

(19)



(11)

EP 4 513 122 A1

(12)

EUROPEAN PATENT APPLICATION

published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.02.2025 Bulletin 2025/09

(51) International Patent Classification (IPC):
F28D 1/053 ^(2006.01) **F28F 9/02** ^(2006.01)

(21) Application number: **22938485.4**

(52) Cooperative Patent Classification (CPC):
F28D 1/05316; F28D 1/053; F28D 1/05366;
F28F 9/02; F28F 9/0273; F28F 9/22; F28F 1/126

(22) Date of filing: **20.04.2022**

(86) International application number:
PCT/JP2022/018298

(87) International publication number:
WO 2023/203683 (26.10.2023 Gazette 2023/43)

(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:
KH MA MD TN

- **ADACHI, Rihito**
Tokyo 100-8310 (JP)
- **KISHIDA, Nanami**
Tokyo 100-8310 (JP)
- **SAIKUSA, Tetsuji**
Tokyo 100-8310 (JP)
- **NAKAO, Yuki**
Tokyo 100-8310 (JP)
- **YATSUYANAGI, Akira**
Tokyo 100-8310 (JP)

(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

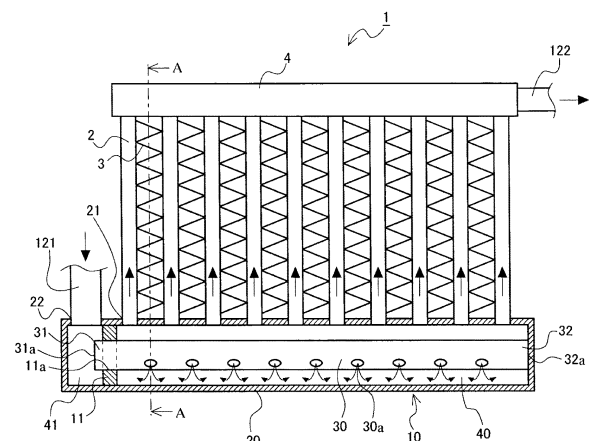
(74) Representative: **Meissner Bolte Partnerschaft mbB**
Patentanwälte Rechtsanwälte
Postfach 86 06 24
81633 München (DE)

(72) Inventors:
• **ONAKA, Yoji**
Tokyo 100-8310 (JP)

(54) HEAT EXCHANGER AND AIR CONDITIONING DEVICE

(57) A heat exchanger of one embodiment of the present invention includes a plurality of heat transfer tubes, an outer pipe having a plurality of connection parts that are arranged at intervals in a longitudinal direction and to each of which a corresponding one of the plurality of heat transfer tubes is connected, an inner pipe provided inside the outer pipe and having a plurality of first orifices at a periphery, and a first partition having a first through-hole in which the inner pipe is fitted, the first partition separating an inside of the outer pipe into a main space and a first space. The main space is a space with which the plurality of first orifices and the plurality of connection parts communicate. The first space communicates with none of the plurality of first orifices and the plurality of connection parts and is a space with which an opening provided at one end of the inner pipe communicates, the one end being a first end. Refrigerant supplied into the first space flows into an inside of the inner pipe, the plurality of first orifices, the main space, the plurality of connection parts, and then the plurality of heat transfer tubes.

FIG. 2



Description

Technical Field

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

Background Art

[0002] Some known heat exchangers include refrigerant distributors having a double-pipe structure (see Patent Literature 1, for example). Such a known double-pipe refrigerant distributor includes an outer pipe, and an inner pipe provided inside the outer pipe. The inner pipe has orifices that are also referred to as refrigerant discharge holes. A plurality of heat transfer tubes are connected to the outer pipe. A two-phase gas-liquid refrigerant is distributed from the known double-pipe refrigerant distributor to the heat transfer tubes.

[0003] In this process, the two-phase refrigerant first flows from the outside into the inner pipe. The two-phase gas-liquid refrigerant thus flowing in the inner pipe flows through the orifices and is discharged to a space provided between the inner pipe and the outer pipe. The two-phase gas-liquid refrigerant thus discharged to the space between the inner pipe and the outer pipe is distributed to the plurality of heat transfer tubes connected to the outer pipe.

[0004] To summarize, in the heat exchanger including the known double-pipe refrigerant distributor, the two-phase gas-liquid refrigerant flowing in the inner pipe is discharged through the orifices to the space provided between the inner pipe and the outer pipe, so that the liquid refrigerant component of the two-phase gas-liquid refrigerant can be distributed evenly to the heat transfer tubes, aiming to reduce the probability of deterioration in the heat-exchange performance of the heat exchanger.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Unexamined Patent Application Publication JP 2012- 2 475 A

Summary of the Invention

Technical Problem

[0006] The heat exchanger including the known double-pipe refrigerant distributor, however, may experience a deterioration of the heat-exchange performance thereof when the liquid refrigerant component of the two-phase gas-liquid refrigerant is unevenly distributed to the heat transfer tubes, depending on the condition of

the two-phase gas-liquid refrigerant flowing inside the inner pipe. Such condition may occur where the liquid refrigerant component of the two-phase gas-liquid refrigerant flows unevenly inside the inner pipe.

[0007] The present invention has been conceived in view of the above circumstances, and a first object of the present invention is to provide a heat exchanger configured to exhibit more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes than in the known art. A second object of the present invention is to provide an air-conditioning apparatus including such a heat exchanger.

Solution to Problem

[0008] A heat exchanger of one embodiment of the present invention includes a plurality of heat transfer tubes, an outer pipe having a plurality of connection parts that are arranged at intervals in a longitudinal direction and to each of which a corresponding one of the plurality of heat transfer tubes is connected, an inner pipe provided inside the outer pipe and having a plurality of first orifices at a periphery, and a first partition having a first through-hole in which the inner pipe is fitted, the first partition separating an inside of the outer pipe into a main space and a first space.

[0009] The main space is a space with which the plurality of first orifices and the plurality of connection parts communicate. The first space communicates with none of the plurality of first orifices and the plurality of connection parts and is a space with which an opening provided at one end of the inner pipe communicates, the one end being a first end. Refrigerant supplied into the first space flows into an inside of the inner pipe, the plurality of first orifices, the main space, the plurality of connection parts, and then the plurality of heat transfer tubes.

[0010] An air-conditioning apparatus of another embodiment of the present invention includes the heat exchanger according to the above embodiment of the present invention.

Advantageous Effects of the Invention

[0011] In the heat exchanger according to the above embodiment of the present invention, a gas refrigerant component and a liquid refrigerant component of a two-phase gas-liquid refrigerant flowing in the first space are mixed together in the first space. The two-phase gas-liquid refrigerant with the gas refrigerant component and the liquid refrigerant component thereof thus mixed together is distributed to the plurality of heat transfer tubes after flowing through the inside of the inner pipe, the first orifices, the main space, and the connection parts of the outer pipe. Hence, in the heat exchanger according to the above embodiment of the present invention, the liquid refrigerant component of the two-phase gas-liquid refrigerant is distributed more evenly to the heat transfer tubes

than in the known art.

Brief Description of the Drawings

[0012]

FIG. 1 is a refrigerant circuit diagram illustrating an air-conditioning apparatus according to Embodiment 1.

FIG. 2 is a schematic side view of a heat exchanger according to Embodiment 1, with a part thereof illustrated in sectional view.

FIG. 3 is a sectional view of a part, including a refrigerant distributor, of the heat exchanger according to Embodiment 1, taken along line A-A given in FIG. 2.

FIG. 4 is a schematic side view of a heat exchanger according to Embodiment 2, with a part thereof illustrated in sectional view.

FIG. 5 is a sectional view of a refrigerant distributor according to Comparative Example.

FIG. 6 is a sectional view of a refrigerant distributor according to Embodiment 2.

FIG. 7 is a sectional view of another exemplary refrigerant distributor according to Embodiment 2.

FIG. 8 is a schematic side view of a heat exchanger according to Embodiment 3, with a part thereof illustrated in sectional view.

FIG. 9 is a sectional view of a refrigerant distributor of the heat exchanger according to Embodiment 3, illustrating a part around a second space.

FIG. 10 is a sectional view of a part, including an exemplary refrigerant distributor, of the heat exchanger according to Embodiment 3.

FIG. 11 is a sectional view of a part, including an exemplary refrigerant distributor, of the heat exchanger according to Embodiment 3.

FIG. 12 is a schematic side view of a heat exchanger according to Embodiment 4, with a part thereof illustrated in sectional view.

FIG. 13 is a schematic side view of another exemplary heat exchanger according to Embodiment 4, with a part thereof illustrated in sectional view.

FIG. 14 is a schematic side view of a heat exchanger according to Embodiment 5, with a part thereof illustrated in sectional view.

FIG. 15 is a schematic side view of a heat exchanger according to Embodiment 6, with a part thereof illustrated in sectional view.

Description of Embodiments

[0013] Embodiments exemplifying the heat exchanger according to the present invention will now be described with reference to the drawings. In Embodiment 1, an example of the air-conditioning apparatus according to the present invention will be described with reference to relevant drawings. In the drawings to be referred to

below, like elements are denoted by like reference signs. Redundant description of the embodiments is omitted, if not necessary. The heat exchanger and the air-conditioning apparatus according to the present invention may include any combination of combinable features to be described in the following embodiments.

Embodiment 1

10 [Air-Conditioning Apparatus 100]

[0014] FIG. 1 is a refrigerant circuit diagram illustrating an air-conditioning apparatus according to Embodiment 1.

15 **[0015]** The air-conditioning apparatus, 100, according to Embodiment 1 includes a heat exchanger 1 according to Embodiment 1. In the air-conditioning apparatus 100 exemplified in FIG. 1, the heat exchanger 1 is employed as an outdoor heat exchanger. Specifically, the air-conditioning apparatus 100 includes a compressor 101; an indoor heat exchanger 105, which serves as a condenser in a heating operation; an expansion valve 104, which is configured to expand refrigerant discharged from the condenser; and the heat exchanger 1, which is employed as an outdoor heat exchanger that serves as an evaporator in the heating operation.

25 **[0016]** The compressor 101, the indoor heat exchanger 105, the expansion valve 104, and the heat exchanger 1 employed as an outdoor heat exchanger are connected to one another by refrigerant pipes, whereby a refrigerant circuit is formed for refrigerant to circulate therethrough. Hereinafter, one of the refrigerant pipes that connects between the compressor 101 and the heat exchanger 1 is denoted as a refrigerant pipe 122, and another one of the refrigerant pipes that connects between the expansion valve 104 and the heat exchanger 1 is denoted as a refrigerant pipe 121.

35 **[0017]** The refrigerant circuit of the air-conditioning apparatus 100 according to Embodiment 1 further includes an accumulator 107, which is configured to accumulate excess refrigerant and is provided on the suction side of the compressor 101. The air-conditioning apparatus 100 according to Embodiment 1 is also capable of performing a cooling operation.

45 **[0018]** Therefore, the air-conditioning apparatus 100 includes a four-way valve 102. The four-way valve 102 is configured to switch the heat exchangers to be connected to the discharge port of the compressor 101 and to switch the heat exchangers to be connected to the suction port of the compressor 101. In the cooling operation, the indoor heat exchanger 105 serves as an evaporator, whereas the heat exchanger 1 employed as an outdoor heat exchanger serves as a condenser.

55 **[0019]** The above elements forming the refrigerant circuit of the air-conditioning apparatus 100 are each included in either an outdoor unit 111 or an indoor unit 112. Specifically, the compressor 101, the four-way valve 102, the heat exchanger 1 employed as an outdoor heat

exchanger, and the accumulator 107 are included in the outdoor unit 111. The indoor heat exchanger 105 and the expansion valve 104 are included in the indoor unit 112. The outdoor unit 111 further includes a fan 103, which is configured to supply outdoor air to the heat exchanger 1 employed as an outdoor heat exchanger.

[0020] The indoor unit 112 further includes a fan 106, which is configured to supply indoor air to the indoor heat exchanger 105. The air-conditioning apparatus 100 includes at least one indoor unit 112. The air-conditioning apparatus 100 exemplified in FIG. 1 includes three indoor units 112. If the air-conditioning apparatus 100 includes a plurality of indoor units 112, the indoor units 112 are, for example, connected in parallel with each other to the outdoor unit 111.

[0021] In the heating operation of the air-conditioning apparatus 100, refrigerant circulates as represented by broken-line arrows in FIG. 1. Specifically, to start the heating operation in the air-conditioning apparatus 100, the four-way valve 102 is switched to establish a passageway represented by broken lines in FIG. 1. Accordingly, the discharge port of the compressor 101 is connected to the indoor heat exchanger 105, and the suction port of the compressor 101 is connected to the heat exchanger 1 employed as an outdoor heat exchanger.

[0022] That is, the indoor heat exchanger 105 serves as a condenser, whereas the heat exchanger 1 employed as an outdoor heat exchanger serves as an evaporator. In this state, a gas refrigerant compressed by the compressor 101 to have a high temperature and a high pressure is discharged from the compressor 101 and flows into the indoor heat exchanger 105. The high-temperature high-pressure gas refrigerant flowing in the indoor heat exchanger 105 condenses while rejecting heat to the indoor air supplied from the fan 106, thereby turning into a high-pressure liquid refrigerant, which is discharged from the indoor heat exchanger 105. In this process, the indoor air is heated.

[0023] The high-pressure liquid refrigerant discharged from the indoor heat exchanger 105 flows into the expansion valve 104. The high-pressure liquid refrigerant flowing in the expansion valve 104 is expanded by the expansion valve 104, thereby turning into a low-temperature low-pressure two-phase gas-liquid refrigerant, which is discharged from the expansion valve 104. The low-temperature low-pressure two-phase gas-liquid refrigerant discharged from the expansion valve 104 flows through the refrigerant pipe 121 into the heat exchanger 1 employed as an outdoor heat exchanger.

[0024] The low-temperature low-pressure two-phase gas-liquid refrigerant flowing in the heat exchanger 1 employed as an outdoor heat exchanger evaporates by receiving heat from the outdoor air supplied from the fan 103, thereby turning into a low-pressure gas refrigerant, which is discharged from the heat exchanger 1 employed as an outdoor heat exchanger. The low-pressure gas refrigerant discharged from the heat ex-

changer 1 employed as an outdoor heat exchanger flows through the refrigerant pipe 122 and is suctioned into the compressor 101. The low-pressure gas refrigerant suctioned into the compressor 101 is compressed by the compressor 101, thereby turning into a high-temperature high-pressure gas refrigerant. The high-temperature high-pressure gas refrigerant is discharged from the compressor 101 again.

[0025] In the cooling operation of the air-conditioning apparatus 100, refrigerant circulates as represented by solid-line arrows in FIG. 1. Specifically, to start the cooling operation in the air-conditioning apparatus 100, the four-way valve 102 is switched to establish a passageway represented by solid lines in FIG. 1. Accordingly, the discharge port of the compressor 101 is connected to the heat exchanger 1 employed as an outdoor heat exchanger, and the suction port of the compressor 101 is connected to the indoor heat exchanger 105. That is, the heat exchanger 1 employed as an outdoor heat exchanger serves as a condenser, whereas the indoor heat exchanger 105 serves as an evaporator.

[0026] In this state, a gas refrigerant compressed by the compressor 101 to have a high temperature and a high pressure is discharged from the compressor 101 and flows through the refrigerant pipe 122 into the heat exchanger 1 employed as an outdoor heat exchanger. The high-temperature high-pressure gas refrigerant flowing in the heat exchanger 1 employed as an outdoor heat exchanger condenses while rejecting heat to the outdoor air supplied from the fan 103, thereby turning into a high-pressure liquid refrigerant, which is discharged from the heat exchanger 1 employed as an outdoor heat exchanger.

[0027] The high-pressure liquid refrigerant discharged from the heat exchanger 1 employed as an outdoor heat exchanger flows through the refrigerant pipe 121 into the expansion valve 104. The high-pressure liquid refrigerant flowing in the expansion valve 104 is expanded by the expansion valve 104, thereby turning into a low-temperature low-pressure two-phase gas-liquid refrigerant, which is discharged from the expansion valve 104. The low-temperature low-pressure two-phase gas-liquid refrigerant discharged from the expansion valve 104 flows into the indoor heat exchanger 105.

[0028] The low-temperature low-pressure two-phase gas-liquid refrigerant flowing in the indoor heat exchanger 105 evaporates by receiving heat from the indoor air supplied from the fan 106, thereby turning into a low-pressure gas refrigerant, which is discharged from the indoor heat exchanger 105. In this process, the indoor air is cooled. The low-pressure gas refrigerant discharged from the indoor heat exchanger 105 is suctioned into the compressor 101. The low-pressure gas refrigerant suctioned into the compressor 101 is compressed by the compressor 101, thereby turning into a high-temperature high-pressure gas refrigerant. The high-temperature high-pressure gas refrigerant is discharged from the compressor 101 again.

[Heat Exchanger 1]

[0029] FIG. 2 is a schematic side view of the heat exchanger according to Embodiment 1, with a part thereof illustrated in sectional view. FIG. 3 is a sectional view of a part, including a refrigerant distributor, of the heat exchanger according to Embodiment 1, taken along line A-A given in FIG. 2. Arrows with black solid heads illustrated in FIGS. 2 and thereafter represent the flow direction of the refrigerant in the heat exchanger 1 when the heat exchanger 1 is used as an evaporator.

[0030] The heat exchanger 1 includes a refrigerant distributor 10, a plurality of heat transfer tubes 2, a plurality of fins 3, and a merging pipe 4. With the heat exchanger 1 installed in the air-conditioning apparatus 100, the refrigerant distributor 10 is laid out in, for example, the horizontal direction. The plurality of heat transfer tubes 2 are arranged side by side at intervals. One end of each of the heat transfer tubes 2 is connected to the refrigerant distributor 10.

[0031] In Embodiment 1, the lower ends of the heat transfer tubes 2 are connected to the refrigerant distributor 10. The plurality of fins 3 are each provided between corresponding adjacent two of the heat transfer tubes 2 and are connected to the heat transfer tubes 2. The merging pipe 4 receives the other end of each of the heat transfer tubes 2. In Embodiment 1, the upper ends of the heat transfer tubes 2 flows in the merging pipe 4.

[0032] When the heat exchanger 1 is used as an evaporator, the refrigerant flowing from the outside toward the heat exchanger 1 first flows into the refrigerant distributor 10. The refrigerant flowing in the refrigerant distributor 10 is distributed in portions to the heat transfer tubes 2, and the refrigerant portions flow into the respective heat transfer tubes 2. The refrigerant portions flowing in the heat transfer tubes 2 exchange heat with air through the heat transfer tubes 2 and the fins 3. The refrigerant portions are then discharged from the heat transfer tubes 2 and are collected together by the merging pipe 4. The collected refrigerant is discharged from the merging pipe 4 to the outside of the heat exchanger 1.

[0033] When the heat exchanger 1 is used as a condenser, the refrigerant flowing from the outside toward the heat exchanger 1 first flows into the merging pipe 4. The refrigerant flowing in the merging pipe 4 is distributed in portions to the heat transfer tubes 2, and the refrigerant portions flow into the respective heat transfer tubes 2. The refrigerant portions flowing in the heat transfer tubes 2 exchange heat with air through the heat transfer tubes 2 and the fins 3.

[0034] The refrigerant portions are then discharged from the heat transfer tubes 2 and are collected together by the refrigerant distributor 10. The collected refrigerant is discharged from the refrigerant distributor 10 to the outside of the heat exchanger 1. Therefore, the refrigerant pipe 121 is connected to the refrigerant distributor 10, and the refrigerant pipe 122 is connected to the merging pipe 4.

[Refrigerant Distributer 10]

[0035] When the heat exchanger 1 is used as an evaporator, as described above, the refrigerant flowing from the outside into the refrigerant distributor 10 is distributed to the heat transfer tubes 2. That is, the refrigerant distributor 10 distributes a two-phase gas-liquid refrigerant to the heat transfer tubes 2. To distribute the two-phase gas-liquid refrigerant to the heat transfer tubes 2 while reducing the probability of deterioration in the heat-exchange performance of the heat exchanger 1, it is important to evenly distribute the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2. In this respect, the heat exchanger 1 according to Embodiment 1 employs the refrigerant distributor 10 configured as illustrated in FIG. 2. Specifically, the refrigerant distributor 10 has a double-pipe structure and includes an outer pipe 20, an inner pipe 30, and a first partition 11.

[0036] The outer pipe 20 is a pipe member with the both ends thereof closed. The outer pipe 20 has a plurality of connection parts 21, which are arranged at intervals in the longitudinal direction of the outer pipe 20 and to each of which a corresponding one of the heat transfer tubes 2 is connected. That is, the plurality of heat transfer tubes 2 are arranged side by side at intervals in the longitudinal direction of the outer pipe 20.

[0037] Herein, the longitudinal direction of the outer pipe 20 refers to the direction in which the outer pipe 20 extends and is also regarded as the axial direction of the outer pipe 20. In FIG. 2, the left-right direction in the plane of the page matches with the longitudinal direction of the outer pipe 20. The outer pipe 20 may be bent at least in part thereof. The longitudinal direction of such an outer pipe 20 at any given point is regarded as the axial direction of the outer pipe 20 at that given point.

[0038] The inner pipe 30 is a pipe member with at least one end thereof open. The one end is referred to as a first end 31. In other words, the inner pipe 30 is a pipe member having an opening 31a at least at the first end 31 thereof. In Embodiment 1, the inner pipe 30 is a pipe member with the both ends thereof open. That is, the inner pipe 30 according to Embodiment 1 is open also at the other end, which is a second end 32 and is located opposite the first end 31.

[0039] In other words, the inner pipe 30 according to Embodiment 1 has an opening 32a at the second end 32 thereof. The inner pipe 30 is provided inside the outer pipe 20. With the inner pipe 30 placed inside the outer pipe 20, the opening 31a at the first end 31 communicates with the space inside the outer pipe 20. Furthermore, with the inner pipe 30 placed inside the outer pipe 20, the opening 32a at the second end 32 is closed by an end wall of the outer pipe 20. The inner pipe 30 has at the periphery thereof a plurality of first orifices 30a, which are also referred to as refrigerant discharge holes. The plurality of first orifices 30a are arranged at intervals in the axial direction of the inner pipe 30.

[0040] In the above-configured refrigerant distributor 10, the two-phase gas-liquid refrigerant flowing inside the inner pipe 30 is discharged through the plurality of first orifices 30a to a space provided between the outer peripheral surface of the inner pipe 30 and the inner peripheral surface of the outer pipe 20, which will be described in detail separately below. The two-phase gas-liquid refrigerant discharged to the space between the outer peripheral surface of the inner pipe 30 and the inner peripheral surface of the outer pipe 20 flows through the connection parts 21 of the outer pipe 20 into the heat transfer tubes 2.

[0041] In terms of distributing the two-phase gas-liquid refrigerant to the heat transfer tubes 2, the plurality of first orifices 30a may preferably be located as illustrated in FIG. 2, although the locations of the plurality of first orifices 30a are not limited. Specifically, the first orifices 30a may each preferably be located between corresponding adjacent two of the heat transfer tubes 2 in the axial direction of the inner pipe 30.

[0042] In the arrangement of the first orifices 30a that is illustrated in FIG. 2, the gas refrigerant component and the liquid refrigerant component of the two-phase gas-liquid refrigerant discharged into the space between the outer peripheral surface of the inner pipe 30 and the inner peripheral surface of the outer pipe 20 are mixed together in the space in a better way before flowing into the heat transfer tubes 2 than in an arrangement where the first orifices 30a are located vertically below the respective heat transfer tubes 2. That is, the arrangement of the first orifices 30a that is illustrated in FIG. 2 realizes more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2.

[0043] In the process of distributing the two-phase gas-liquid refrigerant to the heat transfer tubes 2 as described above, if the axis of the inner pipe 30 is inclined significantly relative to the axis of the outer pipe 20 because of, for example, any bend in the inner pipe 30, the effect of evenly distributing the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2 is reduced. In such a case, since the liquid refrigerant component of the two-phase gas-liquid refrigerant tends to flow unevenly inside the inner pipe 30, the flow of the liquid refrigerant component of the two-phase gas-liquid refrigerant in the space between the outer peripheral surface of the inner pipe 30 and the inner peripheral surface of the outer pipe 20 tends to become uneven.

[0044] Hence, in the refrigerant distributor 10 according to Embodiment 1, the inner pipe 30 is held at positions close to the both ends thereof, whereby the axis of the inner pipe 30 is prevented from incline significantly relative to the axis of the outer pipe 20. Such a configuration realizes more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2.

[0045] Specifically, the outer pipe 20 is provided thereinside with the first partition 11. The first partition 11 has a

first through-hole 11a. A portion of the inner pipe 30 that is close to the first end 31 is fitted in the first through-hole 11a of the first partition 11. Thus, the portion of the inner pipe 30 that is close to the first end 31 is held by the first partition 11. The second end 32 of the inner pipe 30 is held by the outer pipe 20 by, for example, being fixed to the end wall of the outer pipe 20.

[0046] As illustrated in FIG. 3, the first partition 11 closes the space provided between the outer peripheral surface of the inner pipe 30 and the inner peripheral surface of the outer pipe 20. Hence, as illustrated in FIG. 2, the inside of the outer pipe 20 is separated by the first partition 11 into a main space 40 and a first space 41. The main space 40 is a space with which the plurality of first orifices 30a and the plurality of connection parts 21 communicate. The first space 41 communicates with none of the plurality of first orifices 30a and the plurality of connection parts 21. The first space 41 is a space with which the opening 31a provided at the first end 31 of the inner pipe 30 communicates.

[0047] In the refrigerant distributor 10 according to Embodiment 1, the refrigerant flowing from the outside toward the refrigerant distributor 10 is temporarily supplied into the first space 41. Specifically, in the refrigerant distributor 10 according to Embodiment 1, the refrigerant supplied from the outside into the first space 41 flows into the plurality of heat transfer tubes 2 after flowing through the inside of the inner pipe 30, the plurality of first orifices 30a, the main space 40, and the plurality of connection parts 21.

[0048] The outer pipe 20 according to Embodiment 1 has a connection part 22, which communicates with the first space 41. The refrigerant pipe 121 is connected to the connection part 22. Therefore, when the heat exchanger 1 is used as an evaporator, the two-phase gas-liquid refrigerant is supplied into the first space 41 of the refrigerant distributor 10 through the refrigerant pipe 121. In such a configuration where the refrigerant pipe 121 is connected to the outer pipe 20, the way of connection of the refrigerant pipe 121 to the outer pipe 20 may preferably be as illustrated in FIG. 2.

[0049] Specifically, the refrigerant pipe 121 connected to the outer pipe 20 may preferably extend in the direction in which the heat transfer tubes 2 extend. Such a way of connection of the refrigerant pipe 121 to the outer pipe 20 reduces the length of the space occupied by the refrigerant pipe 121 in the direction in which the plurality of heat transfer tubes 2 are arranged side by side.

[0050] Hence, the above way of connection of the refrigerant pipe 121 to the outer pipe 20 allows an increased number of heat transfer tubes 2 to be arranged side by side in the space of the air-conditioning apparatus 100 that is provided for the installation of the heat exchanger 1 and the refrigerant pipe 121. Accordingly, the above way of connection of the refrigerant pipe 121 to the outer pipe 20 increases the installability of the heat transfer tubes 2 in the heat exchanger 1.

[0051] Some known heat exchangers include double-

pipe refrigerant distributors, aiming to realize even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes. Such a known double-pipe refrigerant distributor does not have the first space 41 inside the outer pipe thereof, allowing the refrigerant on the outside to flow directly into the inner pipe. Therefore, the heat exchanger including the known double-pipe refrigerant distributor may experience a deterioration of the heat-exchange performance thereof when the liquid refrigerant component of the two-phase gas-liquid refrigerant is unevenly distributed to the heat transfer tubes, depending on the condition of the two-phase gas-liquid refrigerant flowing inside the inner pipe. Such condition may occur where the distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant flows unevenly inside the inner pipe.

[0052] In contrast, in the heat exchanger 1 according to Embodiment 1, the gas refrigerant component and the liquid refrigerant component of the two-phase gas-liquid refrigerant flowing from the outside flows in the first space 41 of the refrigerant distributor 10 and are mixed together in the first space 41. The two-phase gas-liquid refrigerant with the gas refrigerant component and the liquid refrigerant component thereof thus mixed together is distributed to the plurality of heat transfer tubes 2 after flowing through the inside of the inner pipe 30, the first orifices 30a, the main space 40, and the connection parts 21 of the outer pipe 20.

[0053] Therefore, in the heat exchanger 1 according to Embodiment 1, the liquid refrigerant component of the two-phase gas-liquid refrigerant is prevented from flowing unevenly inside the inner pipe 30, realizing a stable flow of the two-phase gas-liquid refrigerant in the inner pipe 30. Hence, in the heat exchanger 1 according to Embodiment 1, the liquid refrigerant component of the two-phase gas-liquid refrigerant is distributed more evenly to the heat transfer tubes 2 than in the known art.

[0054] To summarize, the heat exchanger 1 according to Embodiment 1 includes the plurality of heat transfer tubes 2, the outer pipe 20, the inner pipe 30, and the first partition 11. The outer pipe 20 has the plurality of connection parts 21 that are arranged at intervals in the longitudinal direction and to each of which a corresponding one of the plurality of heat transfer tubes 2 is connected. The inner pipe 30 has the plurality of first orifices 30a at the periphery. The inner pipe 30 is provided inside the outer pipe 20. The first partition 11 has the first through-hole 11a in which the inner pipe 30 is fitted. The first partition 11 separates the inside of the outer pipe 20 into the main space 40 and the first space 41.

[0055] The main space 40 is a space with which the plurality of first orifices 30a and the plurality of connection parts 21 communicate. The first space 41 communicates with none of the plurality of first orifices 30a and the plurality of connection parts 21. The first space 41 is a space with which the opening 31a provided at the first end 31 of the inner pipe 30 communicates. In the refrigerant distributor 10 according to Embodiment 1, the refrigerant

supplied into the first space 41 flows into the plurality of heat transfer tubes 2 after flowing through the inside of the inner pipe 30, the plurality of first orifices 30a, the main space 40, and the plurality of connection parts 21.

[0056] In the heat exchanger 1 configured as above, the liquid refrigerant component of the two-phase gas-liquid refrigerant is prevented from flowing unevenly inside the inner pipe 30, realizing a stable flow of the two-phase gas-liquid refrigerant in the inner pipe 30. Hence, in the heat exchanger 1 according to Embodiment 1, the liquid refrigerant component of the two-phase gas-liquid refrigerant is distributed more evenly to the heat transfer tubes 2 than in the known art.

[0057] While the heat exchanger 1 according to Embodiment 1 is employed as an outdoor heat exchanger of the air-conditioning apparatus 100, the heat exchanger 1 is not limited thereto. The heat exchanger 1 may alternatively be employed as the indoor heat exchanger 105 of the air-conditioning apparatus 100. Moreover, for example, the heat exchanger 1 may be applied to both the outdoor heat exchanger and the indoor heat exchanger 105 of the air-conditioning apparatus 100.

Embodiment 2

[0058] As to be described in Embodiment 2, if a second space 42 is further provided inside the outer pipe 20 of the refrigerant distributor 10, the liquid refrigerant component of the two-phase gas-liquid refrigerant is distributed further more evenly to the heat transfer tubes 2. Features that are not described in Embodiment 2 are the same as those described in Embodiment 1.

[0059] FIG. 4 is a schematic side view of a heat exchanger according to Embodiment 2, with a part thereof illustrated in sectional view.

[0060] In addition to the elements employed in Embodiment 1, the heat exchanger 1 according to Embodiment 2 includes a second partition 12, which is provided in the refrigerant distributor 10. The second partition 12 is provided inside the outer pipe 20. The second partition 12 has a second through-hole 12a. A portion of the inner pipe 30 that is close to the second end 32 is fitted in the second through-hole 12a of the second partition 12. Thus, the portion of the inner pipe 30 that is close to the second end 32 is held by the second partition 12.

[0061] The second partition 12 closes the space provided between the outer peripheral surface of the inner pipe 30 and the inner peripheral surface of the outer pipe 20. Hence, the inside of the outer pipe 20 is separated by the second partition 12 into the main space 40 and the second space 42. As described above in Embodiment 1, the main space 40 is a space with which the plurality of first orifices 30a and the plurality of connection parts 21 communicate. The second space 42 communicates with none of the plurality of first orifices 30a and the plurality of connection parts 21. The second space 42 is a space with which the opening 32a provided at the second end 32 of the inner pipe 30 communicates.

[0062] The second space 42 has a larger area than the space inside the inner pipe 30 in a section taken perpendicularly to the axis of the inner pipe 30. In the refrigerant distributor 10 having the second space 42, the two-phase gas-liquid refrigerant flowing inside the inner pipe 30 flows into the second space 42 through the opening 32a provided at the second end 32 and strikes the end wall of the outer pipe 20. Thus, the liquid refrigerant component of the two-phase gas-liquid refrigerant is gathered in the second space 42.

[0063] Since the second space 42 is provided inside the outer pipe 20 of the refrigerant distributor 10, the liquid refrigerant component of the two-phase gas-liquid refrigerant is prevented from being distributed by a greater amount to those of the plurality of first orifices 30a that are located closer to the second end 32. That is, providing the second space 42 inside the outer pipe 20 of the refrigerant distributor 10 realizes further more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2.

[0064] The present inventors have elucidated the above mechanism of how the second space 42 provided inside the outer pipe 20 improves the refrigerant distribution, through an experiment of visualizing the flow behavior of the two-phase gas-liquid refrigerant in the refrigerant distributor 10. Now, the mechanism of improvement in the refrigerant distribution that has been demonstrated by the present inventors will be described with reference to FIGS. 5 and 6.

[0065] FIG. 5 is a sectional view of a refrigerant distributor according to Comparative Example. FIG. 6 is a sectional view of the refrigerant distributor according to Embodiment 2. In the following description of a refrigerant distributor 210 according to Comparative Example, elements that are the same as those of the refrigerant distributor 10 according to Embodiment 2 are denoted by same reference signs as used for the refrigerant distributor 10 according to Embodiment 2.

[0066] The refrigerant distributor 210 according to Comparative Example has no second space 42 inside the outer pipe 20. Therefore, in the refrigerant distributor 210 according to Comparative Example, the opening 32a provided at the second end 32 of the inner pipe 30 is closed by the end wall of the outer pipe 20. The other details of the refrigerant distributor 210 according to Comparative Example are the same as those of the refrigerant distributor 10 according to Embodiment 2.

[0067] If, for example, the two-phase gas-liquid refrigerant in the inner pipe 30 flows at a high speed and a large inertial force acts on the two-phase gas-liquid refrigerant flowing in the inner pipe 30, an excessive amount of liquid refrigerant component of the two-phase gas-liquid refrigerant may reach the second end 32 of the inner pipe 30. In the refrigerant distributor 210 according to Comparative Example that has no second space 42, if an excessive amount of liquid refrigerant component of the two-phase gas-liquid refrigerant flows toward the second end 32 of the inner pipe 30, the liquid refrigerant component of the

two-phase gas-liquid refrigerant flowing toward the second end 32 of the inner pipe 30 first strikes the end wall of the outer pipe 20 and is then discharged to the main space 40 through those first orifices 30a that are located close to the second end 32.

[0068] Therefore, in the refrigerant distributor 210 according to Comparative Example, if an excessive amount of liquid refrigerant component of the two-phase gas-liquid refrigerant reaches the second end 32 of the inner pipe 30, a greater amount of liquid refrigerant component of the two-phase gas-liquid refrigerant is distributed to those of the plurality of first orifices 30a that are located closer to the second end 32.

[0069] In contrast, in the refrigerant distributor 10 according to Embodiment 2 that has the second space 42, the liquid refrigerant component of the two-phase gas-liquid refrigerant flowing toward the second end 32 of the inner pipe 30 first flows into the second space 42 through the opening 32a provided at the second end 32 and then strikes the end wall of the outer pipe 20. The liquid refrigerant component of the two-phase gas-liquid refrigerant thus reached the second space 42 is gathered in the second space 42.

[0070] That is, the second space 42 serves as a stagnation space where the liquid refrigerant component of the two-phase gas-liquid refrigerant is to be gathered. The stagnation space may also be referred to as buffer tank. The two-phase gas-liquid refrigerant flowing in the inner pipe 30 is pulsating.

[0071] Therefore, with the elapse of a certain time, some of the liquid refrigerant component gathered in the second space 42 flows backward, toward upstream ones of the first orifices 30a of the inner pipe 30. Therefore, on the basis of time average, providing the second space 42 inside the outer pipe 20 of the refrigerant distributor 10 realizes further more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2.

[0072] If the first space 41 and the second space 42 are provided inside the outer pipe 20 as in Embodiment 2, the first space 41 and the second space 42 may preferably be sized as follows. Referring to FIG. 4, the length of the first space 41 in the longitudinal direction of the outer pipe 20 is defined as a length L1, and the length of the second space 42 in the longitudinal direction of the outer pipe 20 is defined as a length L2. Under such definitions of the length L1 and the length L2, the length L1 may preferably be greater than the length L2. What is important here is that the second space 42 is provided inside the outer pipe 20. Even if the length L2 is small, the above advantageous effects are produced.

[0073] Furthermore, making the length L2 small allows an increased number of heat transfer tubes 2 to be arranged side by side in the space of the air-conditioning apparatus 100 that is provided for the installation of the heat exchanger 1. That is, making the length L2 small increases the installability of the heat transfer tubes 2 in the heat exchanger 1. Therefore, the length L1 may

preferably be greater than the length L2.

[0074] If the first space 41 and the second space 42 are provided inside the outer pipe 20 as in Embodiment 2, the state of fitting of the first end 31 of the inner pipe 30 in the first partition 11 and the state of fitting of the second end 32 of the inner pipe 30 in the second partition 12 may be determined as follows, in correspondence with the advantageous effects desired.

[0075] For example, if the ease of assembly of the refrigerant distributor 10 is desired, as illustrated in FIG. 4, the first end 31 of the inner pipe 30 may preferably project into the first space 41, and the second end 32 of the inner pipe 30 may preferably project into the second space 42. Such a configuration prevents the inner pipe 30 from coming off the first partition 11 and the second partition 12 during the process of assembling the refrigerant distributor 10, and also prevents the axis of the inner pipe 30 from inclining significantly relative to the axis of the outer pipe 20 at the completion of assembling the refrigerant distributor 10.

[0076] In such a configuration, the length of projection of the first end 31 of the inner pipe 30 into the first space 41 and the length of projection of the second end 32 of the inner pipe 30 into the second space 42 may preferably be defined as follows, for example. Referring to FIG. 4, the length by which the inner pipe 30 projects into the first space 41 is defined as a projection length t1, and the length by which the inner pipe 30 projects into the second space 42 is defined as a projection length t2.

[0077] Under such definitions of the projection length t1 and the projection length t2, the projection length t1 may preferably be smaller than the projection length t2. Setting the projection length t1 smaller than the projection length t2 increases the size of the first space 41. The first space 41 is preferred to have a large capacity so that the liquid refrigerant component of the two-phase gas-liquid refrigerant can be distributed evenly to the heat transfer tubes 2.

[0078] If the projection length t1 is set smaller than the projection length t2, it is preferable that, in the process of assembling the refrigerant distributor 10, the inner pipe 30 be inserted into the outer pipe 20 from the end of the outer pipe 20 where the first space 41 is provided. Such a process facilitates the insertion of the inner pipe 30 into the second partition, which is one of the first partition 11 and the second partition 12 that is located on the far side in the assembling process. Hence, the assembly of the refrigerant distributor 10 is further facilitated.

[0079] If the liquid refrigerant component of the two-phase gas-liquid refrigerant is desired distributed further more evenly to the heat transfer tubes 2, the state of fitting of the first end 31 of the inner pipe 30 in the first partition 11 and the state of fitting of the second end 32 of the inner pipe 30 in the second partition 12 may be determined as illustrated in FIG. 7.

[0080] FIG. 7 is a sectional view of another exemplary refrigerant distributor according to Embodiment 2.

[0081] In the refrigerant distributor 10 illustrated in FIG.

7, the first end 31 of the inner pipe 30 is located in the first through-hole 11a of the first partition 11. In other words, the first end 31 of the inner pipe 30 does not project into the first space 41. Likewise, in the refrigerant distributor 10 illustrated in FIG. 7, the second end 32 of the inner pipe 30 is located in the second through-hole 12a of the second partition 12. In other words, the second end 32 of the inner pipe 30 does not project into the second space 42.

[0082] In such a refrigerant distributor 10, the first space 41 and the second space 42 are larger than in the case where the inner pipe 30 projects into the first space 41 and the second space 42. Accordingly, such a refrigerant distributor 10 realizes further more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2.

[0083] The way of holding the inner pipe 30 by the first partition 11 as illustrated in FIG. 7 may also be applied to the heat exchanger 1 according to Embodiment 1. In that case, the first space 41 becomes larger and the distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2 becomes further more even than in the case where the inner pipe 30 projects into the first space 41.

Embodiment 3

[0084] If the heat exchanger 1 includes the second partition 12, the second partition 12 may have a second orifice 12b as in Embodiment 3. Features that are not described in Embodiment 3 are the same as those described in Embodiment 1 or 2.

[0085] FIG. 8 is a schematic side view of a heat exchanger according to Embodiment 3, with a part thereof illustrated in sectional view. FIG. 9 is a sectional view of a refrigerant distributor of the heat exchanger according to Embodiment 3, illustrating a part around a second space.

[0086] As with the case of the heat exchanger 1 according to Embodiment 2, the heat exchanger 1 according to Embodiment 3 includes the second partition 12, and the second space 42 provided inside the outer pipe 20. The second partition 12 of the heat exchanger 1 according to Embodiment 3 has at least one second orifice 12b, which allows the main space 40 and the second space 42 to communicate with each other.

[0087] As described in Embodiment 2, since the second space 42 is provided inside the outer pipe 20, an excessive amount of liquid refrigerant component of the two-phase gas-liquid refrigerant reaching the second end 32 of the inner pipe 30 is gathered in the second space 42. Such a configuration realizes even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2. In the heat exchanger 1 according to Embodiment 2, the pulsation of the two-phase gas-liquid refrigerant flowing in the inner pipe 30 causes some of the liquid refrigerant component gathered in the second space 42 to flow backward into the inner pipe 30.

[0088] In the heat exchanger 1 according to Embodiment 3, some of the liquid refrigerant component gathered in the second space 42 is allowed to flow through the second orifice 12b into the main space 40. That is, in the configuration where the second space 42 is provided to realize even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2, the second orifice 12b provided in the second partition 12 further allows an increased amount of liquid refrigerant component distributed to the heat transfer tubes 2. Consequently, the second orifice 12b provided in the second partition 12 further mitigates deterioration in the heat-exchange performance of the heat exchanger 1.

[0089] As described above, the second partition 12 may have at least one second orifice 12b. That is, the second partition 12 may have a single second orifice 12b or a plurality of second orifices 12b. Any second orifices 12b to be provided in the second partition 12 may preferably be located as follows. Now, a preferable location of the second orifices 12b will be described with reference to FIGS. 10 and 11.

[0090] FIGS. 10 and 11 are each a sectional view of a part, including an exemplary refrigerant distributor, of the heat exchanger according to Embodiment 3. Specifically, FIGS. 10 and 11 each illustrate a section of the part, including the exemplary refrigerant distributor, of the heat exchanger according to Embodiment 3 that is taken perpendicularly to the longitudinal direction of the outer pipe 20. More specifically, FIGS. 10 and 11 each illustrate a section of the part, including the exemplary refrigerant distributor, of the heat exchanger according to Embodiment 3 that is taken along line B-B given in FIG. 8.

[0091] As illustrated in FIG. 10 or 11, in the section perpendicular to the longitudinal direction of the outer pipe 20, each second orifice 12b may preferably be at such a location as not to interfere with the first orifices 30a provided in the inner pipe 30. The location that does not interfere with the first orifices 30a in the section perpendicular to the longitudinal direction of the outer pipe 20 referred to any location that is off the extension of the axis, 30b, of each of the first orifices 30a.

[0092] Providing the second orifice 12b at such a location mitigates interference between the flow of the refrigerant from the second orifice 12b into the main space 40 and the flow of the refrigerant from the first orifices 30a into the main space 40. Consequently, the flow of the refrigerant in the main space 40 is stabilized, realizing more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2.

[0093] As the size of the second orifice 12b is increased, an increased portion of the liquid refrigerant component gathered in the second space 42 is allowed to flow into the main space 40 through the second orifice 12b. In this respect, the second orifice 12b may preferably be sized as follows, for example. The opening area of one of the plurality of first orifices 30a is defined as an

opening area S1, and the sum total of the opening areas of all of the second orifices 12b is defined as an opening area S2. Under such definitions of the opening area S1 and the opening area S2, the opening area S2 may preferably be larger than the opening area S1. That is, the sum total of the refrigerant flow rates at all of the second orifices 12b may preferably be greater than the refrigerant flow rate at each of the first orifices 30a.

10 Embodiment 4

[0094] The heat exchanger 1 may include an intermediate partition 13 as in Embodiment 4. Features that are not described in Embodiment 4 are the same as those described in any of Embodiments 1 to 3.

[0095] FIG. 12 is a schematic side view of a heat exchanger according to Embodiment 4, with a part thereof illustrated in sectional view.

[0096] The heat exchanger 1 according to Embodiment 4 includes at least one intermediate partition 13. The intermediate partition 13 is provided inside the outer pipe 20 and between the first partition 11 and the second partition 12. The intermediate partition 13 has an intermediate-partition through-hole 13a. A middle portion of the inner pipe 30 is fitted in the intermediate-partition through-hole 13a of the intermediate partition 13. That is, the intermediate partition 13 holds the middle portion of the inner pipe 30 and separates the main space 40 into a plurality of spaces. Such spaces are hereinafter referred to as main-space areas 40a.

[0097] Since the intermediate partition 13 is provided, the axis of the inner pipe 30, which may be long, is prevented from inclining significantly relative to the axis of the outer pipe 20 because of a bend in the inner pipe 30 or any other factor. Therefore, even if the inner pipe 30 is long, the liquid refrigerant component of the two-phase gas-liquid refrigerant is distributed evenly to the heat transfer tubes 2 with the aid of the intermediate partition 13.

[0098] FIG. 13 is a schematic side view of another exemplary heat exchanger according to Embodiment 4, with a part thereof illustrated in sectional view.

[0099] In the heat exchanger 1 according to Embodiment 4, as illustrated in FIG. 13, the intermediate partition 13 may have at least one intermediate-partition orifice 13b, or may have no intermediate-partition orifice 13b as illustrated in FIG. 12. The intermediate-partition orifice 13b is a through-hole that allows adjacent ones of the main-space areas 40a to communicate with each other.

[0100] The effects to be produced vary with whether the intermediate partition 13 has any intermediate-partition orifices 13b. For example, if the intermediate partition 13 has no intermediate-partition orifice 13b as illustrated in FIG. 12, an increased effect is produced in terms of fluid-resistance adjustment by the plurality of first orifices 30a provided in the inner pipe 30. Consequently, the liquid refrigerant component of the two-phase gas-liquid refrigerant is distributed more evenly to the heat transfer

tubes 2.

[0101] In another respect, as described for the air-conditioning apparatus 100 according to Embodiment 1, if the heat exchanger 1 is used as a condenser as well, the refrigerant distributor 10 serves as a merging pipe where refrigerant portions discharged from the heat transfer tubes 2 into the refrigerant distributor 10 are collected. In such a case, if the intermediate partition 13 has at least one intermediate-partition orifice 13b as illustrated in FIG. 13, the fluid resistance in the refrigerant distributor 10 is reduced.

Embodiment 5

[0102] Any heat exchanger 1 that includes the second partition 12 may be configured as in Embodiment 5. Features that are not described in Embodiment 5 are the same as those described in any of Embodiments 1 to 4.

[0103] FIG. 14 is a schematic side view of a heat exchanger according to Embodiment 5, with a part thereof illustrated in sectional view.

[0104] The heat exchanger 1 according to Embodiment 5 is configured such that not only the first space 41 but also the second space 42 is supplied with the two-phase gas-liquid refrigerant. Therefore, in the heat exchanger 1 according to Embodiment 5, a refrigerant portion supplied into the first space 41 and a refrigerant portion supplied into the second space 42 flow into the plurality of heat transfer tubes 2 after flowing through the inside of the inner pipe 30, the plurality of first orifices 30a, the main space 40, and the plurality of connection parts 21.

[0105] In Embodiment 5, the outer pipe 20 has a connection part 23, which communicates with the second space 42. The refrigerant pipe 121 is connected to the connection part 23. Therefore, when the heat exchanger 1 is used as an evaporator, a two-phase gas-liquid refrigerant is supplied through the refrigerant pipe 121 into the second space 42 of the refrigerant distributor 10.

[0106] In the refrigerant distributor 10 configured to receive the two-phase gas-liquid refrigerant through the both ends thereof as in Embodiment 5, the following advantageous effects are produced, compared with the refrigerant distributor 10 configured to receive the two-phase gas-liquid refrigerant through one end thereof. The unevenness in the flow of the liquid refrigerant component of the two-phase gas-liquid refrigerant that is caused by any inclination of the axis of the inner pipe 30 relative to the axis of the outer pipe 20 is reduced.

[0107] Consequently, the probability of deterioration in the heat-exchange performance of the heat exchanger 1 is reduced. The liquid refrigerant component of the two-phase gas-liquid refrigerant flowing with an inertial force is prevented from being distributed by a greater amount to those first orifices 30a that are located closer to the downstream end of the inner pipe 30 in the direction of the flow of the two-phase gas-liquid refrigerant.

[0108] Consequently, the probability of deterioration in the heat-exchange performance of the heat exchanger 1 is reduced. As described above, if the heat exchanger 1 is used as a condenser, the refrigerant distributor 10 serves as a merging pipe where refrigerant portions discharged from the heat transfer tubes 2 into the refrigerant distributor 10 are collected. In such a case, the fluid resistance in the refrigerant distributor 10 is significantly reduced.

[0109] The refrigerant distributor 10 according to Embodiment 5 has the second space 42. If the refrigerant distributor 10 is configured to receive the two-phase gas-liquid refrigerant through the both ends thereof, the configuration according to Embodiment 5 facilitates the connection of the refrigerant pipe 121 to each of the both ends of the refrigerant distributor 10.

Embodiment 6

[0110] The heat exchanger 1 may be a finless heat exchanger as in Embodiment 6. Features that are not described in Embodiment 6 are the same as those described in any of Embodiments 1 to 5.

[0111] FIG. 15 is a schematic side view of a heat exchanger according to Embodiment 6, with a part thereof illustrated in sectional view.

[0112] The heat exchanger 1 according to Embodiment 6 is a finless heat exchanger that includes no fins 3. Specifically, the heat exchanger 1 according to Embodiment 6 is obtained by removing the fins 3 from the heat exchanger 1 according to any of Embodiments 1 to 5. FIG. 15 illustrates an example obtained by removing the fins 3 from the heat exchanger 1 according to Embodiment 5.

[0113] What is important in a finless heat exchanger is the ease of dense installation of heat transfer tubes to increase the area of heat transfer. Therefore, the finless heat exchanger has a greater number of heat transfer tubes than the finned heat exchanger. In this respect, the refrigerant distributor 10 according to any of Embodiments 1 to 5 that realizes more even distribution of the liquid refrigerant component of the two-phase gas-liquid refrigerant to the heat transfer tubes 2 than in the known refrigerant distributor is preferable as the refrigerant distributor of the finless heat exchanger.

List of Reference Signs

[0114]

- 1: heat exchanger
- 2: heat transfer tube
- 3: fin
- 4: merging pipe
- 10: refrigerant distributor
- 11: first partition
- 11a: first through-hole
- 12: second partition

12a: second through-hole
 12b: second orifice
 13: intermediate partition
 13a: intermediate-partition through-hole
 13b: intermediate-partition orifice
 20: outer pipe
 21: connection part
 22: connection part
 23: connection part
 30: inner pipe
 30a: first orifice
 30b: axis
 31: first end
 31a: opening
 32: second end
 32a: opening
 40: main space
 40a: main-space area
 41: first space
 42: second space
 100: air-conditioning apparatus
 101: compressor
 102: four-way valve
 103: fan
 104: expansion valve
 105: indoor heat exchanger
 106: fan
 107: accumulator
 111: outdoor unit
 112: indoor unit
 121: refrigerant pipe
 122: refrigerant pipe
 210: refrigerant distributor (Comparative Example)

Claims

1. A heat exchanger comprising:

a plurality of heat transfer tubes;
 an outer pipe having a plurality of connection parts that are arranged at intervals in a longitudinal direction and to each of which a corresponding one of the plurality of heat transfer tubes is connected;
 an inner pipe provided inside the outer pipe and having a plurality of first orifices at a periphery;
 and
 a first partition having a first through-hole in which the inner pipe is fitted, the first partition separating an inside of the outer pipe into a main space and a first space,
 wherein the main space is a space with which the plurality of first orifices and the plurality of connection parts communicate,
 wherein the first space communicates with none of the plurality of first orifices and the plurality of connection parts and is a space with which an opening provided at one end of the inner pipe

communicates, the one end being a first end, and
 wherein refrigerant supplied into the first space flows into an inside of the inner pipe, the plurality of first orifices, the main space, the plurality of connection parts, and then the plurality of heat transfer tubes.

2. The heat exchanger of claim 1, further comprising:

a second partition having a second through-hole in which the inner pipe is fitted, the second partition separating the inside of the outer pipe into the main space and a second space,
 wherein the second space communicates with none of the plurality of first orifices and the plurality of connection parts and is a space with which an opening provided at an other end of the inner pipe communicates, the other end being a second end located opposite the first end.

3. The heat exchanger of claim 2, wherein, letting a length of the first space in the longitudinal direction be a length L1 and a length of the second space in the longitudinal direction be a length L2, the length L1 is greater than the length L2.

4. The heat exchanger of claim 2 or 3, further comprising: an intermediate partition provided between the first partition and the second partition and separating the main space into a plurality of main-space areas.

5. The heat exchanger of claim 4, wherein the intermediate partition has at least one intermediate-partition orifice that allows adjacent ones of the main-space areas to communicate with each other.

6. The heat exchanger of any one of claims 2 to 5, wherein the second partition has at least one second orifice that allows the main space and the second space to communicate with each other.

7. The heat exchanger of claim 6, wherein, letting

an opening area of one of the plurality of first orifices be an opening area S1 and a sum total of opening areas of all of the second orifices be an opening area S2, the opening area S2 is greater than the opening area S1.

8. The heat exchanger of any one of claims 2 to 5, wherein a refrigerant portion supplied into the first

space and a refrigerant portion supplied into the second space flow into an inside of the inner pipe, the plurality of first orifices, the main space, the plurality of connection parts, and then the plurality of heat transfer tubes.

5

9. The heat exchanger of any one of claims 2 to 8,

wherein the first end of the inner pipe projects into the first space, and
wherein the second end of the inner pipe projects into the second space.

10

10. The heat exchanger of claim 9,
wherein, letting

15

a length by which the inner pipe projects into the first space be a projection length t_1 and
a length by which the inner pipe projects into the second space be a projection length t_2 ,
the projection length t_1 is smaller than the projection length t_2 .

20

11. The heat exchanger of any one of claims 2 to 10,
wherein the second end of the inner pipe is located in the second through-hole of the second partition.

25

12. The heat exchanger of any one of claims 1 to 11,
wherein the first end of the inner pipe is located in the first through-hole of the first partition.

30

13. An air-conditioning apparatus comprising:
a heat exchanger of any one of claims 1 to 12.

35

40

45

50

55

FIG. 1

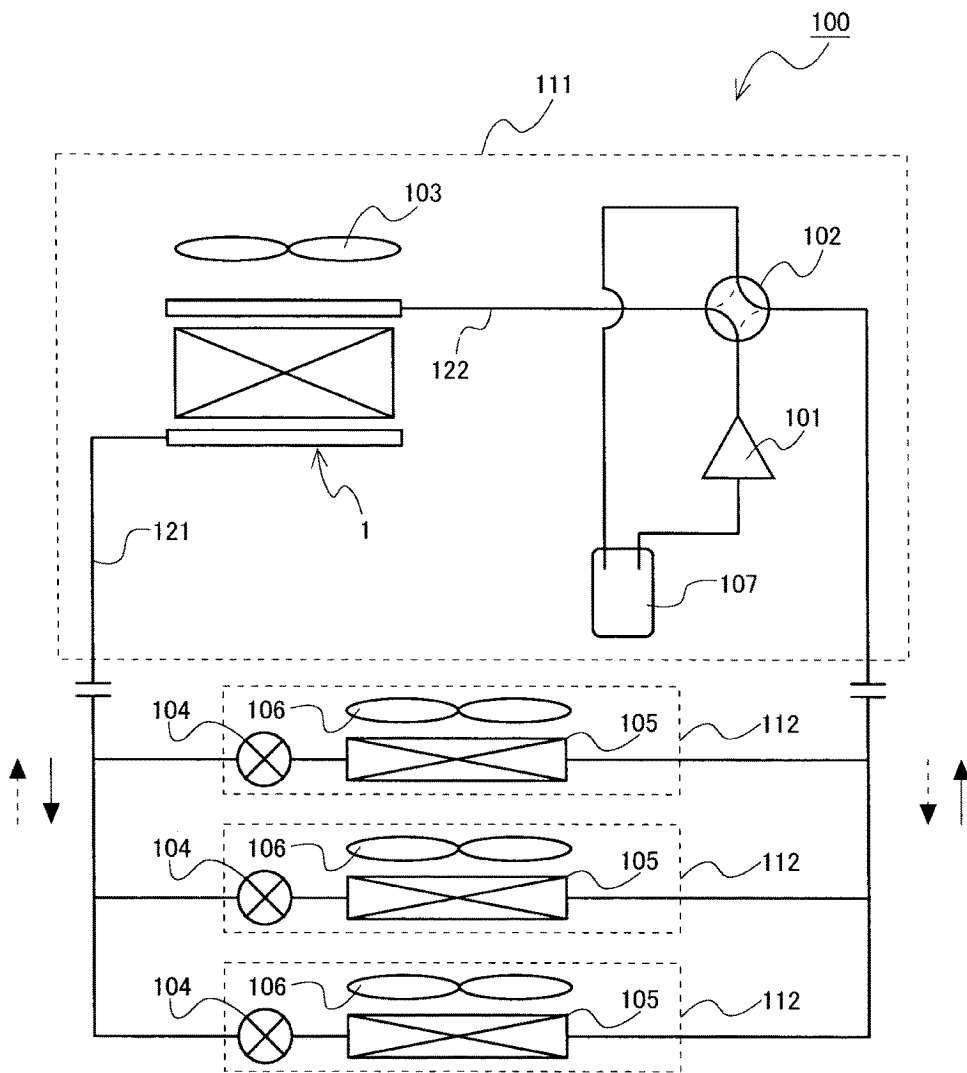


FIG. 2

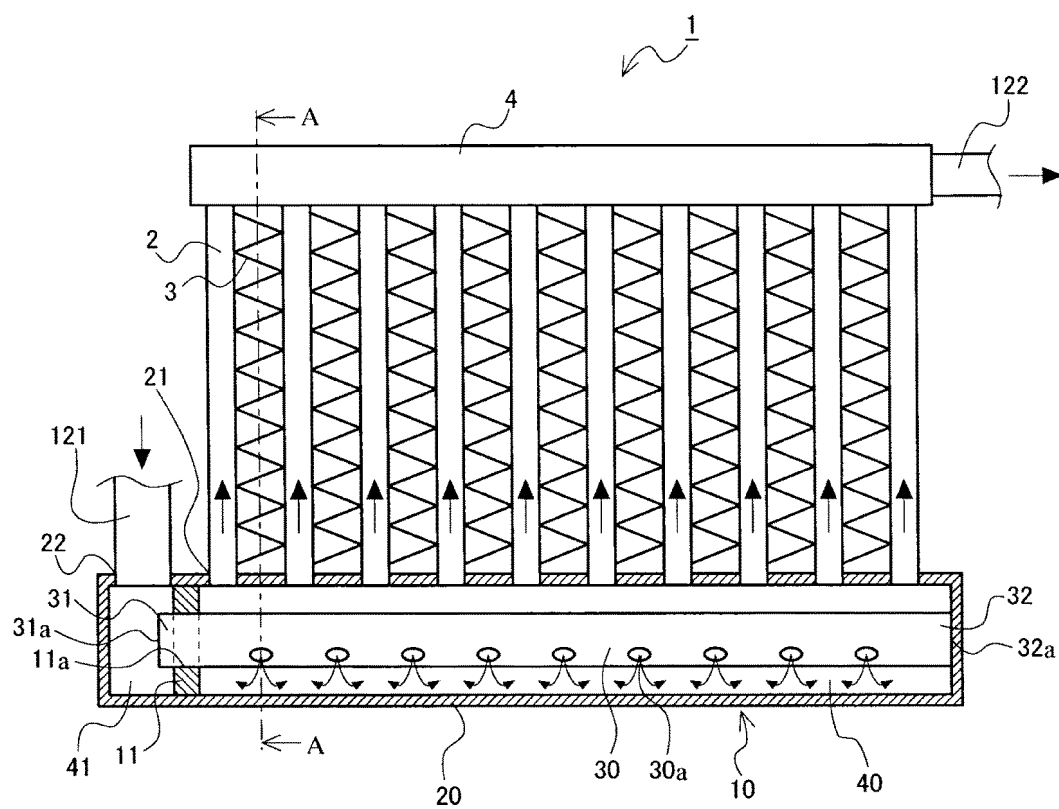


FIG. 3

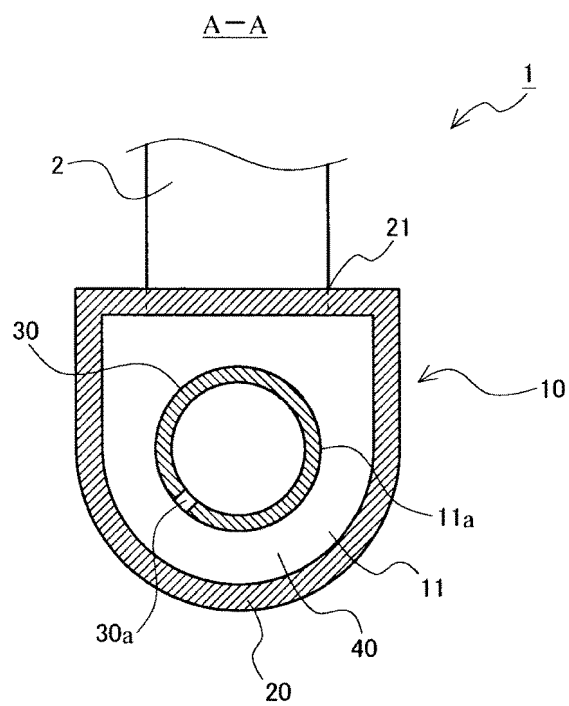


FIG. 4

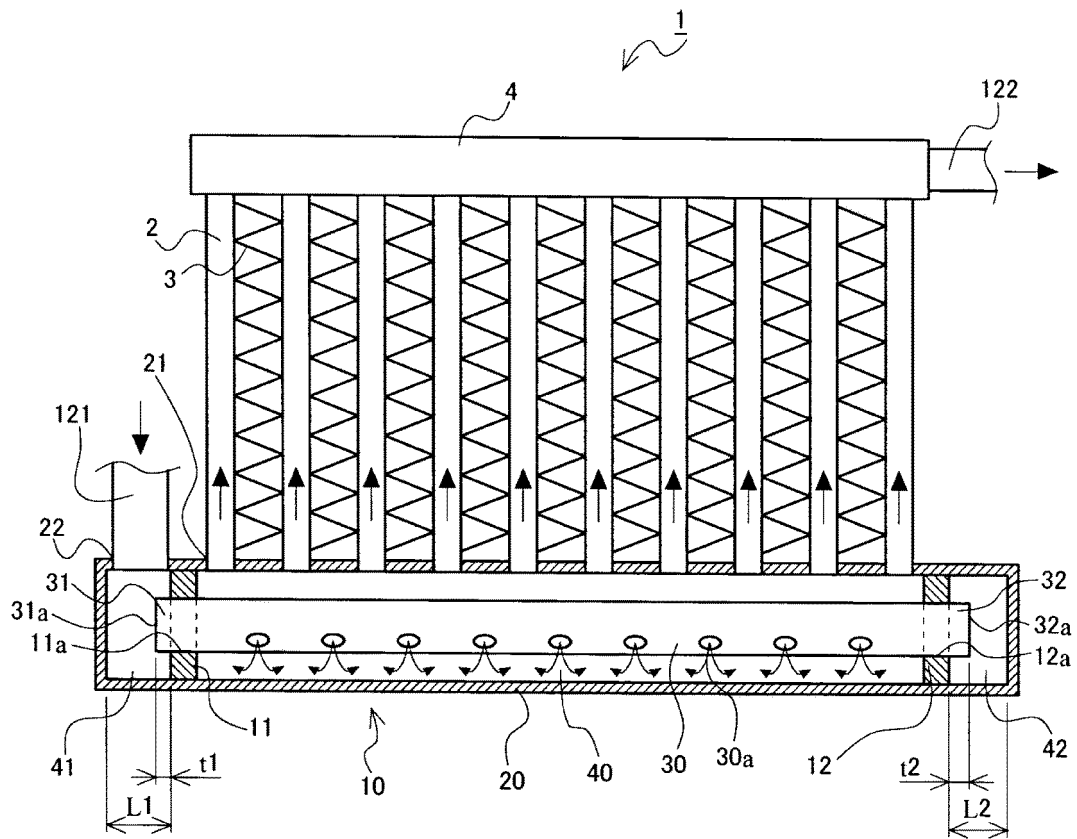


FIG. 5

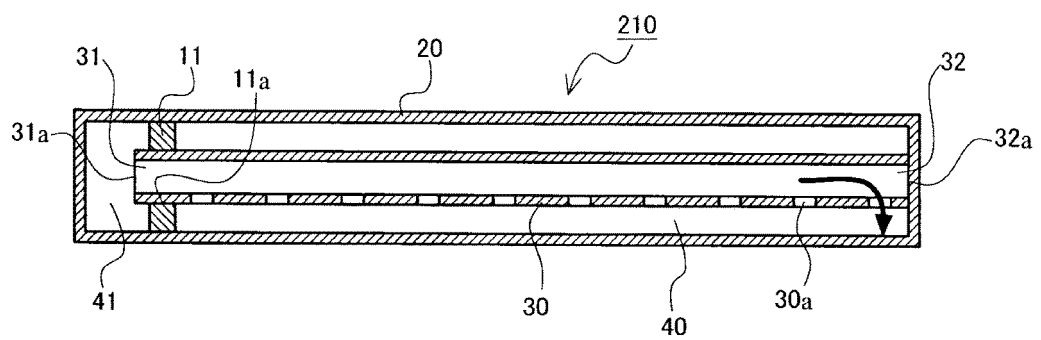


FIG. 6

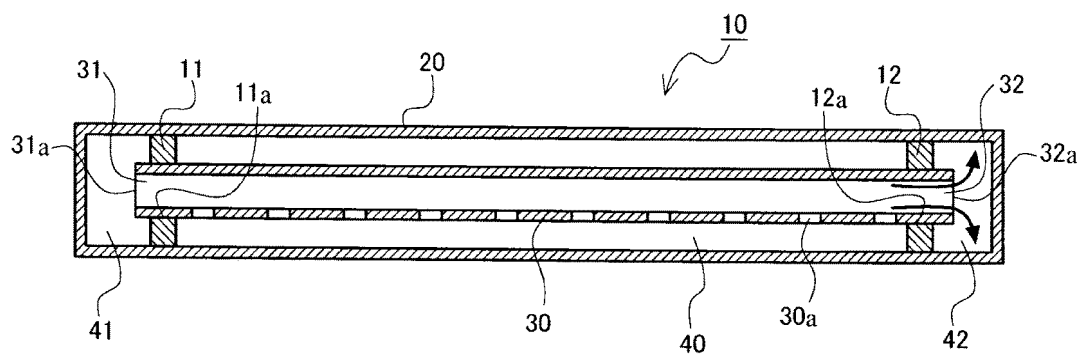


FIG. 7

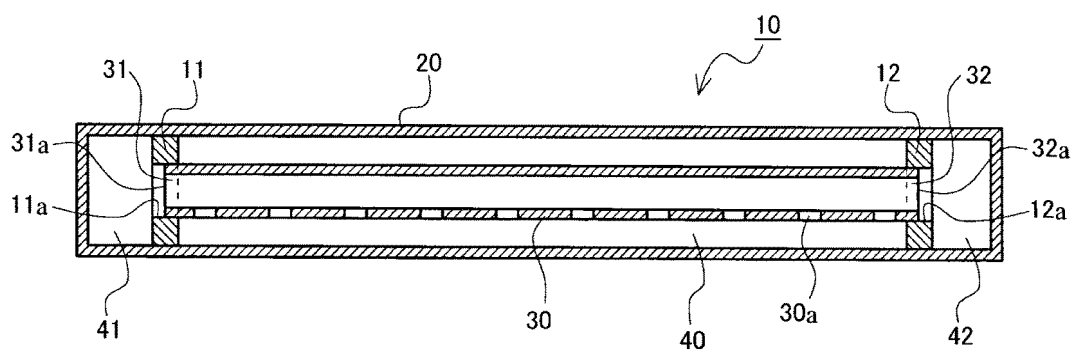


FIG. 8

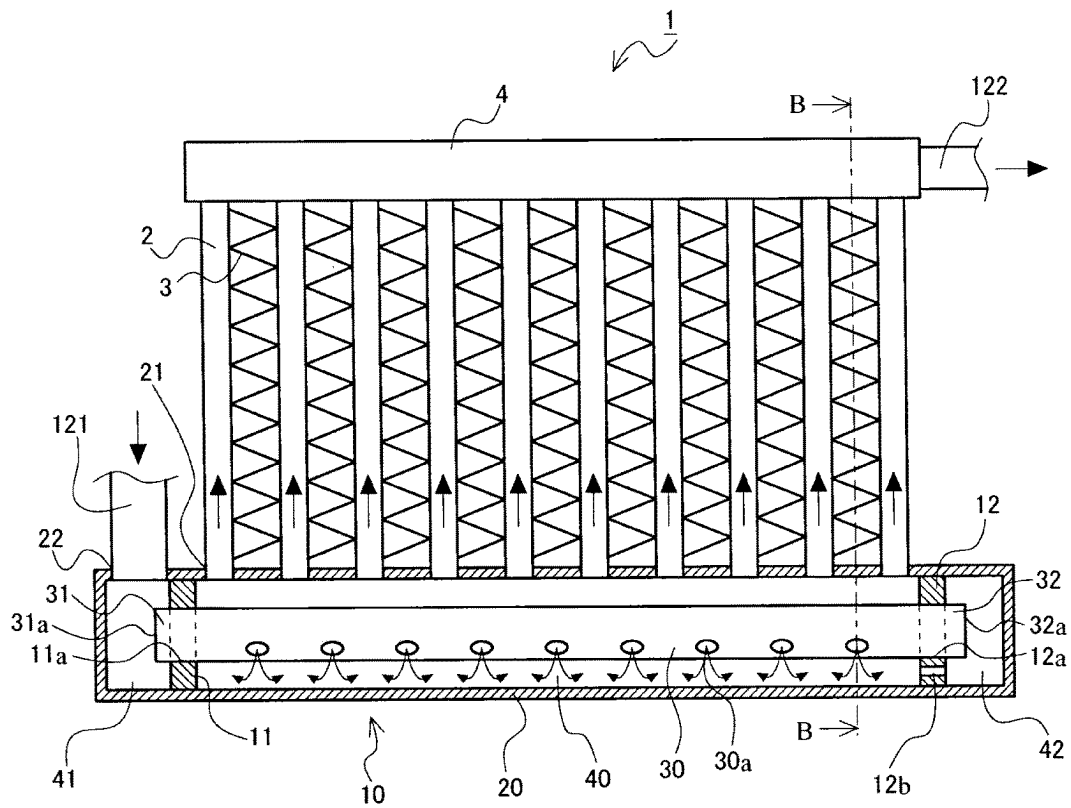


FIG. 9

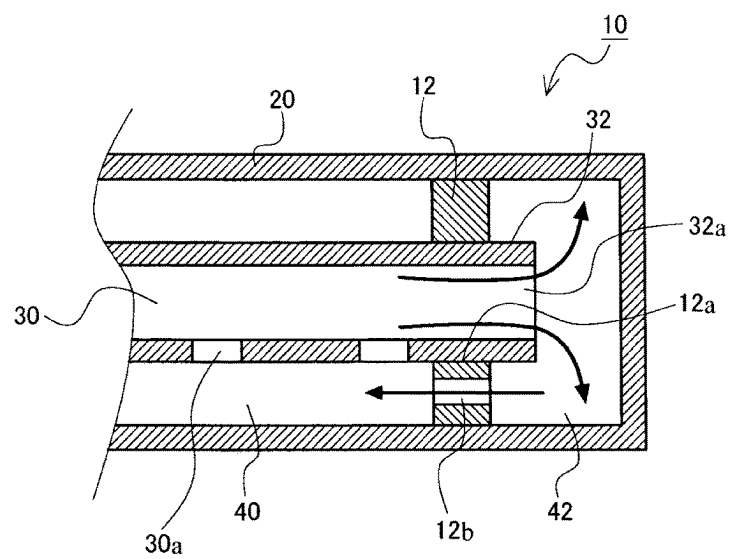


FIG. 10

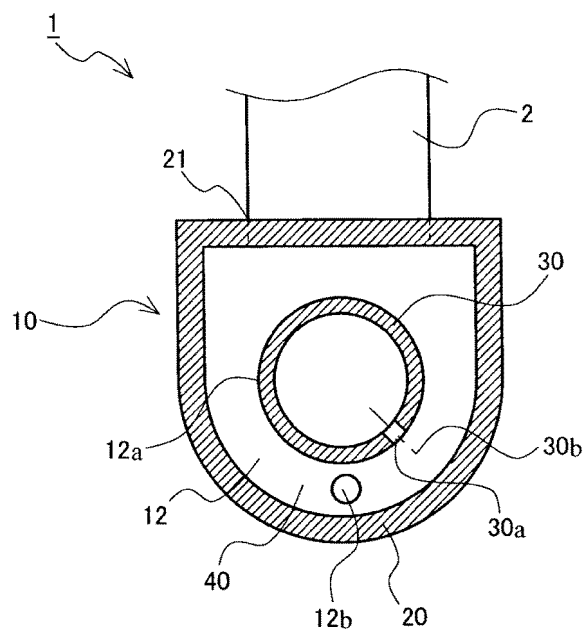


FIG. 11

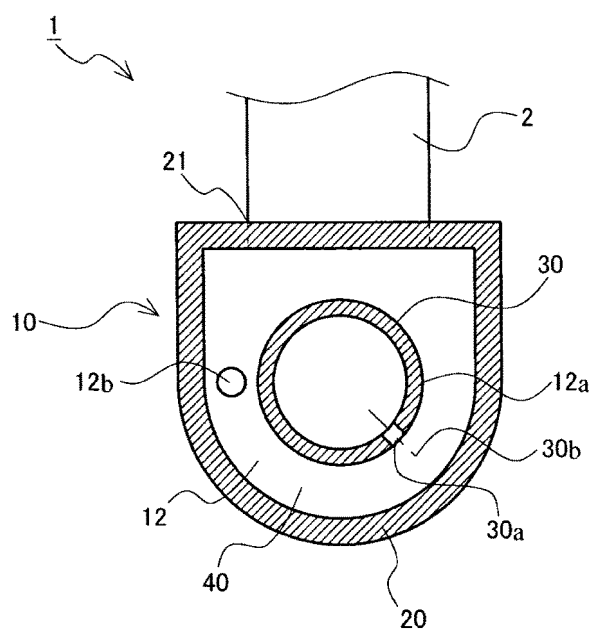


FIG. 12

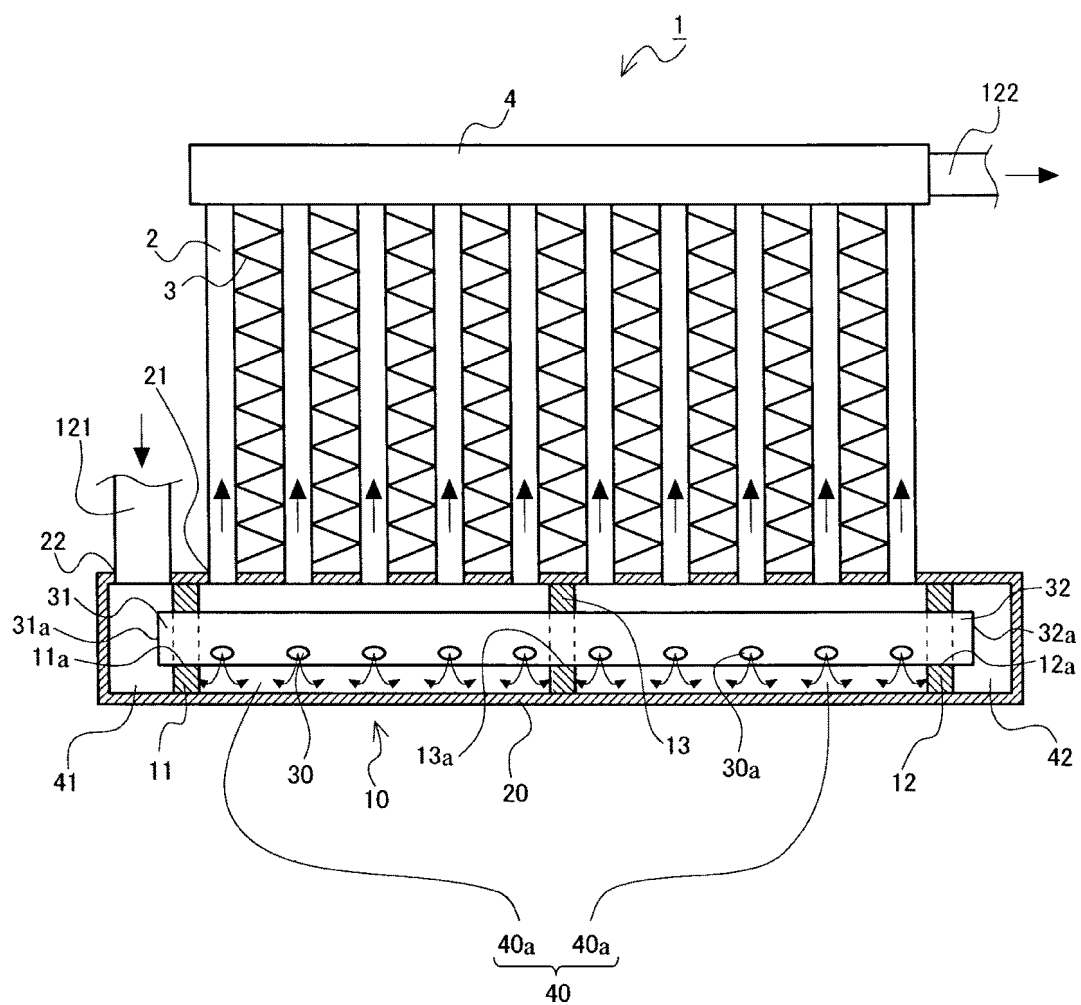


FIG. 13

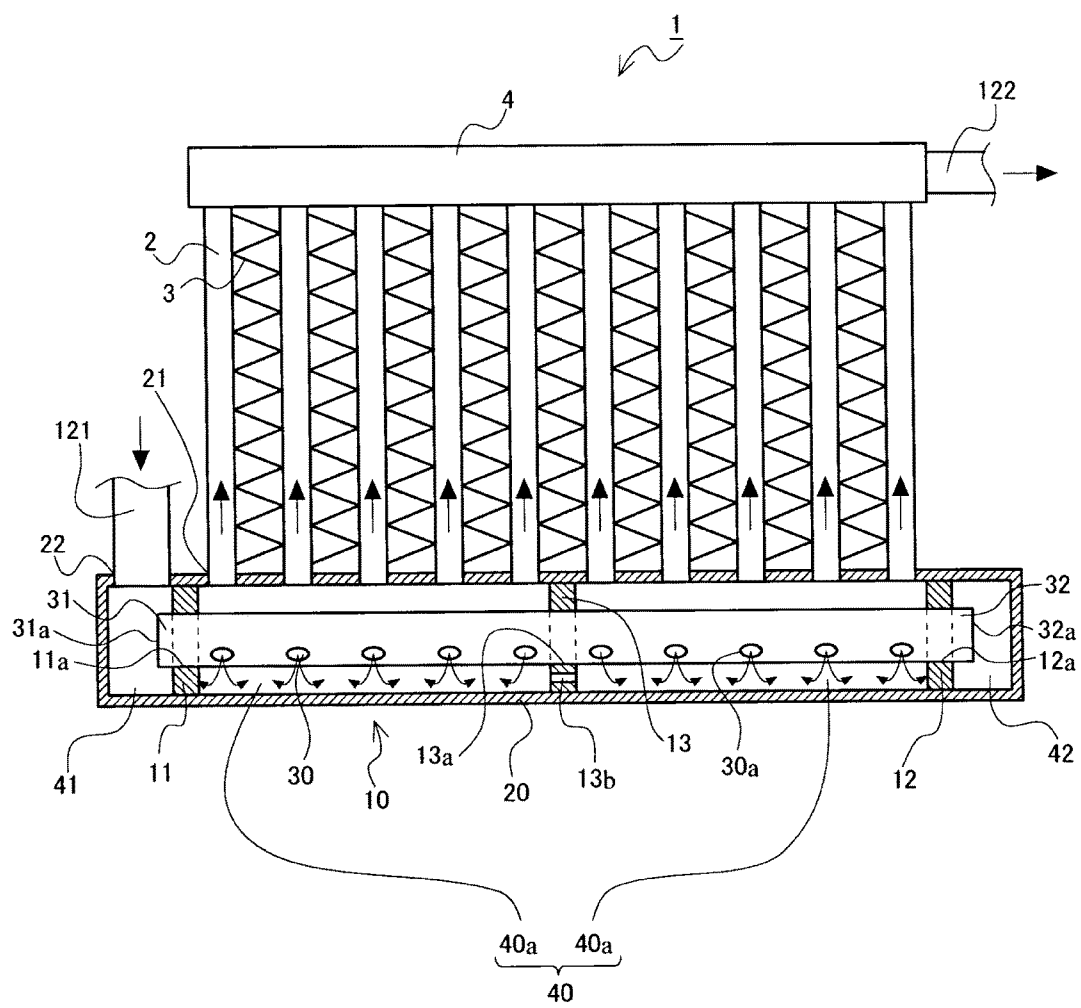


FIG. 14

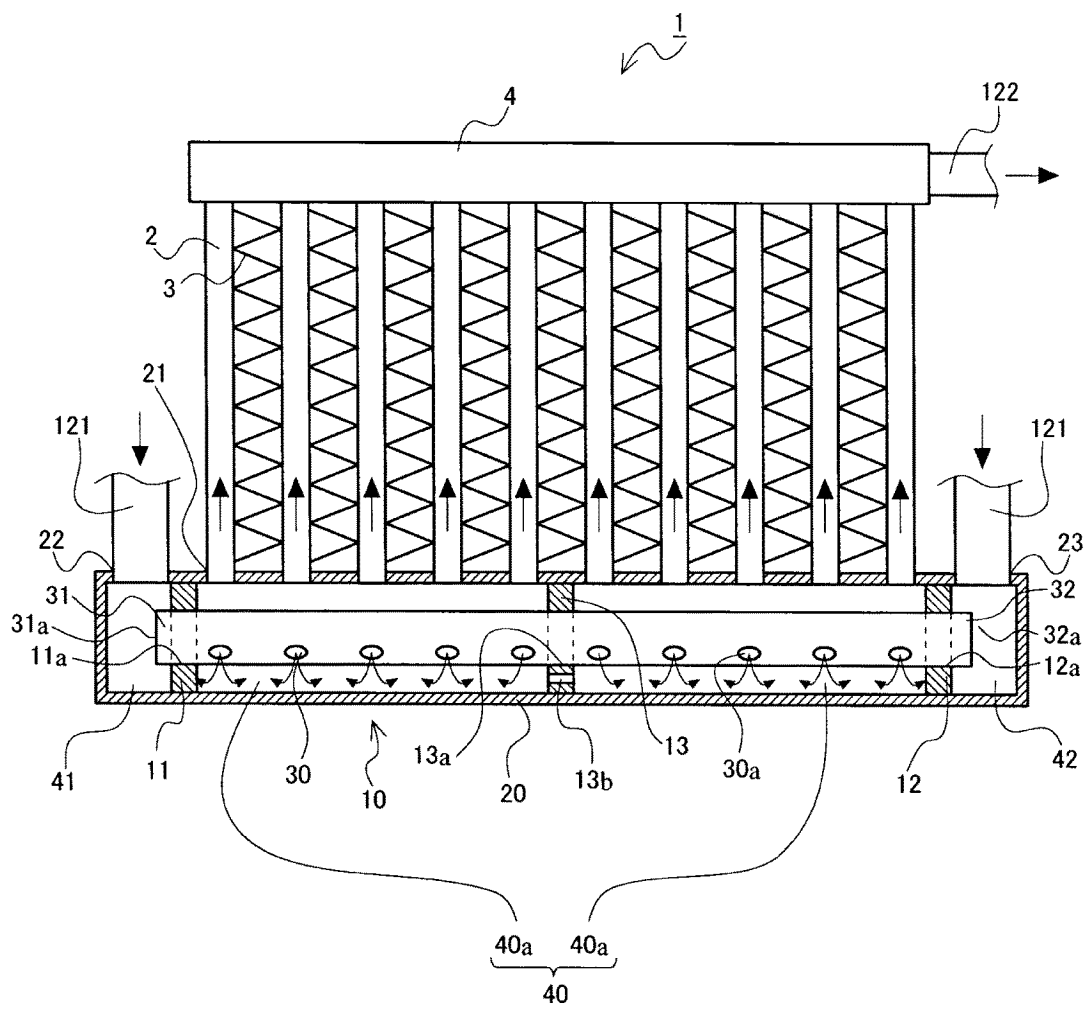
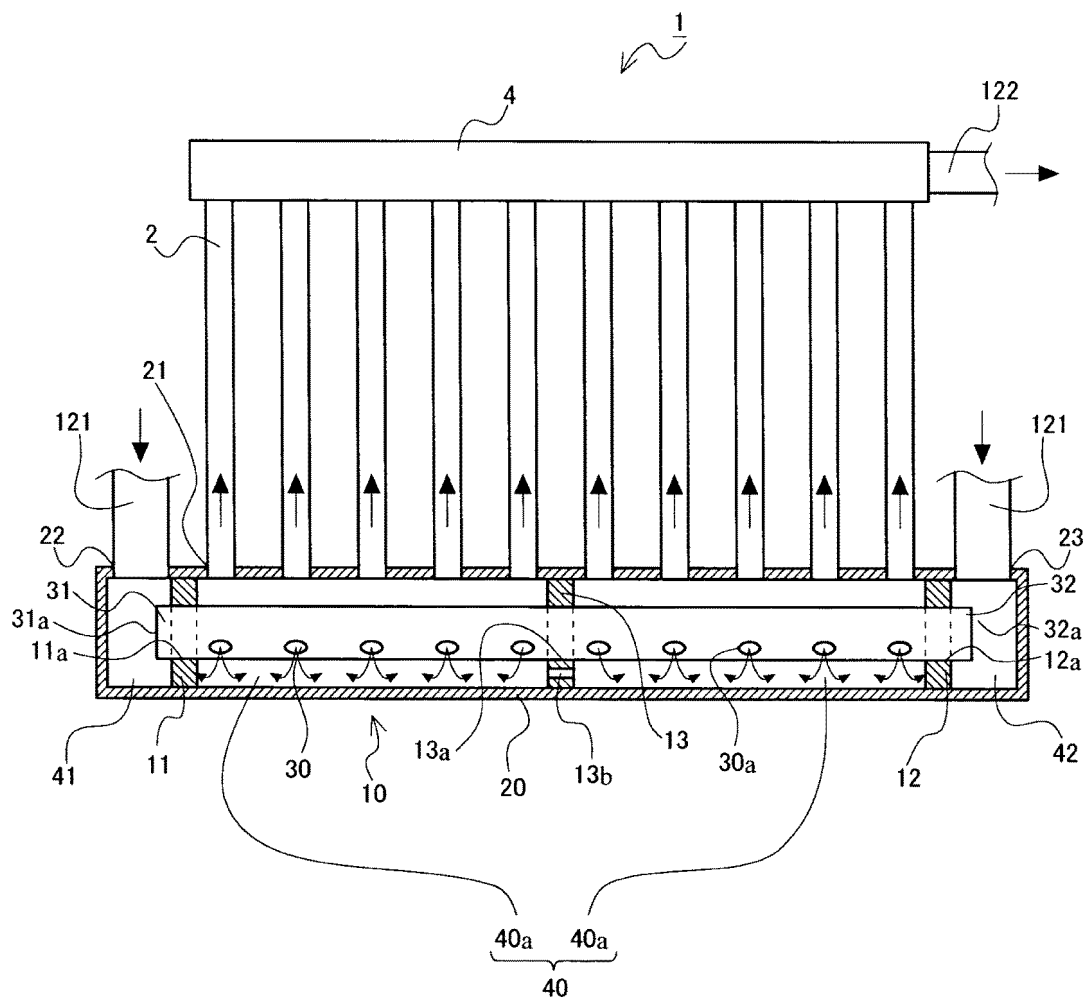


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/018298

A. CLASSIFICATION OF SUBJECT MATTER

F28D 1/053(2006.01)n; **F28F 9/02**(2006.01)i
 FI: F28F9/02 301D; F28D1/053 A

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)

F28D1/053; F28F9/02

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

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2022
 Registered utility model specifications of Japan 1996-2022
 Published registered utility model applications of Japan 1994-2022

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 2018-162901 A (HITACHI-JOHNSON CONTROLS AIR CONDITIONING, INC.) 18 October 2018 (2018-10-18) paragraphs [0030], [0032], [0034], [0073], [0074], fig. 20	1, 12-13
A		2-11
Y	JP 2014-533819 A (LG ELECTRONICS INC.) 15 December 2014 (2014-12-15) paragraphs [0080]-[0090], fig. 8, 9	1, 12-13
A		2-11
Y	JP 2014-37898 A (DAIKIN INDUSTRIES, LTD.) 27 February 2014 (2014-02-27) paragraphs [0062]-[0073], fig. 11	1, 12-13

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

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

“&” document member of the same patent family

Date of the actual completion of the international search

26 May 2022

Date of mailing of the international search report

07 June 2022

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/018298

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2018-162901 A	18 October 2018	WO 2018/173356 A1	
JP 2014-533819 A	15 December 2014	WO 2013/073842 A1 paragraphs [0093]-[0103], fig. 8, 9	
		EP 2597413 A1	
		KR 10-2013-0055244 A	
		CN 103123186 A	
JP 2014-37898 A	27 February 2014	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2012002475 A [0005]