Electric Corp.), 26 April 2012 (26.04.2012), claim 1; fig. 3, 4, 6 (Family: none)	1, 13 2-4, 8-12 5-7
X Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 93633/1983(Laid-open No. 2087/1985) (Nippon Light Metal Co., Ltd.), 09 January 1985 (09.01.1985), page 5, lines 10 to 15; fig. 7 (Family: none)	1 2-4, 8-12 5-7

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

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Date of the actual completion of the international search
21 November, 2013 (21.11.13)

Date of mailing of the international search report
03 December, 2013 (03.12.13)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/079248

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 2010-185614 A (Mitsubishi Electric Corp.), 26 August 2010 (26.08.2010), paragraph [0017]; fig. 5 (Family: none)	2, 3, 11, 12
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 124160/1984 (Laid-open No. 38389/1986) (Sekisui Chemical Co., Ltd.), 10 March 1986 (10.03.1986), fig. 1 (Family: none)	3, 4, 10
Y	JP 2011-127831 A (Mitsubishi Electric Corp.), 30 June 2011 (30.06.2011), front page (Family: none)	8, 9
Y	JP 2013-134016 A (Daikin Industries, Ltd.), 08 July 2013 (08.07.2013), fig. 4, 5 (Family: none)	8-12

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013142454 A [0003]