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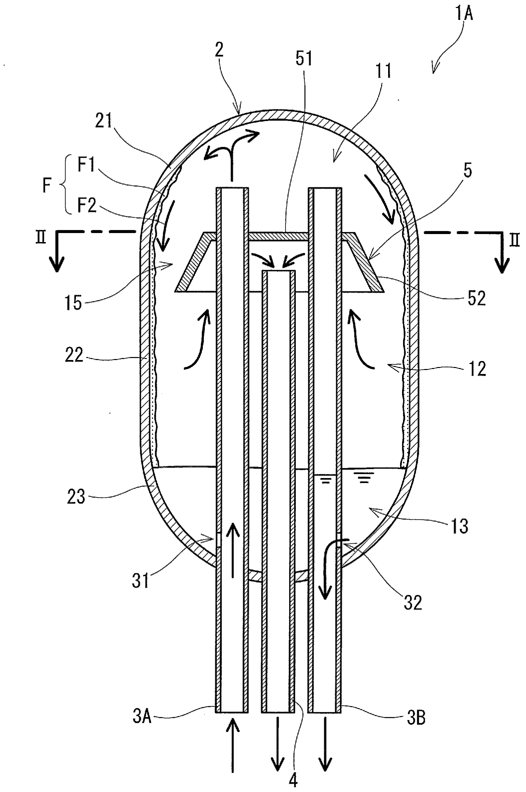
(54) **GAS LIQUID SEPARATOR AND FREEZE CYCLE DEVICE**

(57) A gas liquid separator (1A) includes: a sealed container (2) including an upper cover portion (21), a tubular portion (22), and a lower cover portion (23); and three pipes extending from the outside of the sealed container (2) to the inside thereof, that is, a first pipe (3A), a second pipe (3B), and a gas outlet pipe (4). A guide member (5) that forms an inflow space (11) between the guide member (5) and the upper cover portion (21) and forms a flow passage (15) for a two-layer flow F between the guide member (5) and the inner peripheral face of the tubular portion (22) is disposed in the sealed container (2). The first pipe (3A) and the second pipe (3B) are configured such that when one of the first pipe (3A) and the second pipe (3B) is used to introduce a gas-liquid two-phase fluid into the inflow space (11) from outside the sealed container (2), the other one is used to discharge a liquid in a liquid reservoir (13) from the sealed container (2) through a liquid outlet port (31 or 32) of the other one while forming a liquid surface at a level above the liquid outlet port (31 or 32).

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a gas liquid separator suitable for miniaturization and a refrigeration cycle apparatus using this gas liquid separator.

BACKGROUND ART

[0002] Gas liquid separators for separating a gas-liquid two-phase fluid into a liquid and a gas using centrifugal force created by a swirling flow are conventionally known. Such gas liquid separators must have a size large enough to create strong centrifugal force. On the other hand, gas liquid separators using surface tension have recently been proposed. Since these gas liquid separators using surface tension do not involve the formation of a swirling flow, their size can be reduced.

[0003] For example, Patent Literature 1 discloses a gas liquid separator 100 as shown in FIG. 15. In this gas liquid separator 100, an inlet pipe 151 for introducing a gas-liquid two-phase fluid into a sealed container 100 is connected to the top of a sealed container 110, and a liquid outlet pipe 152 for discharging a liquid separated in the sealed container 110 to the outside of the sealed container 110 is connected to the side portion of the sealed container 110. A gas outlet pipe 153 for discharging a gas separated in the sealed container 110 to the outside of the sealed container 110 extends through the bottom of the sealed container 110.

[0004] In the sealed container 110, a partition plate 120 that partitions the inside of the sealed container 110 into an inflow space 111 and an enlarged space 113 and forms an annular narrow space 112 between the spaces 111 and 113 along the inner peripheral face of the sealed container 110 is disposed. Thus, the gas-liquid two-phase fluid introduced into the inflow space 111 through the inlet pipe 151 is allowed to flow into the enlarged space 113 through the narrow space 112, and the cross-sectional area of the flow path increases rapidly from the narrow space 112 to the enlarged space 113.

[0005] Furthermore, a separation member 130 having a tubular shape along the inner peripheral face of the sealed container 110 is disposed beneath and in contact with the partition plate 120. This separation member 130 has a plurality of vertical grooves opening radially inwardly. The presence of these vertical grooves in a region where the cross-sectional area of the flow path rapidly increases allows the gas and the liquid to be separated using surface tension. More specifically, the liquid in the gas-liquid two-phase fluid flowing into the vertical grooves is retained in the grooves by surface tension, and only the gas flows out of the grooves. The liquid separated in the separation member 130 is collected in the lower part of the sealed container 110 and discharged outside through the liquid outlet pipe 152. On the other hand, the separated gas is collected in the center of the sealed container 100 and discharged outside through the gas outlet pipe 153.

CITATION LIST

Patent Literature

[0006] Patent Literature 1: WO 2007-055386 A1

SUMMARY OF INVENTION

Technical Problem

[0007] For example, in a refrigeration cycle apparatus used for air conditioning, the flow direction of a refrigerant flowing in a heat pump circuit in a heating operation is opposite to the flow direction thereof in a cooling operation. Therefore, there is a demand for a reversible-flow gas-liquid separator. However, in the gas-liquid separator 100 shown in FIG. 15, the fluid flows in only one direction. Therefore, it cannot be used in a section where the flow of the fluid is reversed.

[0008] Under these circumstances, it is an object of the present invention to provide a reversible-flow gas liquid separator suitable for miniaturization and a refrigeration cycle apparatus using this gas liquid separator.

Solution to Problem

[0009] The present invention provides a gas liquid separator including: a sealed container including an upper cover portion that disperses an upward-injected gas-liquid two-phase fluid and directs the dispersed gas-liquid two-phase fluid downward so that a liquid contained in the gas-liquid two-phase fluid is pressed against an inner face of the upper cover portion and the gas-liquid two-phase fluid is converted into a two-layer flow including a liquid layer and a gas-rich layer, a tubular portion that allows the liquid layer to flow down along an inner peripheral face of the tubular portion, and a lower cover portion that retains the liquid layer to form a liquid reservoir; a guide member that is disposed in the sealed container to form an inflow space between the guide member and the upper cover portion and to form a flow passage for the two-layer flow between the guide member and the inner peripheral face of the tubular portion, and that guides the gas-rich layer down along the inner peripheral face of the tubular potion; a first pipe that extends through the lower cover portion and through the guide member so that one end of the first pipe opens into the inflow space, and that is provided with a liquid outlet port in a portion submerged in the liquid reservoir; a second pipe that extends through the lower cover portion and through the guide member so that one end of the second pipe opens into the inflow space, and that is provided with a liquid outlet port in a portion submerged in the liquid reservoir; and a gas outlet pipe for discharging, to the outside of the sealed container, a gas resulting from removal of a liquid from the gas-rich layer by surface tension of the liquid layer. In this gas liquid separator, the first pipe and the second pipe are configured such that when one of the first pipe and the second pipe is used to introduce the gas-liquid two-phase fluid into the inflow space from outside the sealed container, the other one is used to discharge the liquid in the liquid reservoir to the outside of the sealed container through the liquid outlet port of the other one while forming a liquid surface at a level above the liquid outlet port.

[0010] The present invention also provides a refrigeration cycle apparatus including: a heat pump circuit including a compressor that compresses a refrigerant, an indoor heat exchanger that exchanges heat between indoor air and the refrigerant, a first expansion mechanism and a second expansion mechanism that expand the refrigerant, an outdoor heat exchanger that exchanges heat between outdoor air and the refrigerant, and the gas liquid separator described above, in which the first pipe is connected to the second expansion mechanism and the second pipe is connected to the first expansion mechanism; an injection pipe that connects the gas outlet pipe of the gas liquid separator and the compressor so that the refrigerant is injected into the compressor during compression of the refrigerant; and a switching means capable of switching a direction of the refrigerant flowing in the heat pump circuit to a first direction along which the refrigerant discharged from the compressor is directed to the indoor heat exchanger in a heating operation and to a second direction along which the refrigerant discharged from the compressor is directed to the outdoor heat exchanger in a cooling operation.

Advantageous Effects of Invention

[0011] In the above configuration, the direction of the gas-liquid two-phase fluid is completely reversed by the upper cover portion of the sealed container. Therefore, the gas-liquid two-phase fluid can be separated into a gas and a liquid to some extent by centrifugal force (inertial force) created by the reversal of the direction. In addition, since the two-layer flow thus formed flows down along the inner peripheral face of the tubular portion, the gas and the liquid can be separated almost completely by surface tension of the liquid layer. This configuration allows miniaturization of the gas-liquid separator.

[0012] In addition, in the above configuration, when the one of the first pipe and the second pipe serves as an inlet pipe of the gas-liquid two-phase fluid, the other one serves as an outlet pipe of the liquid. The functions of the first pipe and the second pipe are switched automatically according to the nature of the fluid only by selecting the pipe to which the gas-liquid two-phase fluid is to be supplied. Thus, with such a simple configuration suitable for miniaturization, a reversible-flow gas liquid separator can be obtained.

BRIEF DESCRIPTION OF DRAWINGS

[0013]

FIG. 1 is a longitudinal sectional view of a gas liquid separator according to a first embodiment of the present invention.
FIG. 2 is a transverse sectional view taken along the line II-II in FIG. 1.
FIG. 3A is an enlarged view showing a circular liquid outlet port.
FIG. 3B is an enlarged view showing an oval liquid outlet port.
FIG. 4 is a configuration diagram of a refrigeration cycle apparatus using the gas liquid separator shown in FIG. 1.
FIG. 5 is a longitudinal sectional view of a gas liquid separator according to a second embodiment of the present invention.
FIG. 6 is a transverse sectional view taken along the line VI-VI in FIG. 5.
FIG. 7 is a longitudinal sectional view of a gas liquid separator according to a third embodiment of the present invention.
FIG. 8 is a longitudinal sectional view of a gas liquid separator according to a fourth embodiment of the present invention.
FIG. 9 is a transverse sectional view taken along the line IX-IX in FIG. 8.

FIG. 10 is a longitudinal sectional view of a gas liquid separator according to a fifth embodiment of the present invention.
FIG. 11 is a transverse sectional view taken along the line XI-XI in FIG. 10.
FIG. 12 is a longitudinal sectional view of a gas liquid separator according to a sixth embodiment of the present invention.
FIG. 13A is a transverse sectional view taken along the line XIIIA-XIIIA in FIG. 12.
FIG. 13B is a transverse sectional view taken along the line XIIIB-XIIIB in FIG. 12.
FIG. 14 is a longitudinal sectional view of a gas liquid separator according to a seventh embodiment of the present invention.
FIG. 15 is a longitudinal sectional view of a conventional gas liquid separator.

DESCRIPTION OF EMBODIMENTS

[0014] Hereinafter, embodiments of the present invention will be described with reference to the drawings. The present invention is not limited to the following embodiments.

(First Embodiment)

[0015] FIG. 1 and FIG. 2 show a gas liquid separator 1A according to the first embodiment of the present invention. This gas liquid separator 1A includes a sealed container 2 extending in the vertical direction, and three pipes extending from the outside of the sealed container 2 to the inside thereof, that is, a first pipe 3A, a second pipe 3B, and a gas outlet pipe 4. In the present embodiment, the gas outlet pipe 4 is disposed along the central axis of the sealed container 2, and the first pipe 3A and the second pipe 3B are disposed on 180-degree opposite sides of the gas outlet pipe 4.

[0016] The sealed container 2 includes a hemispherical upper cover portion 21 opening downward, a tubular portion 22 having a tubular shape, and a hemispherical lower cover portion 23 opening upward. The upper cover portion 21 disperses an upward-injected gas-liquid two-phase fluid and directs the dispersed fluid downward so that a liquid contained in the gas-liquid two-phase fluid is pressed against the inner face of the upper cover portion 21 and the gas-liquid two-phase fluid is converted into a two-layer flow F including a liquid layer F1 and a gas-rich layer F2. The upward direction in which the gas-liquid two-phase fluid is injected does not necessarily have to be parallel to the vertical direction. It may be a direction slightly inclined from the vertical direction. The tubular portion 22 allows the liquid layer F1 to flow down along the inner peripheral face of the tubular portion 22. The lower cover portion 23 retains the liquid layer F1 to form a liquid reservoir 13.

[0017] The upper cover portion 21 and the lower cover portion 23 do not necessarily have to be hemispherical. For example, they may have a bucket-like shape having a disc-shaped main wall and a peripheral wall raised from the main wall. The heights of the upper cover portion 21 and the lower cover portion 23 are not particularly limited, and they may be arbitrarily determined.

[0018] In the sealed container 2, a guide member 5 is disposed at a position corresponding to the upper part of the tubular portion 22. The guide member 5 forms an inflow space 11 between the guide member 5 and the upper cover portion 21, and forms a flow passage 15 for the two-layer flow F between the guide member 5 and the inner peripheral face of the tubular portion 22. The guide member 5 guides the gas-rich layer F2 down along the inner peripheral face of the tubular portion 22. A separation space 12 is formed below the guide member 5. In other words, the guide member 5 partitions the inside of the sealed container 2 into the inflow space 11 and the separation space 12 such that these spaces 11 and 12 communicate with each other only through an annular narrow space formed therebetween along the inner peripheral face of the tubular portion 22.

[0019] The guide member 5 has an axisymmetric container-like shape opening downward and having a ceiling portion 51 and a side wall portion 52 hanging from the outer edge of the ceiling portion 51. One end of the gas outlet pipe 4 is located in a space surrounded by the guide member 5. The ceiling portion 51 has a disc shape and forms a flat top face of the guide member 5. The side wall portion 52 forms a tapered outer peripheral face of the guide member 5 having a diameter gradually increasing downward and facing the inner peripheral face of the tubular portion 22. The top face of the guide member 5 does not necessarily have to be flat. It may be a dome-like curved surface leading to the outer peripheral face of the guide member 5, or may be a conical surface. The shape of the guide member 5 does not necessarily have to be an axisymmetric shape or a container-like shape.

[0020] The gas outlet pipe 4 is a pipe for discharging, to the outside of the sealed container 2, the gas resulting from removal of the liquid from the gas-rich layer F2 by surface tension of the liquid layer F1. Specifically, the gas outlet pipe 4 extends through the lower cover portion 23 of the sealed container 2 so that one end of the gas outlet pipe 4 opens upward. In the present embodiment, the gas outlet pipe 4 extends in the vertical direction.

[0021] The first pipe 3A and the second pipe 3B extend through the lower cover portion 23 of the sealed container 2 and through the ceiling portion 51 of the guide member 5 so that one end of the first pipe 3A and one end of the second pipe 3B open into the inflow space 11. The first pipe 3A and the second pipe 3B may be bent at an angle of approximately 90 degrees in the liquid reservoir 13, but preferably, they are substantially straight. As used herein, "a substantially straight pipe" refers to a pipe being straight or being bent at an angle of 10 degrees or less. In the present embodiment, the first pipe 3A and the second pipe 3B extend in the vertical direction.

[0022] The first pipe 3A is provided with a liquid outlet port 31 in a portion submerged in the liquid reservoir 13, and the second pipe 3B is provided with a liquid outlet port 32 in a portion submerged in the liquid reservoir 13. The first pipe 3A and the second pipe 3B are configured such that when one of the first pipe 3A and the second pipe 3B is used to introduce the gas-liquid two-phase fluid into the inflow space 11 from outside the sealed container 2, the other one is used to discharge the liquid in the liquid reservoir 13 to the outside of the sealed container 2 through the liquid outlet port (31 or 32) of the other one while forming a liquid surface at a level above the liquid outlet port (31 or 32).

[0023] Specifically, the liquid outlet ports 31 and 32 are provided near the bottom of the sealed container 13 so that the ports 31 and 32 are located below the liquid surface in the liquid reservoir 13 even if the level of the liquid surface falls.

[0024] Here, it is assumed that there is no pressure loss anywhere but between the inflow space 11 and the separation space 12 in the sealed container 2, and the height from the level of the liquid outlet ports 31 and 32 to the level of the liquid surface in the liquid reservoir 13, the height from the level of the liquid outlet ports 31 and 32 to the level of the ends of the first pipe 3A and the second pipe 3B, the density of the liquid, and the density of the gas are defined as H_1 [m], H_2[m], ρ_1[kg/m^3], and ρ_2[kg/m^3], respectively.

[0025] When the gas-liquid two-phase fluid is introduced through the first pipe 3A, the liquid flows into the second pipe 3B through the liquid outlet port 32 and forms, in the second pipe 3B, a liquid surface at a level close to the level of the liquid surface in the liquid reservoir 13. Conversely, when the gas-liquid two-phase fluid is introduced through the second pipe 3B, the liquid flows into the first pipe 3A through the liquid outlet port 31 and forms, in the first pipe 3A, a liquid surface at a level close to the level of the liquid surface in the liquid reservoir 13.

[0026] When the gas-liquid two-phase fluid is introduced through the first pipe 3A, assuming that the gas flows into the second pipe 3B through the end thereof, a pressure P_{IN} in the second pipe 3B relative to a reference pressure at the liquid outlet port 32 is represented as follows:

$$P_{IN} = \rho_2 \cdot g \cdot H_2 + P_2 \qquad \text{... (Equation 1)}$$

where P_2 is the pressure in the inflow space 11.

A pressure P_{OUT} in the liquid reservoir 13 relative to the reference pressure at the liquid outlet port 32 is represented as follows:

$$P_{OUT} = \rho_1 \cdot g \cdot H_1 + P_1 + \rho_2 \cdot g \cdot (H_2 - H_1) \qquad \text{... (Equation 2)}$$

where P_1 is the pressure in the separation space 12.

Based on the relationship with a pressure loss ΔP between the inflow space 11 and the separation space 12, the pressure P_1 is represented as follows:

$$P_1 = P_2 - \Delta P \qquad \text{... (Equation 3)}$$

The following equation is obtained by eliminating P_1 and P_2 from these equations 1 to 3:

$$P_{OUT} - P_{IN} = g \cdot H_1 \cdot (\rho_1 - \rho_2) - \Delta P \qquad \text{... (Equation 4)}$$

Since $P_{OUT} > P_{IN}$ must be satisfied in order to prevent the gas from flowing into the second pipe 3B through the end thereof and to allow the liquid to be discharged through the liquid outlet port 32 so as to form the liquid surface in the second pipe 3B, the following equation 5 is derived. This equation 5 is also satisfied when the gas-liquid two-phase fluid is introduced through the second pipe 3B.

$$g \cdot H_1 \cdot (\rho_1 - \rho_2) - \Delta P > 0 \qquad \text{... (Equation 5)}$$

Therefore, the shape of the guide member 5 and the positions of the liquid outlet ports 31 and 32 need to be designed so that the pressure loss ΔP between the inflow space 11 and the separation space 12, that is, the pressure loss ΔP that occurs in the flow passage 15 formed between the guide member 5 and the inner peripheral face of the tubular portion 22 of the sealed container 2 and in the vicinity of the flow passage 15 satisfies Equation 5.

[0027] The shape of the liquid outlet ports 31 and 32 may be circular as shown in FIG. 3A, but it may be oval as shown in FIG. 3B. The area of the liquid outlet port 31 is set to be equal to or smaller than the cross-sectional area of the flow path in the first pipe 3A, and the area of the liquid outlet port 32 is set to be equal to or smaller than the cross-sectional area of the flow path in the second pipe 3B.

[0028] Next, the operation of the gas liquid separator 1A is described. The only difference between the case where the gas-liquid two-phase fluid is introduced through the first pipe 3A and the case where the gas-liquid two-phase fluid is introduced through the second pipe 3B is that the functions of the first pipe 3A and the second pipe 3B are reversed. Therefore, only the case where the gas-liquid two-phase fluid is introduced through the first pipe 3A is described below.

[0029] The gas-liquid two-phase fluid is introduced into the sealed container 2 through the first pipe 3A. The liquid outlet port 31 provided in the first pipe 3A opens laterally, but since the flow tends to go straight by inertia, most of the gas-liquid two-phase fluid flows into the inflow space 11 from the end of the first pipe 3A. Even if some of the liquid in the liquid reservoir 13 flows into the first pipe 3A through the liquid outlet port 31 or some of the gas-liquid two-phase fluid flows out of the first pipe 3A through the liquid outlet port 31, there is no particular problem.

[0030] Since the inflow space 11 is covered over by the upper cover portion 21, the gas-liquid two-phase fluid flowing into the inflow space 11 is dispersed around. The dispersed gas-liquid two-phase fluid may or may not hit the upper cover portion 21. Then, the gas-liquid two-phase fluid changes to the two-layer flow F while gradually changing its direction downward. Specifically, since the direction of the gas-liquid two-phase fluid is completely reversed by the upper cover portion 21 of the sealed container 2, the gas-liquid two-phase fluid can be separated into a gas and a liquid to some extent by centrifugal force (inertial force) created by the reversal of the direction.

[0031] The two-layer flow F created by the upper cover portion 21 passes through the flow passage 15 and flows down along the inner peripheral face of the tubular portion 22. Since the downflow speed of the gas-rich layer F2 is higher than that of the liquid layer F1, the gas-rich layer F2 slides down the surface of the liquid layer F1. Therefore, most of the liquid is removed from the gas-rich layer F2 by the surface tension of the liquid layer F1, and thus the two-layer flow F is separated into a gas and a liquid.

[0032] The gas thus separated flows upward in the separation space 12 and then changes its direction downward in the space surrounded by the guide member 5. At this time, traces of liquid mist contained in the gas are removed by centrifugal force and gravity. Then, the gas is discharged to the outside of the sealed container 2 through the gas outlet pipe 4.

[0033] On the other hand, the separated liquid flows down along the inner peripheral face of the tubular portion 22 to form the liquid reservoir 13, and then flows into the second pipe 3B through the liquid outlet port 32 provided in the second pipe 3B to open laterally and is discharged to the outside of the sealed container 2. At this time, the liquid flows into the second pipe 3B through the liquid outlet port 32 and forms, in the second pipe 3B, a liquid surface at a level close to the level of the liquid surface in the liquid reservoir 13, as described above. Thus, the liquid blocks the second pipe 3B, and this blocking action prevents the gas-liquid two-phase fluid in the inflow space 11 from being discharged to the outside of the sealed container 2 through the second pipe 3B.

[0034] As described above, in the present embodiment, the reversal of the direction of the gas-liquid two-phase fluid by the upper cover portion 21 and the surface tension of the liquid layer F1 make it possible to separate the gas-liquid two-phase fluid into a gas and a liquid almost completely, resulting in miniaturization of the gas-liquid separator 1A.

[0035] In addition, when the one of the first pipe 3A and the second pipe 3B serves as an inlet pipe of the gas-liquid two-phase fluid, the other one serves as an outlet pipe of the liquid. The functions of the first pipe 3A and the second pipe 3B are switched automatically according to the nature of the fluid only by selecting the pipe to which the gas-liquid two-phase fluid is to be supplied. Thus, with such a simple configuration suitable for miniaturization, a reversible-flow gas liquid separator can be obtained. Furthermore, since there is no need to switch the flow path by an actuator or the like in the sealed container 2, the cost can be reduced compared to conventional gas liquid separators using a check valve or the like.

[0036] In addition, since the outer peripheral face of the guide member 5 has a tapered shape having a diameter gradually increasing downward, it is possible to increase the flow rate of the gas-rich layer F2 gradually while allowing the two-layer flow F to flow smoothly into the flow passage 15.

[0037] Furthermore, since the end of the gas outlet pipe 4 is located in the space surrounded by the guide member 5, the downward flow direction of the gas along the inner peripheral face of the tubular portion 22 is changed to the upward direction in the separation space 12. This change in the flow direction to a direction against gravity allows traces of liquid contained in the gas to be removed by gravity and centrifugal force. Furthermore, in the present embodiment, since the end of the gas outlet pipe 4 opens upward, the upward flow of the gas is changed to the downward flow in the space surrounded by the guide member 5. As a result, traces of liquid contained in the gas can be removed more precisely by centrifugal force created by the change in the flow direction.

[0038] Moreover, since the first pipe 3A and the second pipe 3B are substantially straight, the liquid outlet ports 31 and 32 can be provided near the deepest part of the liquid reservoir 13. Therefore, even if the liquid surface level changes, the height H_1 from the level of the liquid outlet ports 31 and 32 to the level of the liquid surface in the liquid reservoir 13 can be kept high enough. Thereby, the stability of the separation performance of the gas liquid separator 1A can be improved.

[0039] Next, a refrigeration cycle apparatus 9 using the gas liquid separator 1A is described with reference to FIG. 4.

[0040] This refrigeration cycle apparatus 9 is used for air conditioning for heating and cooling a room, and includes a heat pump circuit 90 in which a refrigerant is circulated and an injection pipe 97 through which the refrigerant is bypassed.

[0041] The heat pump circuit 90 includes a compressor 91 that compresses the refrigerant, an indoor heat exchanger 93 that exchanges heat between the indoor air and the refrigerant, a first expansion mechanism 94 and a second expansion mechanism 95 that expand the refrigerant, and an outdoor heat exchanger 96 that exchanges heat between the outdoor air and the refrigerant. The gas liquid separator 1A is incorporated in the heat pump circuit 90 such that the first pipe 3A is connected to the second expansion mechanism 95 and the second pipe 3B is connected to the first expansion mechanism 94.

[0042] The compressor 91 has a configuration in which a low-stage working chamber and a high-stage working chamber are connected by an internal flow path. The injection pipe 97 connects the gas outlet pipe 4 of the gas-liquid separator 1A and the internal flow path of the compressor 91 so that the refrigerant is injected into the compressor 91 during the compression of the refrigerant.

[0043] The heat pump circuit 90 is further provided with a four-way valve 92 as a switching means. The four-way valve 92 switches the direction of the refrigerant flowing in the heat pump circuit 90 to a first direction along which the refrigerant discharged from the compressor 91 is directed to the indoor heat exchanger 93 in the heating operation and to a second direction along which the refrigerant discharged from the compressor 91 is directed to the outdoor heat exchanger 96 in the cooling operation. In the heating operation, the refrigerant absorbs heat in the outdoor heat exchanger 96 and releases heat in the indoor heat exchanger 93, while in the cooling operation, the refrigerant absorbs heat in the indoor heat exchanger 93 and releases heat in the outdoor heat exchanger 96. The switching means of the present invention is not limited to the four-way valve 92, and it may be a bridge circuit, for example.

[0044] In the case where the conventional gas liquid separator 100 as shown in FIG. 15 is used in the refrigeration cycle apparatus 9 in which the flow direction of the refrigerant in the heating operation is reversed from the flow direction in the cooling operation, another four-way valve needs to be added to maintain the direction of the refrigerant flowing into the gas liquid separator 100. In contrast, the use of the reversible-flow gas liquid separator 1A in the refrigeration cycle apparatus 9 eliminates the need to provide such an additional four-way valve, and thus achieves an injection cycle in which a gas refrigerant in the expansion process is injected from the gas liquid separator 1A to a point in the middle of the compression process. Thereby, the efficiency of the refrigeration cycle apparatus 9 can be increased by a decrease in the pressure loss of the refrigerant pipe in the indoor heat exchanger 93 in the cooling operation or the outdoor heat exchanger 96 in the heating operation that exchanges heat with a low-temperature side heat source using the latent heat of evaporation of the refrigerant, a decrease in the compression power of the compressor 91, and the like. In addition, the discharge temperature at a low outdoor temperature which causes an increase in the compression ratio can be lowered by the cooling effect of the refrigerant injected in the middle of the compression process. Thereby, the upper limit of the rotational speed of the compressor 91 can be relaxed, and thus the heating capacity can be improved.

(Second Embodiment)

[0045] FIG. 5 and FIG. 6 show a gas liquid separator 1B according to the second embodiment of the present invention. In the present embodiment, the same components as those described in the first embodiment are denoted by the same reference numerals, and the description thereof is omitted. This also applies to the third to seventh embodiments described below.

[0046] In the present embodiment, a tubular separation member 6 is disposed along the inner peripheral face of the tubular portion 22 and below the flow passage 15 formed between the inner peripheral face of the tubular portion 22 and the outer peripheral face of the guide member 5. Except for this, the gas liquid separator 1B has the same configuration as that of the gas liquid separator 1A of the first embodiment.

[0047] The separation member 6 may be disposed spaced apart below the guide member 5, or may be disposed in contact with the guide member 5. Instead, the upper part of the separation member 6 may protrude slightly into the flow passage 15. The liquid surface in the liquid reservoir 13 is normally maintained at a level below the separation member 6 in a stable state.

[0048] The separation member 6 makes the surface area of the liquid layer F1 on the separation member 6 larger than that of the liquid layer F1 on the inner peripheral face of the tubular portion 22. As this separation member 6, a corrugated member having a plurality of vertical grooves or a mesh member can be used. In the present embodiment, an accordion-folded corrugated member having vertical grooves opening radially inwardly and vertical grooves opening radially outwardly that are arranged alternately in the circumferential direction is used. The corrugated member may have only the vertical grooves opening radially inwardly.

[0049] The separation member 6 is supported from below by a supporting plate 65. In the present embodiment, the supporting plate 65 is fixed to the gas outlet pipe 4 by brazing or the like, and the first pipe 3A and the second pipe 3B extend through through-holes provided in the supporting plate 65. The supporting plate 65 may be fixed to the first pipe 3A and the second pipe 3B.

[0050] In the present embodiment in which the separation member 6 is provided, the surface area of the liquid layer F2 can be increased in the radial direction compared to that in the first embodiment. Therefore, it is possible to reduce the height of the separation space 12 so as to further reduce the size of the gas liquid separator 1B or to improve the separation efficiency.

[0051] In addition, since a corrugated member having a plurality of vertical grooves is used as the separation member 6, it is possible to retain the liquid in the grooves by surface tension and introduce the liquid in the grooves smoothly into the liquid reservoir 13 by gravity.

(Third Embodiment)

[0052] FIG. 7 shows a gas liquid separator 1C according to the third embodiment of the present invention. In the present embodiment, a partition member 7 is disposed in the inflow space 11 so as to divide the inflow space 11 into an upper space and a lower space. Except for this, the gas liquid separator 1C has the same configuration as that of the gas liquid separator 1B of the second embodiment.

[0053] Like the upper cover portion 21 of the sealed container 2, the partition member 7 disperses the upward-injected gas-liquid two-phase fluid and directs the dispersed gas-liquid two-phase fluid downward so that a liquid contained in the gas-liquid two-phase fluid is pressed against the inner face of the partition member 7 and the gas-liquid two-phase fluid is converted into a two-layer flow F including a liquid layer F1 and a gas-rich layer F2.

[0054] In the present embodiment, the partition member 7 has a container-like shape opening downward, which is similar to the shape of the guide member 5, and the second pipe 3B extends through the partition member 7. However, the shape of the partition member 7 is not limited to this shape, and it may be a hemispherical shape opening downward, for example. Instead of the second pipe 3B, the first pipe 3A may extend through the partition member 7.

[0055] The basic operation of the gas liquid separator 1C of the present embodiment is the same as that of the gas liquid separator 1B of the second embodiment. However, when the gas-liquid two-phase fluid is introduced through the first pipe 3A, the gas-liquid two-phase fluid is directed from the space below the partition member 7 to the flow passage 15, and when the gas-liquid two-phase fluid is introduced through the second pipe 3B, the gas-liquid two-phase fluid is directed from the space above the partition member 7 to the flow passage 15.

[0056] As described in the first embodiment, when the gas-liquid two-phase fluid is introduced through the first pipe 3A, a pressure difference between the gas and the liquid at the position of the liquid outlet port 32 of the second pipe 3B is effective in preventing the gas-liquid two-phase fluid that has flowed into the inflow space 11 through the end of the first pipe 3A from being discharged through the end of the second pipe 3B. There is another effect. The presence of the partition member 7 spatially separates the end of the first pipe 3A and the end of the second pipe 3B and prevents these ends from being linearly connected to each other. With such a simple structure, the effect of preventing the gas-liquid two-phase fluid from flowing from the first pipe 3A directly to the second pipe 3B in the inflow space 11 can be further enhanced, and the separation performance of the gas liquid separator 1C can be further improved. Needless to say, the same effect can be obtained when the gas-liquid two-phase fluid is introduced through the second pipe 3B.

[0057] The separation member 6 is illustrated in FIG. 7, but the separation member 6 can be omitted as in the first embodiment.

(Fourth Embodiment)

[0058] FIG. 8 and FIG. 9 show a gas liquid separator 1D according to the fourth embodiment of the present invention. In the present embodiment, the first pipe 3A and the second pipe 3B are disposed adjacent to each other, and the gas outlet pipe 4 extends through the tubular portion 22 and the side wall portion 52 of the guide member 5 so that the end of the gas outlet pipe 4 opens laterally toward both the first pipe 3A and the second pipe 3B.

[0059] In this configuration, since the first pipe 3A and the second pipe 3B can be disposed adjacent to each other, the diameter of the sealed container 2 can be reduced. Thus, the gas liquid separator 1D can be compactly configured. As a result, for example, the flexibility in the placement of the gas liquid separator in a limited space of a housing of an outdoor unit for air conditioning is enhanced, and the effect of reducing the cost by reducing the size of the components also can be expected.

[0060] In addition, since the end of the gas outlet pipe 4 opens laterally toward the first pipe 3A and the second pipe 3B, the gas flowing upward in the separation space 12 turns laterally along the first pipe 3A and the second pipe 3B in a space opposite to the gas outlet pipe 4, and then flows into the end of the gas outlet pipe 4. Thereby, even if the gas and the liquid are not completely separated in the sealed container 2 and traces of liquid mist remain in the gas, it is possible to hit or press the liquid mist against the side face of the first pipe 3A and the second pipe 3B by centrifugal force to separate the liquid from the gas. Therefore, even the compactly configured gas liquid separator 1D can achieve a high separation effect.

[0061] In FIG. 8 and FIG. 9, the end of the gas outlet pipe 4 opens toward both the first pipe 3A and the second pipe 3B disposed adjacent to each other so as to maximize the effect, but needless to say, the same effect can be obtained if the end of the gas outlet pipe 4 opens toward at least one of the first pipe 3A and the second pipe 3B.

[0062] Also needless to say, the separation effect increases as the end of the gas outlet pipe 4 approaches the first pipe 3A or the second pipe 3B. However, a too small distance between them causes an increase in pressure loss that occurs when the gas flows into the gas outlet pipe 4. This is not preferable. In view of the balance between the separation effect and the pressure loss, it is preferable to set the distance from the end of the gas outlet pipe 4 to the first pipe 3A or the second pipe 3B in the direction in which the end of the gas outlet pipe 4 opens to at least 0.5 times but not more than 1.5 times the outer diameter of the gas outlet pipe 4 so that the pressure loss near the end of the gas outlet pipe 4 becomes equal to the pressure loss of the flow in the gas outlet pipe 4.

[0063] The separation member 6 is illustrated in FIG. 8, but the separation member 6 can be omitted as in the first embodiment.

(Fifth Embodiment)

[0064] FIG. 10 and FIG. 11 show a gas liquid separator 1E according to the fifth embodiment of the present invention. In the present embodiment, the first pipe 3A and the second pipe 3B are disposed adjacent to each other, and the gas outlet pipe 4 extends through the upper cover portion 21 and the ceiling portion 51 of the guide member 5 so that the end of the gas outlet pipe 4 opens downward.

[0065] In this configuration, since the first pipe 3A and the second pipe 3B can be disposed adjacent to each other, the diameter of the sealed container 2 can be reduced, as in the fourth embodiment. In addition, the end of the gas outlet pipe 4 is located at the uppermost position in the space surrounded by the guide member 5. Therefore, even if the gas and the liquid are not completely separated in the sealed container 2 and traces of liquid mist remain in the gas, it is possible to obtain a pronounced effect of separating the liquid mist from the gas by gravity in the separation space 12.

[0066] The separation member 6 is illustrated in FIG. 10, but the separation member 6 can be omitted as in the first embodiment.

(Sixth Embodiment)

[0067] FIG. 12, FIG. 13A and FIG. 13B show a gas liquid separator 1F according to the sixth embodiment of the present invention. In the present embodiment, an inflow barrier 81 that partitions the inflow space 11 into a first pipe 3A side space and a second pipe 3B side space and an outflow barrier 82 that partitions the liquid reservoir 13 into a first pipe 3A side reservoir and a second pipe 3B side reservoir are provided in the sealed container 2. In addition, in the present embodiment, a mesh member made of metal or resin is used as the separation member 6, and the upper part of the separation member 6 protrudes slightly into the flow passasge 15 and the separation member 6 and the guide member 5 are in close contact with each other. Except for these, the gas liquid separator 1F has the same configuration as that of the second embodiment.

[0068] The inflow barrier 81 is fixed to the upper face of the guide member 5, but it may be fixed to the inner face of the upper cover portion 21. The inflow barrier 81 only has to be located on a straight line connecting the end of the first pipe 3A and the end of the second pipe 3B to prevent the gas-liquid two-phase fluid released from the end of the first pipe 3A (or the end of the second pipe 3B) into the inflow space 11 from flowing directly into the end of the second pipe 3B (or the end of the first pipe 3A). That is, in the inflow space 11, the first pipe 3A side space and the second pipe 3B side space may communicate with each other above or below the end of the first pipe 3A and the end of the second pipe 3B or in front of or behind the longitudinal section in FIG. 12.

[0069] The outflow barrier 82 is fixed to the sealed container 2 or the gas outlet pipe 4. The outflow barrier 82 only has to be located on a straight line connecting the liquid outlet ports 31 and 32 to prevent the gas in the gas-liquid two-phase fluid leaked from the liquid outlet port 31 of the first pipe 3A (or the liquid outlet port 32 of the second pipe 3B) from flowing directly into the liquid outlet port 32 of the second pipe 3B (or the liquid outlet port 31 of the first pipe 3A). That is, in the liquid reservoir 13, the first pipe 3A side reservoir and the second pipe 3B side reservoir may communicate with each other above or below the liquid outlet ports 31 and 32 or in front of or behind the longitudinal section in FIG. 12.

[0070] The use of a mesh member as the separation member 6 as in the present embodiment allows a compact configuration with a high separation efficiency to be achieved at low cost. The mesh member may be previously formed in a tubular shape. Instead, two or three mesh strips may be rolled into a tubular shape and fitted into the sealed container 2.

[0071] Furthermore, in the present embodiment, the inflow barrier 81 is provided in the inflow space 11. Therefore, in the case where the gas-liquid two-phase fluid is introduced through the first pipe 3A, it is possible to reliably prevent the gas-liquid two-phase fluid released from the end of the first pipe 3A into the inflow space 11 from flowing directly into the end of the second pipe 3B in the inflow space 11 and being discharged outside without passing through the separation space. Thereby, the separation efficiency of the gas liquid separator 1F can be further improved. The same applies when the gas-liquid two-phase fluid is introduced through the second pipe 3B.

[0072] In addition, the outflow barrier 82 is provided in the liquid reservoir 13. Therefore, in the case where the gas-liquid two-phase fluid is introduced through the first pipe 3A, it is possible to prevent a portion of the gas-liquid two-phase fluid flowing from the first pipe 3A from leaking through the first liquid outlet port 31 and thus to prevent a gas contained in the leaked fluid from being mixed with the liquid and being discharged outside together with the liquid through the second pipe 3B of the liquid outlet port 32. Thereby, the separation efficiency of the gas liquid separator 1F can be further improved. The same applies when the gas-liquid two-phase fluid is introduced through the second pipe 3B.

[0073] The separation member 6 is illustrated in FIG. 12, but the separation member 6 can be omitted as in the first embodiment.

(Seventh Embodiment)

[0074] FIG. 14 shows a gas liquid separator 1G according to the seventh embodiment of the present invention. In the present embodiment 6, each of the first pipe 3A and the second pipe 3B is provided with a movable valve 35 therein.

[0075] The movable valves 35 is axially slidably fitted into the first pipe 3A or the second pipe 3B, and has a tubular shape to prevent closing of the first pipe 3A or the second pipe 3B. The movable range of the open/close valve 35 is limited to the vicinity of the liquid outlet port 31 or 32 by projections or the like provided inside the first pipe 3A or the second pipe 3B. The lower limit of the movable range is a first position where the movable valve 35 is located below the liquid outlet port 31 or 32 so as to open the liquid outlet port 31 or 32, and the upper limit of the movable range is a second position where the movable valve 35 closes the liquid outlet port 31 or 32.

[0076] FIG. 14 shows a state in which the movable valve 35 in the first pipe 3A is located at the second position, and the movable valve 35 in the second pipe 3B is located at the first position.

[0077] The operation of the gas liquid separator 1G of the present embodiment is the same as that of the gas liquid separator 1B of the second embodiment, except for the movement of the movable valve 35.

[0078] The movable valve 35 is normally located at the first position by gravity. In the case where the gas-liquid two-phase fluid is introduced through the first pipe 3A (hereinafter referred to as a "first operation mode"), a pressure loss occurs in the first pipe 3A when the gas-liquid two-phase fluid passes through the open/close valve 35. As a result, the pressure above the open/close valve 35 on the downstream side of the flow becomes lower than the pressure below the open/close valve 35 on the upstream side of the flow. Due to this pressure difference, the open/close valve 35 is lifted against gravity and held at the second position to close the liquid outlet port 31. Therefore, all of the gas-liquid two-phase fluid introduced into the first pipe 3A flows into the inflow space 11 through the end of the first pipe 3A without leaking from the liquid outlet port 31.

[0079] On the other hand, in the second pipe 3B from which the liquid is discharged in the first operation mode, the open/close valve 35 is maintained at the first position by gravity and thus the liquid outlet port 32 is kept open. Therefore, the open/close valve 35 never blocks the discharge of the liquid through the liquid outlet port 32. Furthermore, since the open/close valve 35 is pressed downward due to pressure loss that occurs when the liquid to be discharged passes through the movable valve 35, vibration or the like of the open/close valve 35 can be prevented.

[0080] The same applies when the gas-liquid two-phase fluid is introduced through the second pipe 3B (hereinafter referred to as a "second operation mode").

[0081] In the first operation mode, by the movements of the open/close valves 35 described above, the liquid outlet port 31 of the first pipe 3A is closed by the open/close valve 35 and the liquid outlet port 32 of the second pipe 3B is kept open. In the second operation mode in which the flows in the first pipe 3A and the second pipe 3B are reversed, the liquid outlet port 32 of the second pipe 3B is closed by the open/close valve 35 and the liquid outlet port 31 of the first pipe 3A is kept open.

[0082] Therefore, in both the first operation mode and the second operation mode, it is possible to prevent leakage of a portion of the gas-liquid two-phase fluid through the liquid outlet ports 31 and 32, and all of the gas-liquid two-phase fluid can be directed to the inflow space 11. Thus, the gas-liquid separation effect can be made more pronounced. Moreover, in the present embodiment, the movable valve 35 is actuated by the flow of the fluid and there is no need to use a special member such as a spring. Therefore, the above-mentioned effect can be obtained with a low-cost configuration.

[0083] The separation member 6 is illustrated in FIG. 14, but the separation member 6 can be omitted as in the first embodiment.

Claims

1. A gas liquid separator comprising:

   a sealed container comprising: an upper cover portion that disperses an upward-injected gas-liquid two-phase fluid and directs the dispersed gas-liquid two-phase fluid downward so that a liquid contained in the gas-liquid two-phase fluid is pressed against an inner face of the upper cover portion and the gas-liquid two-phase fluid is converted into a two-layer flow including a liquid layer and a gas-rich layer; a tubular portion that allows the liquid layer to flow down along an inner peripheral face of the tubular portion; and a lower cover portion that retains the liquid layer to form a liquid reservoir;
   a guide member that is disposed in the sealed container to form an inflow space between the guide member and the upper cover portion and to form a flow passage for the two-layer flow between the guide member and the inner peripheral face of the tubular portion, and that guides the gas-rich layer down along the inner peripheral face of the tubular potion;
   a first pipe that extends through the lower cover portion and through the guide member so that one end of the first pipe opens into the inflow space, and that is provided with a liquid outlet port in a portion submerged in the liquid reservoir;
   a second pipe that extends through the lower cover portion and through the guide member so that one end of the second pipe opens into the inflow space, and that is provided with a liquid outlet port in a portion submerged in the liquid reservoir; and
   a gas outlet pipe for discharging, to the outside of the sealed container, a gas resulting from removal of a liquid from the gas-rich layer by surface tension of the liquid layer, wherein
   the first pipe and the second pipe are configured such that when one of the first pipe and the second pipe is used to introduce the gas-liquid two-phase fluid into the inflow space from outside the sealed container, the other one is used to discharge the liquid in the liquid reservoir to the outside of the sealed container through the liquid outlet port of the other one while forming a liquid surface at a level above the liquid outlet port.

2. The gas liquid separator according to claim 1, wherein the guide member has a tapered outer peripheral face having a diameter gradually increasing downward and facing the inner peripheral face of the tubular portion.

3. The gas liquid separator according to claim 1 or 2, wherein the guide member has a container-like shape opening downward, and one end of the gas outlet pipe is located in a space surrounded by the guide member.

4. The gas liquid separator according to claim 3, wherein the gas outlet pipe extends through the tubular portion and the guide member so that the end of the gas outlet pipe opens laterally toward at least one of the first pipe and the second pipe.

5. The gas liquid separator according to claim 4, wherein a distance from the end of the gas outlet pipe to the first pipe or the second pipe in a direction in which the end of the gas outlet pipe opens is at least 0.5 times but not more than 1.5 times an outer diameter of the gas outlet pipe.

6. The gas liquid separator according to claim 3, wherein the gas outlet pipe extends through the upper cover portion and the guide member so that the end of the gas outlet pipe opens downward.

7. The gas liquid separator according to any one of claims 1 to 6, further comprising a partition member that is disposed to divide the inflow space into an upper space and a lower space, and that disperses the upward-injected gas-liquid two-phase fluid and directs the dispersed gas-liquid two-phase fluid downward so that a liquid contained in the gas-liquid two-phase fluid is pressed against an inner face of the partition member and the gas-liquid two-phase fluid is converted into a two-layer flow including a liquid layer and a gas-rich layer, wherein
   one of the first pipe and the second pipe extends through the partition member.

8. The gas liquid separator according to any one of claims 1 to 6, further comprising an inflow barrier that partitions the inflow space into a first pipe side space and a second pipe side space.

9. The gas liquid separator according to any one of claims 1 to 8, further comprising an outflow barrier that partitions the liquid reservoir into a first pipe side reservoir and a second pipe side reservoir.

10. The gas liquid separator according to any one of claims 1 to 9, wherein the first pipe and the second pipe are

substantially straight.

11. The gas liquid separator according to any one of claims 1 to 10, wherein
each of the first pipe and the second pipe is provided with a movable valve having a tubular shape and axially slidably fitted into the first pipe or the second pipe, and
the movable valve is normally located at a first position by gravity to open the liquid outlet port, and when the gas-liquid two-phase fluid passes through the movable valve, the movable valve is lifted by the gas-liquid two-phase fluid to a second position to close the liquid outlet port.

12. The gas liquid separator according to any one of claims 1 to 11, further comprising a separation member having a tubular shape and disposed below the flow passage and along the inner peripheral face of the tubular portion, and that makes a surface area of the liquid layer on the separation member larger than a surface area of the liquid layer on the inner peripheral face.

13. The gas liquid separator according to claim 12, wherein the separation member is a corrugated member having a plurality of vertical grooves.

14. The gas liquid separator according to claim 12, wherein the separation member is a mesh member.

15. A refrigeration cycle apparatus comprising:

a heat pump circuit comprising: a compressor that compresses a refrigerant; an indoor heat exchanger that exchanges heat between indoor air and the refrigerant; a first expansion mechanism and a second expansion mechanism that expand the refrigerant; an outdoor heat exchanger that exchanges heat between outdoor air and the refrigerant; and the gas liquid separator according to any one of claims 1 to 14 in which the first pipe is connected to the second expansion mechanism and the second pipe is connected to the first expansion mechanism;
an injection pipe that connects the gas outlet pipe of the gas liquid separator and the compressor so that the refrigerant is injected into the compressor during compression of the refrigerant; and
a switching means capable of switching a direction of the refrigerant flowing in the heat pump circuit to a first direction along which the refrigerant discharged from the compressor is directed to the indoor heat exchanger in a heating operation and to a second direction along which the refrigerant discharged from the compressor is directed to the outdoor heat exchanger in a cooling operation.

FIG.1

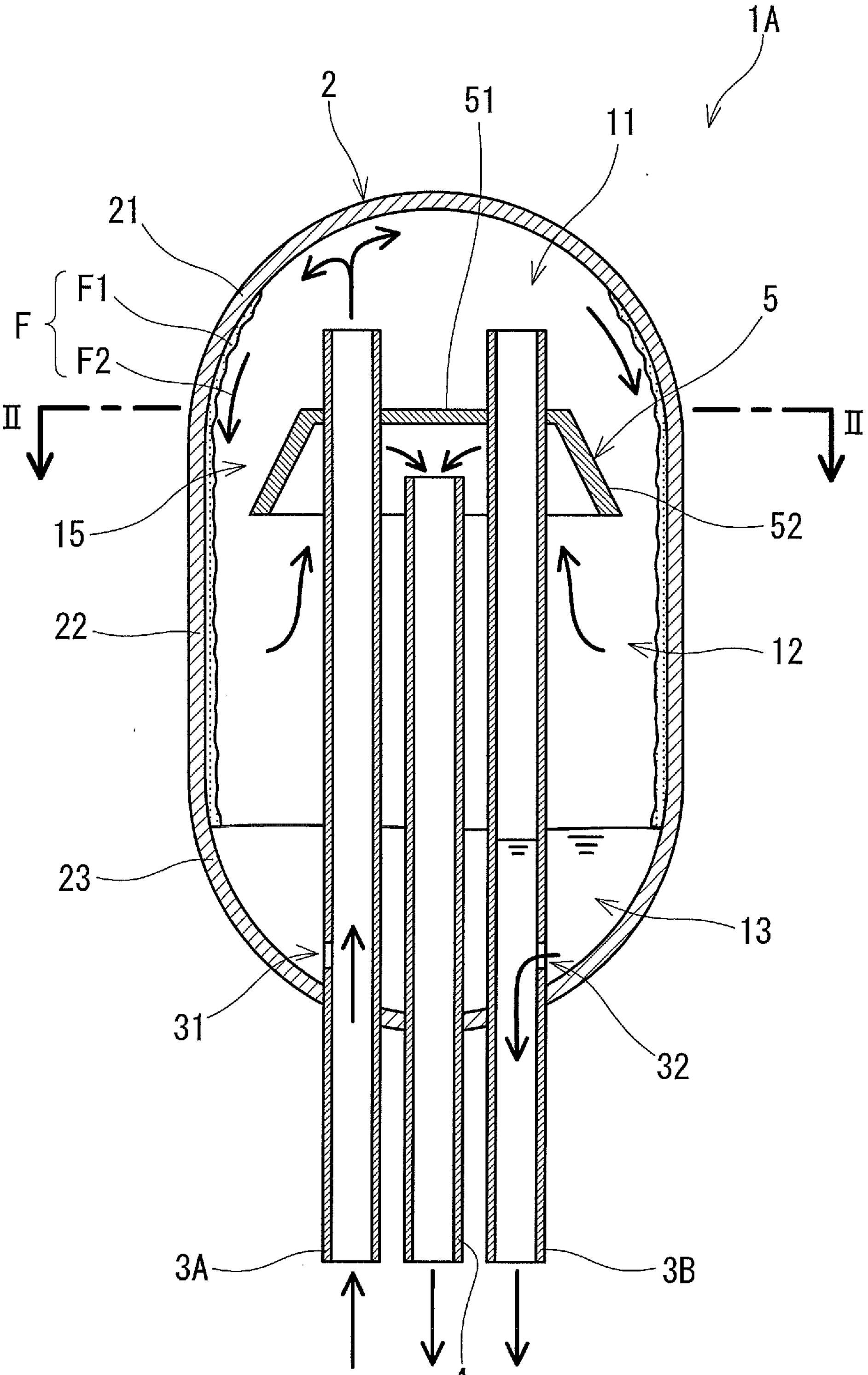


FIG.2

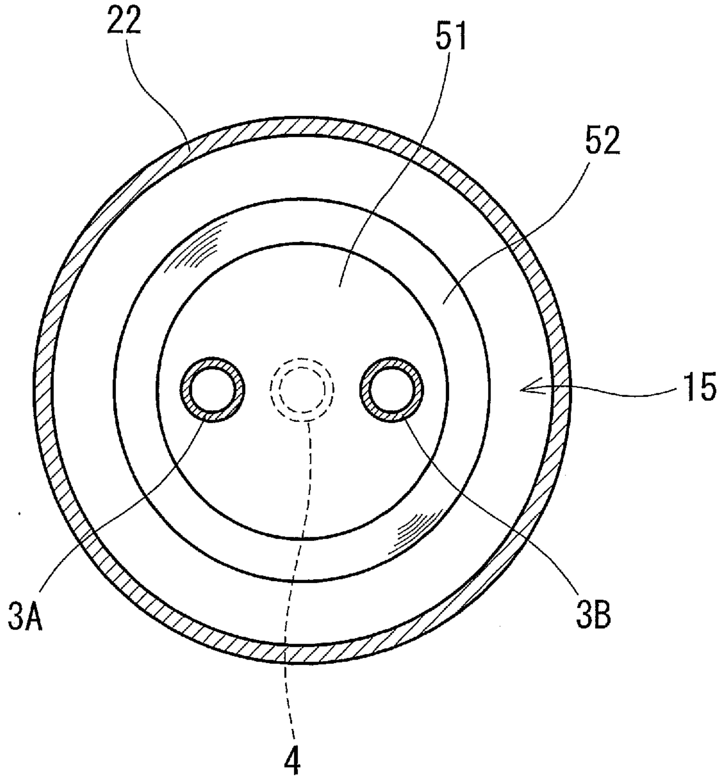


FIG.3A

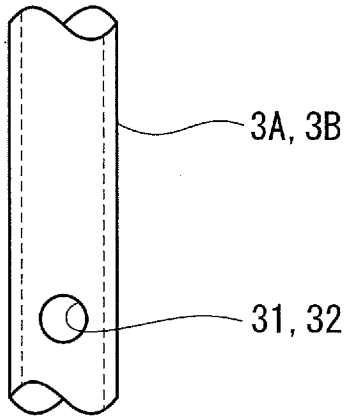


FIG.3B

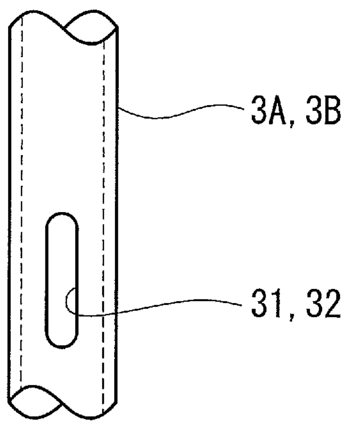


FIG.4

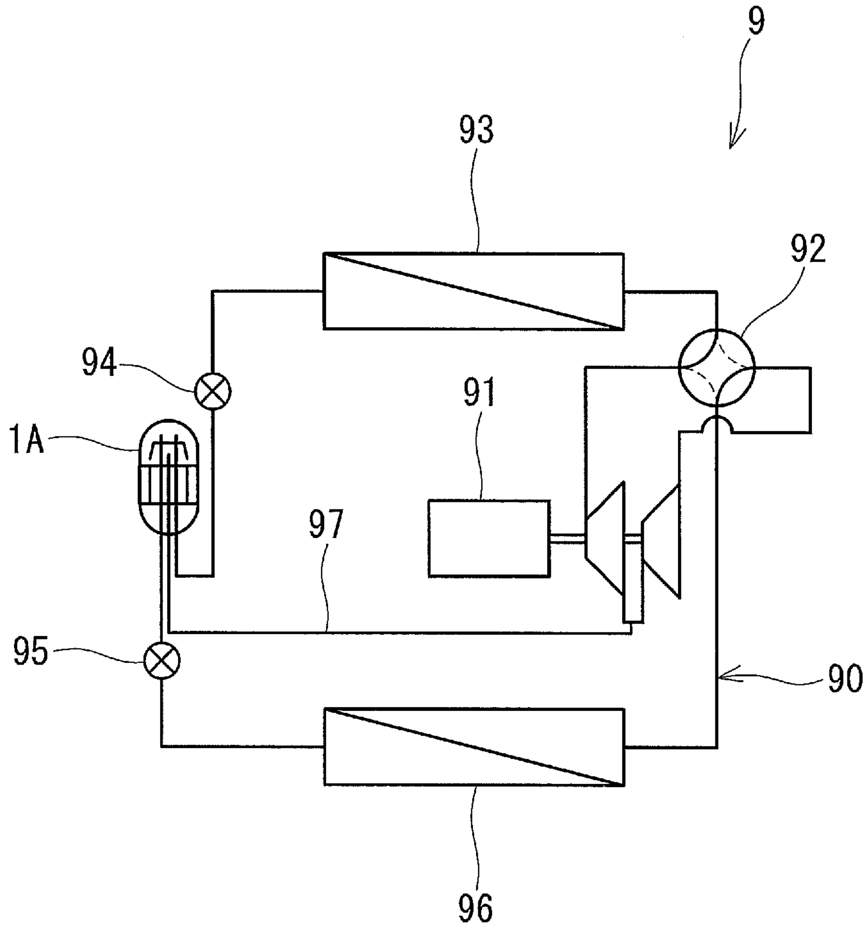


FIG.5

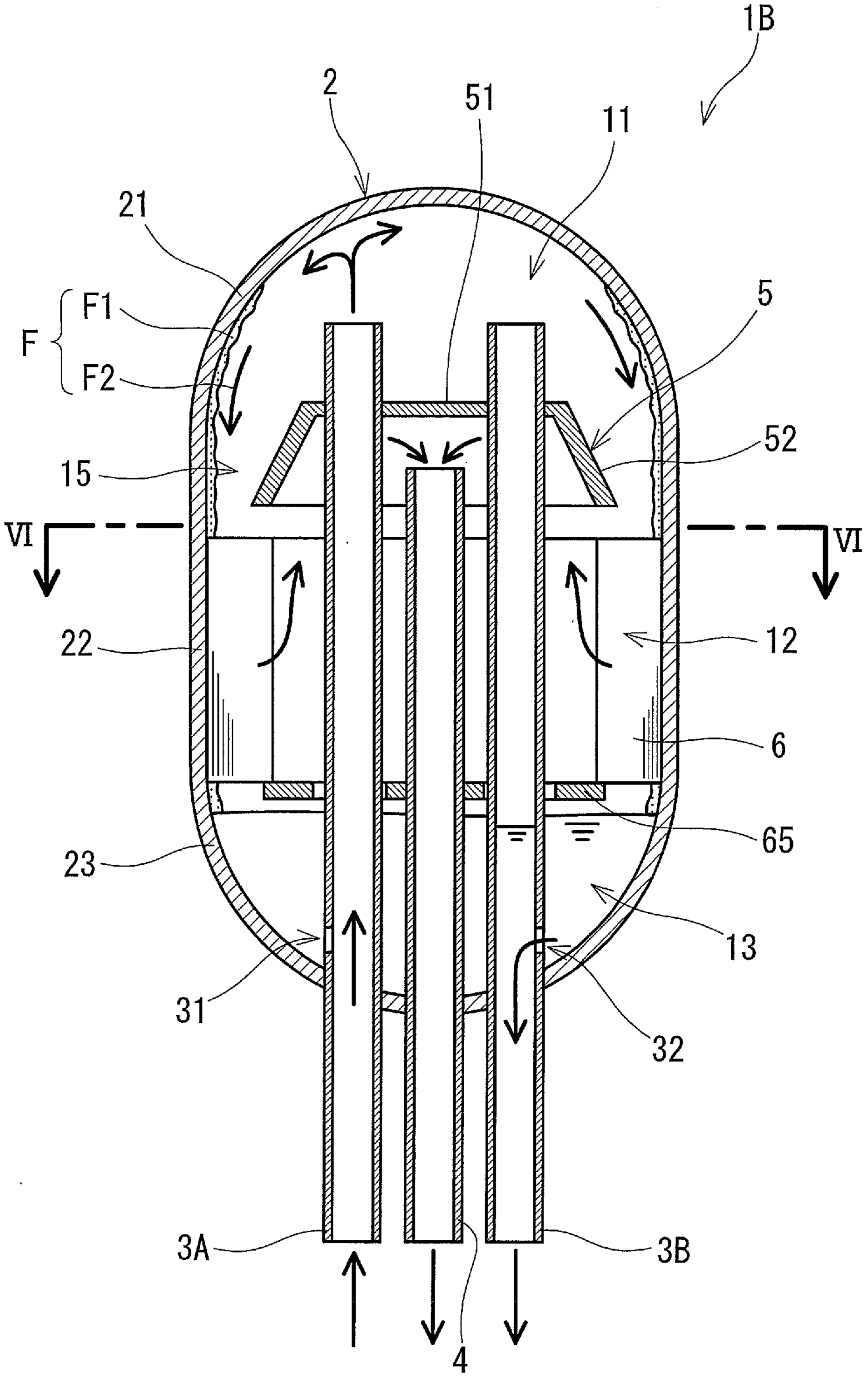


FIG.6

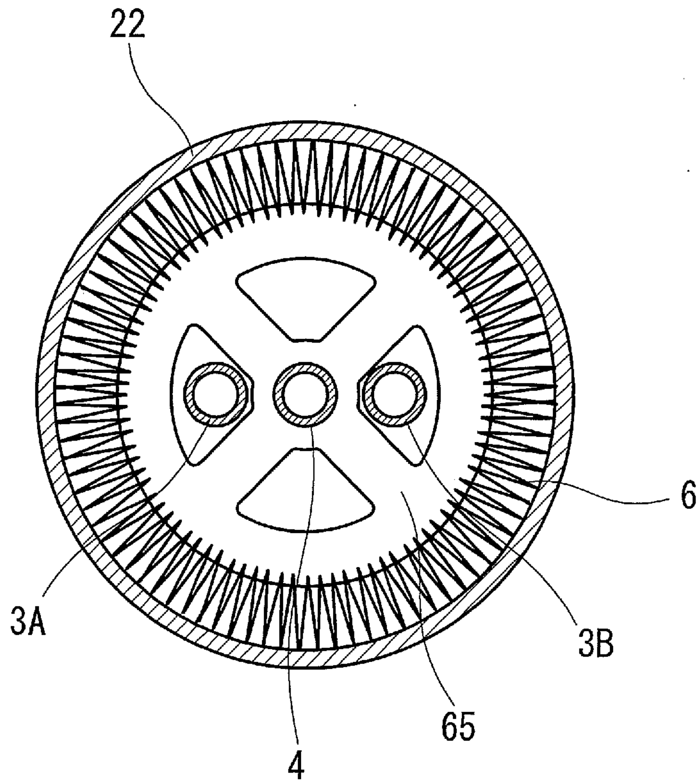


FIG.7

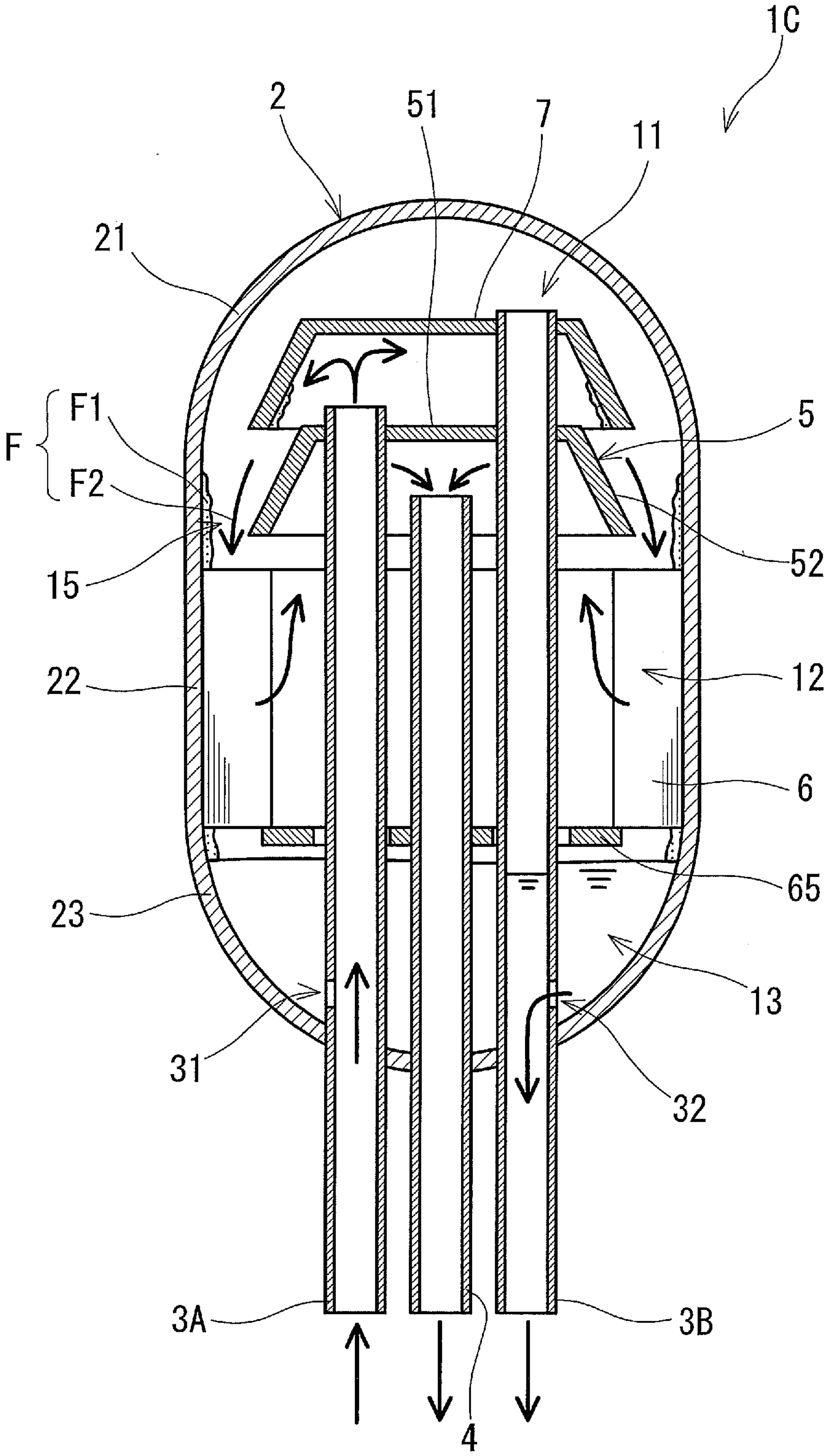


FIG.8

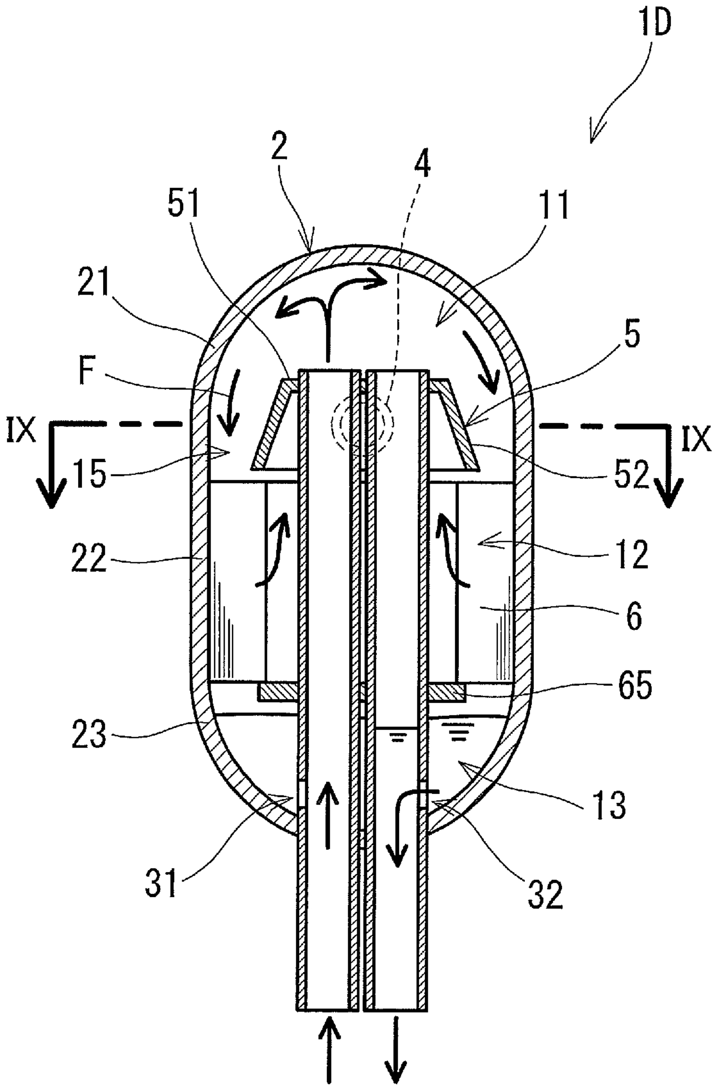


FIG.9

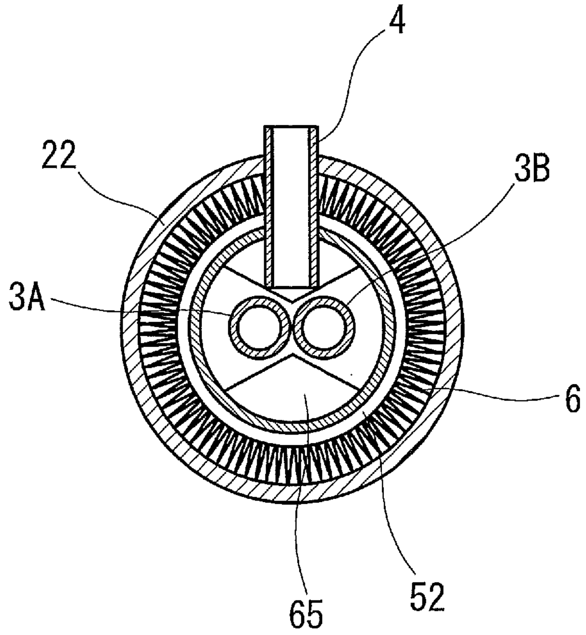


FIG.10

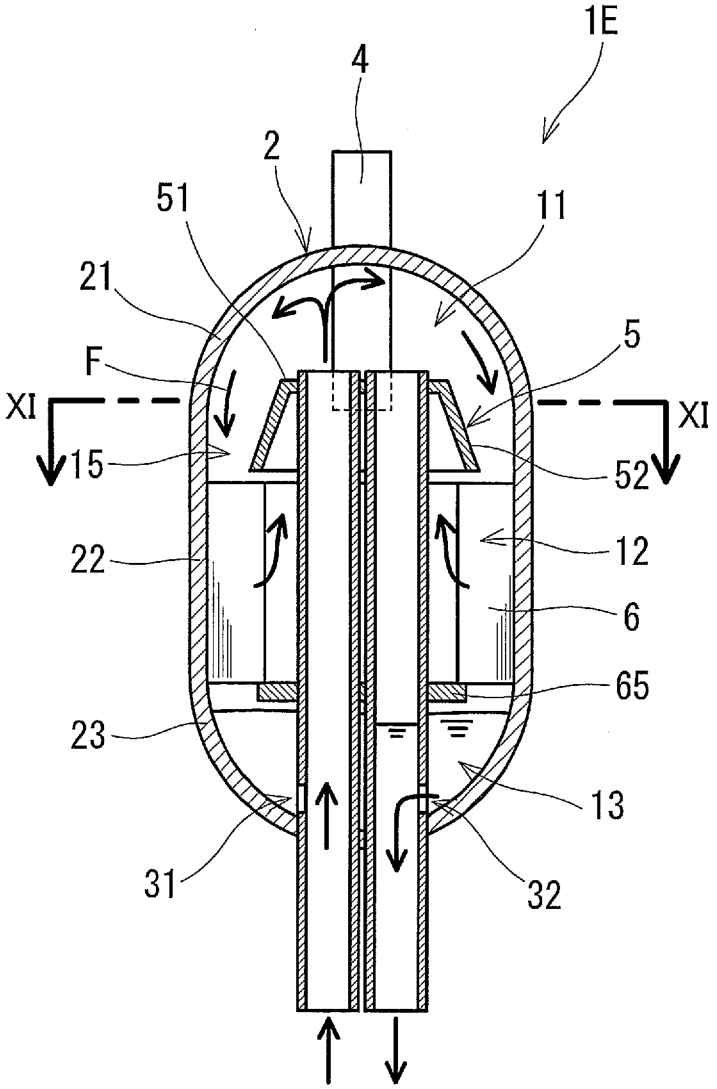


FIG.11

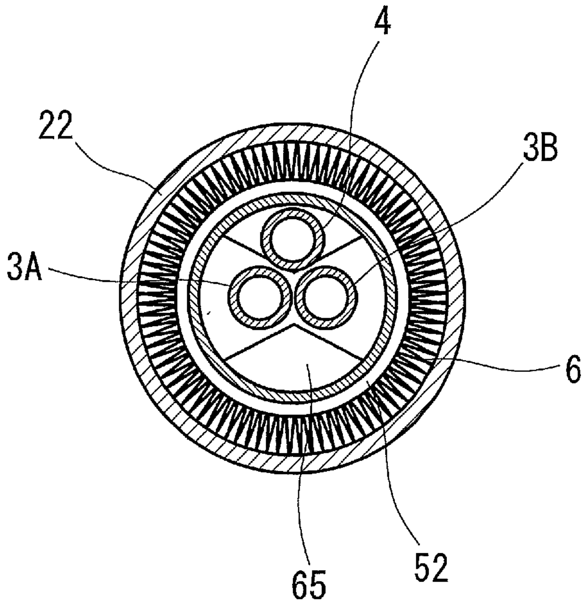
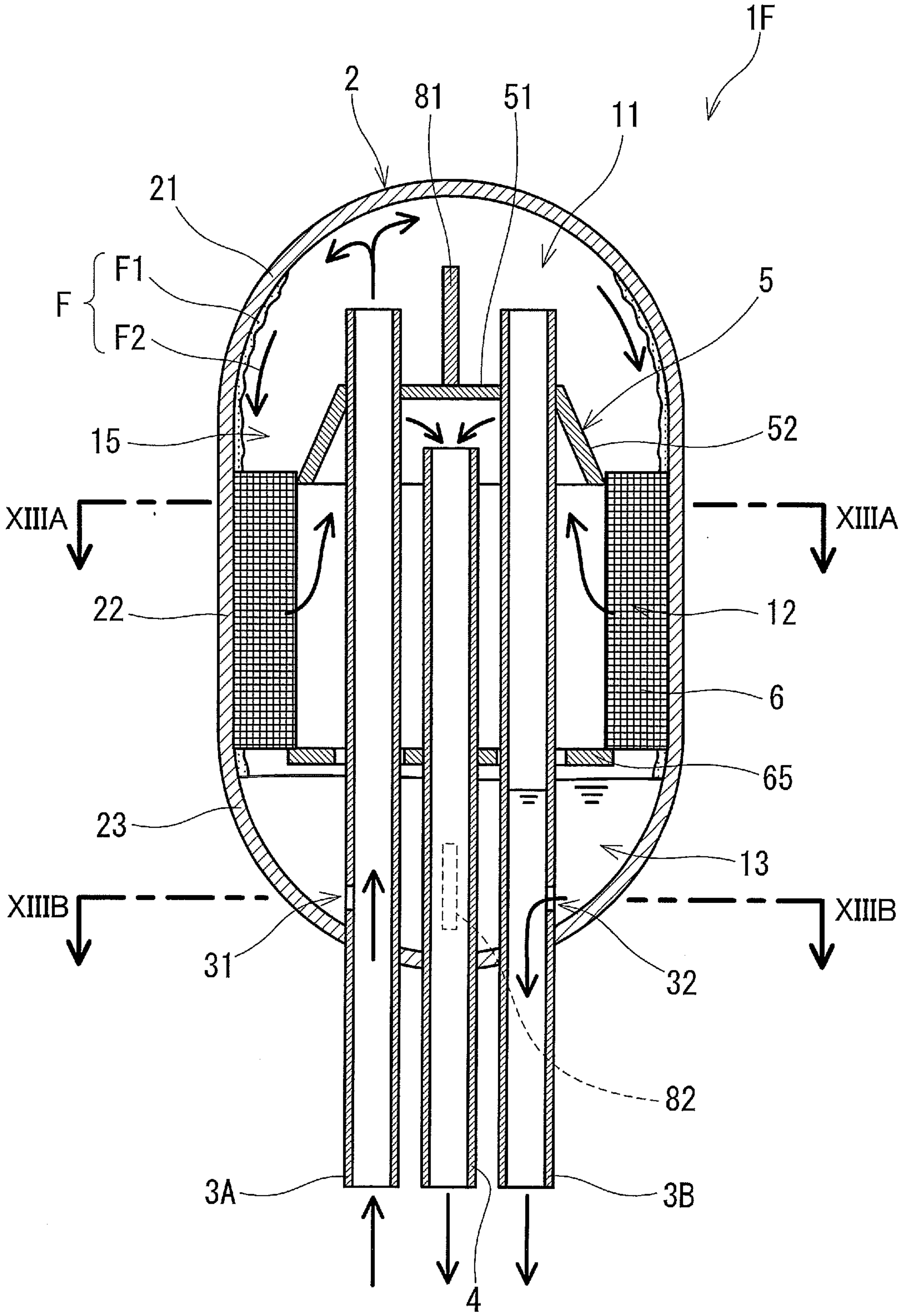


FIG.12


1F
2
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F2
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XIIIA
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6
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13
XIIIB
XIIIB
31
32
82
3A
3B
4

FIG.13A

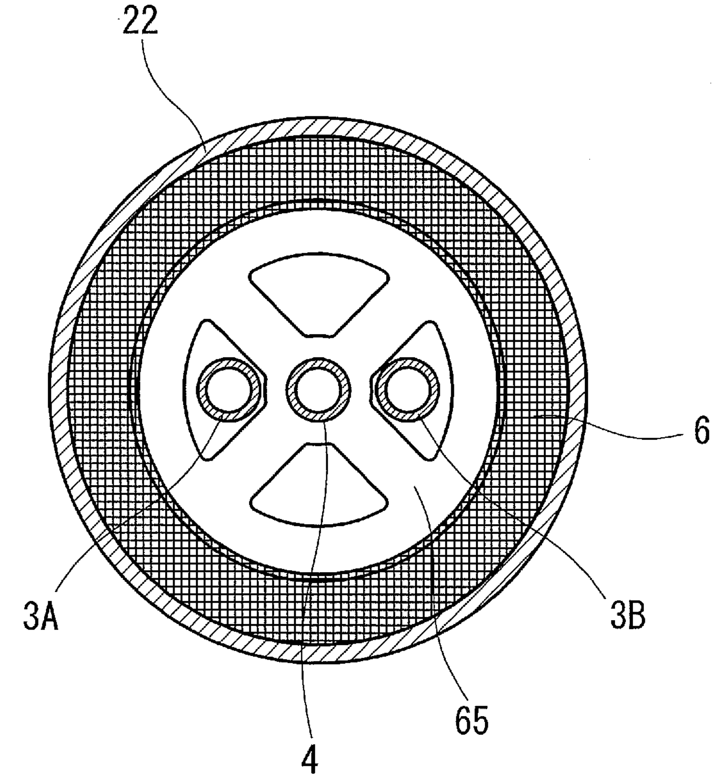


FIG.13B

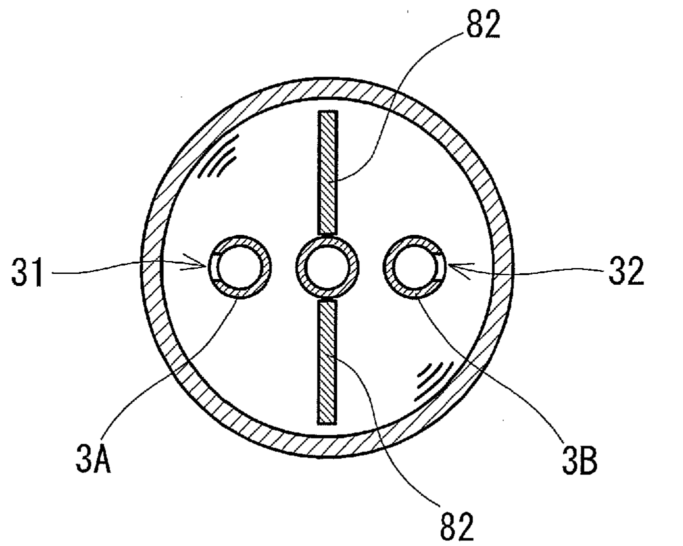


FIG.14

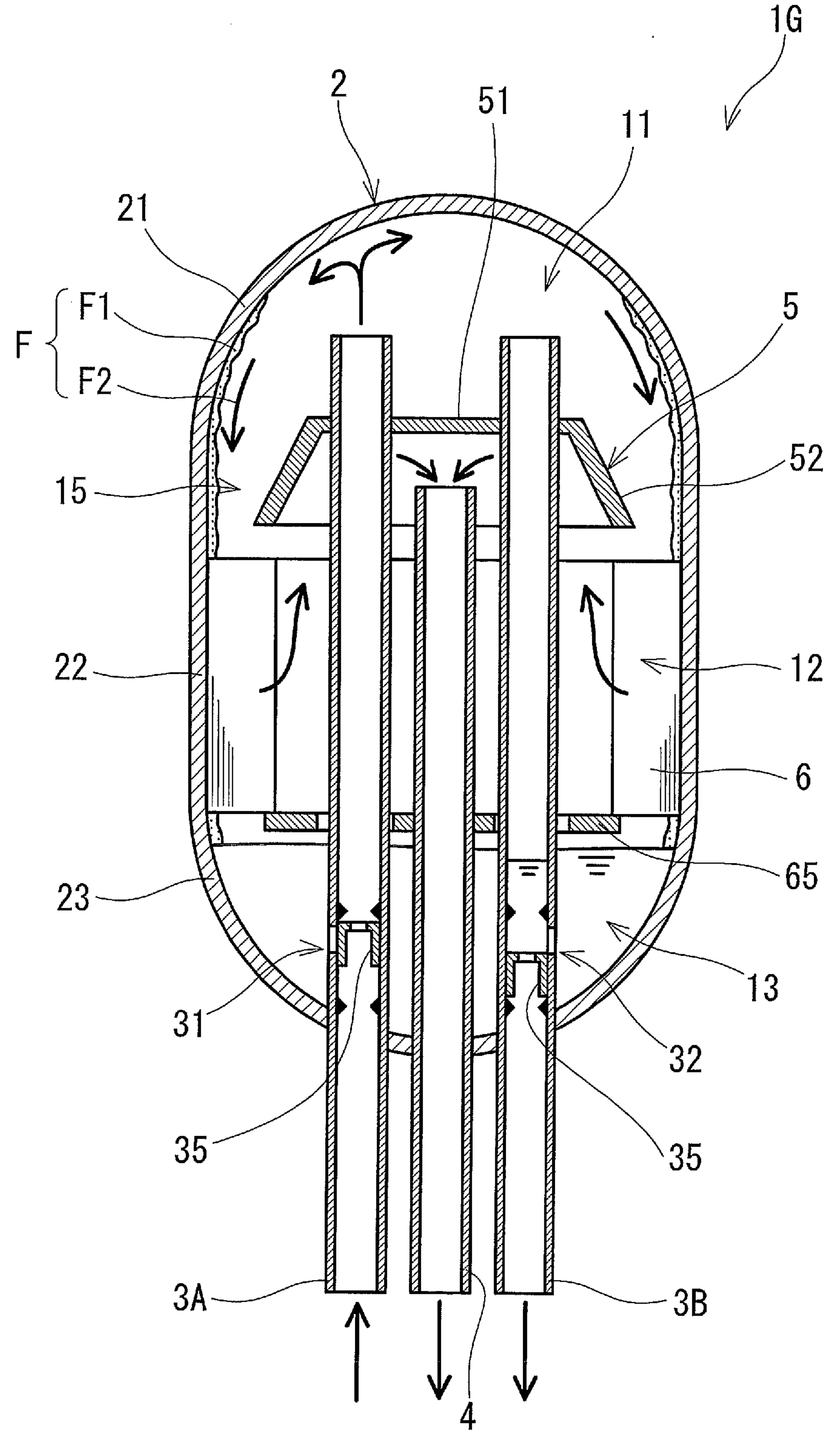
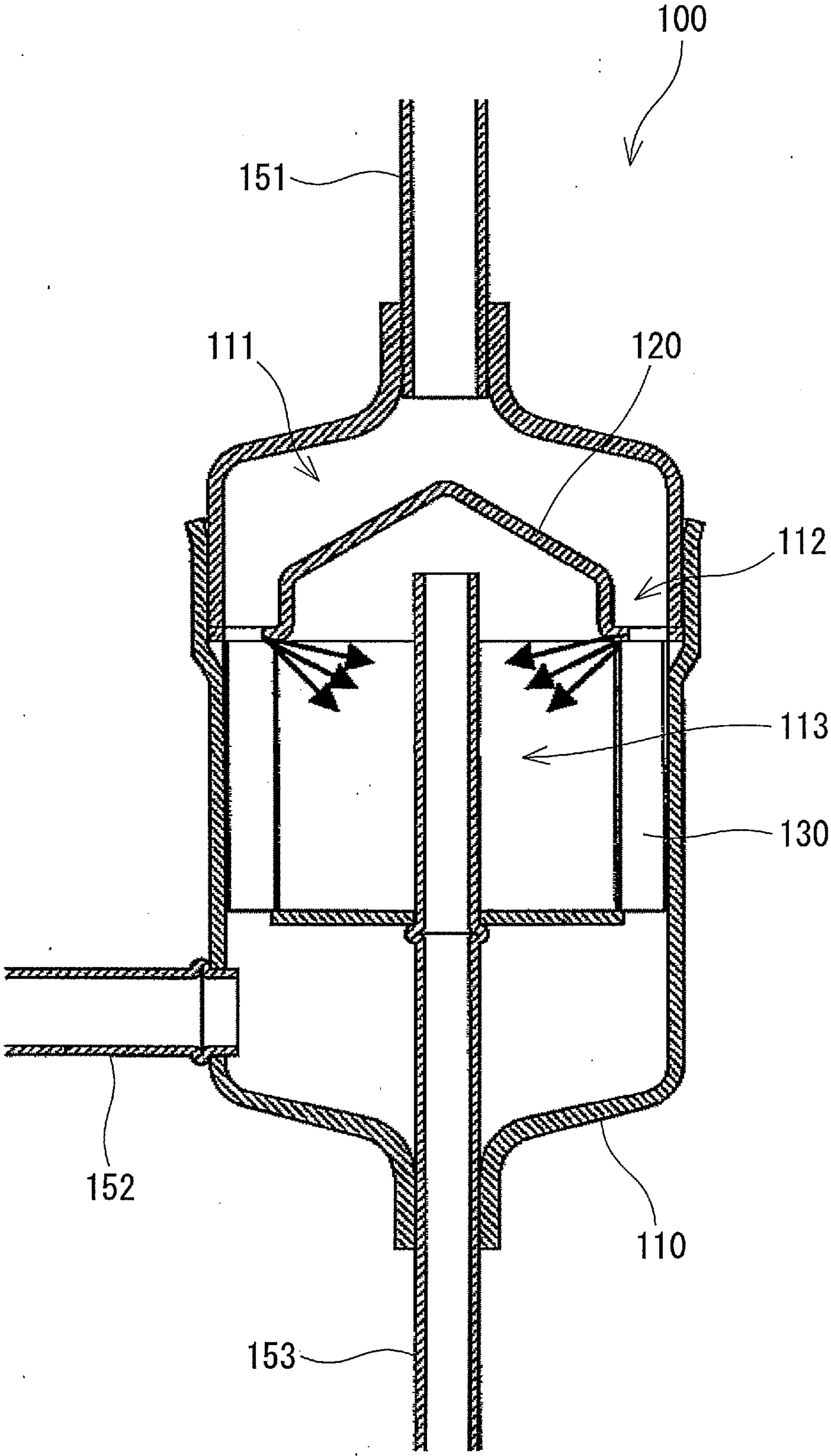


FIG.15



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/000704

A. CLASSIFICATION OF SUBJECT MATTER
F25B43/00(2006.01)i, *F25B1/00*(2006.01)i, *F25B1/10*(2006.01)i, *F25B13/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B43/00, F25B1/00, F25B1/10, F25B13/00

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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 61-114058 A (Daikin Industries, Ltd.), 31 May 1986 (31.05.1986), page 5, upper left column, line 14 to page 7, upper left column, line 2; fig. 1 to 3 (Family: none)	1-15
Y	JP 2009-174836 A (Nichirei Industries Co., Ltd.), 06 August 2009 (06.08.2009), paragraphs [0034] to [0036], [0048] to [0049]; fig. 1 to 4, 18 & CN 101493275 A & KR 10-2009-0081320 A	1-15

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

* Special categories of cited documents:
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"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
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"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	Date of mailing of the international search report
24 April, 2012 (24.04.12)	01 May, 2012 (01.05.12)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/000704

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 36909/1992(Laid-open No. 94663/1993) (Mitsubishi Heavy Industries, Ltd.), 24 December 1993 (24.12.1993), paragraphs [0009] to [0011]; fig. 1 (Family: none)	1-15
Y	JP 2000-241049 A (Zexel Corp.), 08 September 2000 (08.09.2000), paragraph [0050]; fig. 3 (Family: none)	1-15
Y	JP 4-366377 A (Daikin Industries, Ltd.), 18 December 1992 (18.12.1992), paragraphs [0031] to [0035]; fig. 2 (Family: none)	4,5,7-9,11
Y	JP 2002-31438 A (Hitachi, Ltd.), 31 January 2002 (31.01.2002), paragraph [0049]; fig. 5 to 6 (Family: none)	7-9,11
Y	JP 10-325622 A (Mitsubishi Electric Corp.), 08 December 1998 (08.12.1998), paragraph [0058]; fig. 12 (Family: none)	9,11
Y	JP 2008-39205 A (Daikin Industries, Ltd.), 21 February 2008 (21.02.2008), paragraphs [0040] to [0043]; fig. 1 to 2 (Family: none)	11

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

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Patent documents cited in the description

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