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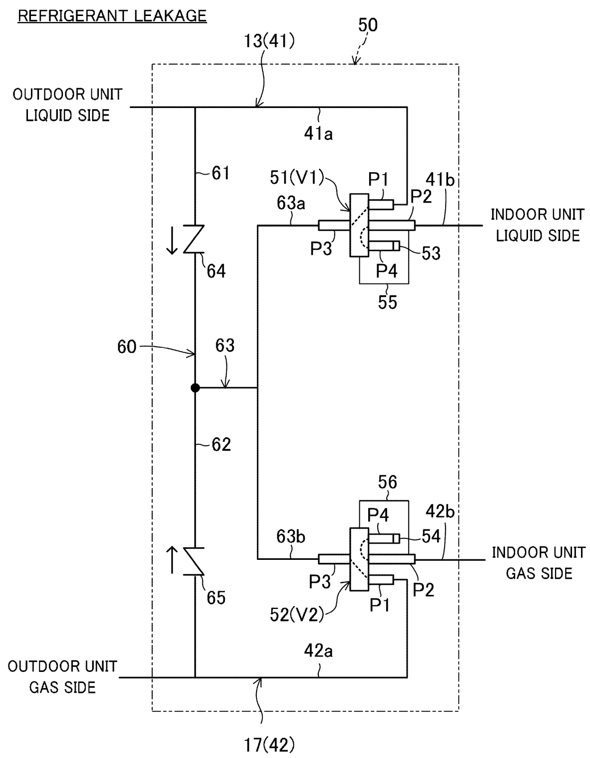
(54) AIR CONDITIONER AND FLOW PATH SWITCHING VALVE

(57) An air conditioner (10) includes two cut-off valves connected to respective refrigerant flow paths (41, 42). At least one of the two cut-off valves is configured as a flow path switching valve (V1, V2) configured to switch a flow path so as to block the refrigerant flow paths (41, 42) when a refrigerant leaks in a utilization circuit (30a).

FIG.4



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to an air conditioner and a flow path switching valve.

BACKGROUND ART

[0002] Patent Document 1 discloses an air conditioner including an indoor unit and an outdoor unit. An electromagnetic valve and an expansion valve are connected to a refrigerant pipe that is connected to the indoor unit. If a refrigerant leakage detector detects leakage of a refrigerant in the indoor unit, the electromagnetic valve and the expansion valve are closed.

CITATION LIST

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Unexamined Patent Publication No. 2012-13339

SUMMARY

TECHNICAL PROBLEM

[0004] The electromagnetic valve and the expansion valve disclosed in Patent Document 1 have a structure of opening/closing an internal flow path. Due to this structure, the internal flow path is relatively narrow. A cut-off valve such as that disclosed in Patent Document 1 is closed when the refrigerant leaks. Otherwise, the cut-off is basically in the open state during a normal operation. For this reason, providing the cut-off valve has caused an increase in pressure loss in a refrigerant flow path during the normal operation.

[0005] It is therefore an object of the present disclosure to reduce the pressure loss caused by the cut-off valve.

SOLUTION TO THE PROBLEM

[0006] A first aspect is directed to an air conditioner including: a refrigerant circuit (10a) that includes a heat source circuit (20a) to which a compressor (21) and a heat source heat exchanger (22) are connected, and includes a utilization circuit (30a) to which a utilization heat exchanger (31) is connected, and that is configured to perform a refrigeration cycle. The refrigerant circuit (10a) further includes: two refrigerant flow paths (41, 42) connected to respective ends of the utilization circuit (30a), and two cut-off valves connected to the respective refrigerant flow paths (41, 42). At least one of the cut-off valves is configured as a flow path switching valve (V1, V2) configured to switch a flow path so as to block the refrigerant flow paths (41, 42) when a refrigerant leaks in the utilization circuit (30a).

[0007] In the first aspect, the cut-off valve is configured as the flow path switching valve (V1, V2). This allows a reduction in the pressure loss caused by the cut-off valve as compared to an electromagnetic valve or an expansion valve, for example.

[0008] A second aspect is an embodiment of the first aspect. In the second aspect, the refrigerant flow paths (41, 42) include respective first flow paths (41a, 42a) formed between the flow path switching valve (V1, V2) and the heat source circuit (20a), and respective second flow paths (41b, 42b) formed between the flow path switching valve (V1, V2) and the utilization circuit (30a), and the flow path switching valve (V1, V2) is configured as a four-way switching valve (51, 52) having a first port (P1) connected to associated one of the first flow paths (41a, 42a), a second port (P2) connected to associated one of the second flow paths (41b, 42b), a third port (P3), and a fourth port (P4).

[0009] In the second aspect, the flow path switching valve (V1, V2) is configured as a four-way switching valve (51, 52). When the four-way switching valve (51, 52) is placed in a first state, the refrigerant flow paths (41, 42) are conductive. When the four-way switching valve (51, 52) is placed in a second state, the refrigerant flow paths (41, 42) are blocked.

[0010] A third aspect is an embodiment of the second aspect. In the third aspect, the refrigerant circuit (10a) further includes a high-pressure introduction circuit (60) configured to introduce a high-pressure refrigerant in the first flow paths (41a, 42a) into the third port (P3), and the four-way switching valve (51, 52) is of a differential pressure drive type using the high-pressure refrigerant introduced into the third port (P3) as a drive source.

[0011] In the third aspect, the high-pressure refrigerant flowing through the first flow paths (41a, 42a) is introduced into the third port (P3). The flow path in the four-way switching valve (51, 52) is switched using the pressure of the high-pressure refrigerant as a drive source.

[0012] A fourth aspect is an embodiment of the third aspect. In the fourth aspect, the refrigerant circuit (10a) is configured to perform a first refrigeration cycle in which the heat source heat exchanger (22) serves as a radiator and the utilization heat exchanger (31) serves as an evaporator, and a second refrigeration cycle in which the utilization heat exchanger (31) serves as a radiator and the heat source heat exchanger (22) serves as an evaporator, and the high-pressure introduction circuit (60) is configured to introduce at least the high-pressure refrigerant in the first flow path (41a, 42a) having higher pressure out of the two first flow paths (41a, 42a) of the refrigerant flow paths (41, 42) into the third port (P3).

[0013] The fourth aspect allows the high-pressure refrigerant to be introduced into the third port (P3) during both the first refrigeration cycle and the second refrigeration cycle. This high-pressure refrigerant can be used as a drive source for the four-way switching valve (51, 52).

[0014] A fifth aspect is an embodiment of the fourth aspect. In the fifth aspect, the high-pressure introduction circuit (60) includes a liquid-side introduction path (61) for allowing the first flow path (41a, 42a) of the refrigerant flow path (41) on a liquid side to communicate with the third port (P3), and a gas-side introduction path (62) for allowing the first flow path (41a, 42a) of the refrigerant flow path (42) on a gas side to communicate with the third port (P3), the liquid-side introduction path (61) is provided with a first on-off valve (64) that is open during the first refrigeration cycle, and the gas-side introduction path (62) is provided with a second on-off valve (65) that is open during the second refrigeration cycle.

[0015] In the fifth aspect, the first on-off valve (64) is open during the first refrigeration cycle, which allows the high-pressure liquid refrigerant to be introduced into the third port (P3). Further, the second on-off valve (65) is open during the second refrigeration cycle, which allows the high-pressure gas refrigerant to be introduced into the third port (P3).

[0016] A sixth aspect is an embodiment of any one of the third to fifth aspects. In the sixth aspect, the four-way switching valve (51, 52) has a fourth port (P4) that is closed, the four-way switching valve (51, 52) in a first state makes the first port (P1) and the second port (P2) communicate with each other, and the third port (P3) and the fourth port (P4) communicate with each other, and the four-way switching valve (51, 52) in a second state makes the first port (P1) and the third port (P3) communicate with each other, and the second port (P2) and the fourth port (P4) communicate with each other.

[0017] In the sixth aspect, when the four-way switching valve (51, 52) is placed in the first state, the first port (P1) and the second port (P2) communicate with each other, and the refrigerant flow path (41, 42) becomes conductive. The refrigerant on a side of the third port (P3) does not pass through the fourth port (P4) that is closed. When the four-way switching valve (51, 52) is placed in the second state, the utilization circuit (30a) is substantially closed with the fourth port (P4). The utilization circuit (30a) becomes a closed circuit.

[0018] A seventh aspect is an embodiment of any one of the second to sixth aspects. In the seventh aspect, the four-way switching valve (51, 52) includes a low-pressure pipe (55, 56) that communicates with the utilization circuit (30a), and is switched to a second state by differential pressure between the high-pressure refrigerant and internal pressure of the low-pressure pipe (55, 56).

[0019] In the seventh aspect, when the refrigerant leaks in the utilization circuit (30a), the internal pressure of the utilization circuit (30a) decreases, and in turn, the internal pressures of the low-pressure pipes (55, 56) decrease. The four-way switching valve (51, 52) is switched to the second state using the differential pressure between the high-pressure refrigerant and the internal pressure of the low-pressure pipe (55, 56) in this state. When the refrigerant leaks, the four-way switching valve (51, 52) can be switched to the second state automatically.

[0020] An eighth aspect is an embodiment of the first aspect. In the eighth aspect, the refrigerant flow paths (41, 42) include respective first flow paths (41a, 42a) formed between the flow path switching valve (V1, V2) and the heat source circuit (20a), and respective second flow paths (41b, 42b) formed between the flow path switching valve (V1, V2) and the utilization circuit (30a), the flow path switching valve (V1, V2) is of an electric rotary-type and has a first port (P1) connected to associated one of the first flow paths (41a, 42a), a second port (P2) connected to associated one of the second flow paths (41b, 42b), a rotating portion (76) in which an internal flow path (77) is formed, and an electric motor (75) configured to rotatably drive the rotating portion (76), and the rotating portion (76) of the flow path switching valve (V1, V2) is placed at a rotational angle position of a first state in which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77), and is placed at a rotational angle position of a second state in which the first port (P1) and the second port (P2) are closed.

[0021] In the eighth aspect, the rotational angle position of the rotating portion (76) is changed by the electric motor (75), which switches the electric-rotary-type flow path switching valve (V1, V2) between the first state and the second state.

[0022] A ninth aspect is an embodiment of the eighth aspect. In the ninth aspect, the flow path switching valve (V1, V2) is configured as a three-way switching valve (71, 72) of an electric rotary type and has a third port (P3) that is closed, and the rotating portion (76) of the three-way switching valve (71, 72) in the first state is placed at a rotational angle position at which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77), and the rotating portion (76) of the three-way switching valve (71, 72) in the second state is placed at a rotational angle position at which one of the first port (P1) or the second port (P2) communicates with the third port (P3) via the internal flow path (77), and the other one of the first port (P1) or the second port (P2) is closed with the rotating portion (76).

[0023] In the ninth aspect, the rotational angle position of the rotating portion (76) is changed by the electric motor (75), which switches the three-way switching valve (71, 72) between the first state and the second state.

[0024] A tenth aspect is an embodiment of any one of the first to ninth aspects. In the tenth aspect, the flow path switching valve (V1, V2) is connected to at least the refrigerant flow path (42) on a gas side, out of the two refrigerant flow paths (41, 42).

[0025] In the tenth aspect, the flow path switching valve (V1, V2) is connected to the gas-side refrigerant flow path (42) having a pipe diameter larger than the liquid-side refrigerant flow path (41). Thus, a decrease in pressure loss in the gas-side refrigerant flow path (42) can be decreased.

[0026] An eleventh aspect is directed to a flow path switching valve that is a flow path switching valve (V1, V2) connected to a refrigerant flow path (41, 42) of the air conditioner (10) of any one of the first to tenth aspects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

FIG. 1 is a piping system diagram illustrating a schematic configuration of an air conditioner of an embodiment.
FIG. 2 is an enlarged circuit diagram of a cut-off unit, illustrating a flow of a refrigerant during a normal cooling operation.
FIG. 3 is an enlarged circuit diagram of a cut-off unit, illustrating a flow of the refrigerant during a normal heating operation.
FIG. 4 is an enlarged circuit diagram of a cut-off unit, illustrating a state in which the refrigerant leaks.
FIGS. 5A and 5B are enlarged circuit diagrams illustrating a cut-off unit of a second variation. FIG. 5A shows a state during a normal operation. FIG. 5B shows a state in which a refrigerant has leaked.
FIGS. 6A and 6B are enlarged circuit diagrams illustrating a cut-off unit of a third variation. FIG. 6A shows a state during a normal operation. FIG. 6B shows a state in which a refrigerant has leaked.
FIG. 7 is a piping system diagram illustrating a schematic configuration of an air conditioner of a first example according to another embodiment.
FIG. 8 is a piping system diagram illustrating a schematic configuration of an air conditioner of a second example according to another embodiment.
FIG. 9 is a table showing refrigerants used in a refrigerant circuit of the air conditioner of the embodiment, variations, and other embodiments.

DESCRIPTION OF EMBODIMENTS

[0028] An embodiment of the present disclosure will be described below with reference to the drawings. The following embodiment is merely exemplary in nature, and is not intended to limit the scope, applications, or use of the present invention.

«Embodiment»

<General Configuration of Air Conditioner>

[0029] An air conditioner (10) of this embodiment conditions air in an indoor space that is a target space. As shown in FIG. 1, the air conditioner (10) of this example is a multiple-type air conditioner and includes an outdoor unit (20) and a plurality of indoor units (30). The air conditioner (10) of this example switches between cooling and heating of air in the target space. The number of the indoor units (30) may be three or more.

[0030] The outdoor unit (20) is placed outside. The outdoor unit (20) constitutes a heat source unit. The outdoor unit (20) is provided with a heat source circuit (20a). The indoor units (30) are placed inside. The indoor units (30) each constitute a utilization unit. The indoor units (30) are each provided with a utilization circuit (30a). In the air conditioner (10), the outdoor unit (20) is connected to the indoor units (30) via connection pipes (11, 15).

[0031] The air conditioner (10) includes a refrigerant circuit (10a). The refrigerant circuit (10a) is filled with a refrigerant. In the refrigerant circuit (10a), a vapor compression refrigeration cycle is performed by circulation of the refrigerant. The refrigerant circuit (10a) includes a heat source circuit (20a) in the outdoor unit (20) and a plurality of utilization circuits (30a) in the respective indoor units (30). In the refrigerant circuit (10a), the utilization circuits (30a) are connected in parallel to each other. The heat source circuit (20a) is connected to the utilization circuits (30a) via connection pipes (11, 15).

<Connection Pipe>

[0032] The connection pipes include a liquid connection pipe (11) and a gas connection pipe (15).

[0033] The liquid connection pipe (11) includes a main liquid pipe (12) and a plurality of liquid branch pipes (13). One end of the liquid connection pipe (11) is connected to a liquid stop valve (25) of the heat source circuit (20a). One ends of the liquid branch pipes (13) are connected to the main liquid pipe (12). The other ends of the liquid branch pipes (13) are connected to the respective liquid ends (liquid-side joints) of the utilization circuits (30a).

[0034] The gas connection pipe (15) includes a main gas pipe (16) and a plurality of gas branch pipes (17). One end of the gas connection pipe (15) is connected to a gas stop valve (26) of the heat source circuit (20a). One ends of the gas branch pipes (17) are connected to the main gas pipe (16). The other ends of the gas branch pipes (17) are connected to the respective gas ends (gas-side joints) of the utilization circuits (30a).

[0035] The liquid branch pipes (13) each constitute a liquid refrigerant flow path (41) connected to the liquid end of the associated one of the utilization circuits (30a). The gas branch pipes (17) each constitute a gas refrigerant flow path (42) connected to the gas end of the associated one of the utilization circuits (30a). The gas refrigerant flow paths (42) each have a pipe diameter larger than the pipe diameters of the liquid refrigerant flow paths (41). The gas refrigerant flow paths (42) each have an outer pipe diameter of 12.7 mm or 15.9 mm, for example.

<Outdoor Unit>

[0036] As shown in FIG. 1, the air conditioner (10) includes one outdoor unit (20). The outdoor unit (20) includes a casing (not shown) that houses the heat source circuit (20a). The heat source circuit (20a) connects a compressor (21), an outdoor heat exchanger (22), an outdoor four-way switching valve (23), an outdoor expansion valve (24), the gas stop valve (26), and the liquid stop valve (25). The compressor (21) compresses a refrigerant sucked thereinto and discharges the compressed refrigerant. The outdoor heat exchanger (22) constitutes a heat source heat exchanger that exchanges heat between the refrigerant and outdoor air. An outdoor fan (22a) is provided adjacent to the outdoor heat exchanger (22). The outdoor fan (22a) transfers the outdoor air passing through the outdoor heat exchanger (22).

[0037] The outdoor four-way switching valve (23) switches between a first state indicated by solid lines in FIG. 1 and a second state indicated by broken lines in FIG. 1. The outdoor four-way switching valve (23) in the first state makes a discharge side of the compressor (21) and a gas end of the outdoor heat exchanger (22) communicate with each other, and makes a suction side of the compressor (21) and the gas stop valve (26) communicate with each other. The outdoor four-way switching valve (23) in the second state makes the discharge side of the compressor (21) and the gas stop valve (26) communicate with each other, and makes the suction side of the compressor (21) and the gas end of the outdoor heat exchanger (22) communicate with each other.

[0038] The outdoor expansion valve (24) is connected between the outdoor heat exchanger (22) and the liquid stop valve (25), in the heat source circuit (20a). The outdoor expansion valve (24) is configured as an electronic expansion valve having an adjustable opening degree.

[0039] The outdoor unit (20) is provided with an outdoor controller (27). The outdoor controller (27) controls components including the compressor (21), the outdoor expansion valve (24), and the outdoor fan (22a), in the outdoor unit (20). The outdoor controller (27) includes a microcomputer mounted on a control board, and a memory device (specifically, a semiconductor memory) storing software for operating the microcomputer.

<Indoor Unit>

[0040] As shown in FIG. 1, the air conditioner (10) includes a plurality of indoor units (30). The indoor units (30) are of a ceiling-mounted type. That is, the indoor units (30) may each be embedded in the ceiling or suspended from the ceiling. The outdoor units (20) each include a casing (not shown) that houses the associated one of the utilization circuits (30a). The utilization circuit (30a) connects an indoor heat exchanger (31) and an indoor expansion valve (32). The indoor heat exchanger (31) constitutes a utilization heat exchanger that exchanges heat between the refrigerant and indoor air. An indoor fan (31a) is provided adjacent to the indoor heat exchanger (31). The indoor fan (31a) transfers the indoor air passing through the indoor heat exchanger (31).

[0041] The indoor expansion valve (32) is connected between the liquid-side joint and the indoor heat exchanger (31) in the utilization circuit (30a). The indoor expansion valve (32) is configured as an electronic expansion valve having an adjustable opening degree.

[0042] The indoor units (30) are each provided with an indoor controller (33). The indoor controller (33) controls components including the indoor expansion valves (32) and the indoor fan (31a), in the indoor unit (30). The indoor controller (33) includes a microcomputer mounted on a control board, and a memory device (specifically, a semiconductor memory) storing software for operating the microcomputer.

[0043] The indoor units (30) are each connected to a remote control (34). The remote control (34) is operated to switch the operating mode and the set temperature of the associated one of the indoor units (30).

[0044] The indoor units (30) each include an LED light (not shown). During the operation of the air conditioner (10), the LED light is turned on when a cut-off unit (50) is open and closed. The lighting state of the LED light is different between when the valve is open and when the valve is closed. A user can determine whether or not the cut-off unit (50) (strictly speaking, a flow path switching valve (V1, V2)) is open or closed by checking the lighting state of the LED light.

<Refrigerant Leakage Detection Sensor>

[0045] The air conditioner (10) includes refrigerant leakage detection sensors (35). In this example, the refrigerant leakage detection sensors (35) are provided in the respective indoor units (30). The refrigerant leakage detection sensors (35) are each disposed inside the casing of the associated one of the indoor units (30). The refrigerant leakage detection sensors (35) each constitute a detection unit that detects the leakage of the refrigerant in the utilization circuit (30a) of the associated one of the indoor units (30). The refrigerant leakage detection sensors (35) may each be disposed outside the casing of the indoor unit (30).

<Cut-off Unit>

[0046] The air conditioner (10) includes the cut-off units (50). The cut-off units (50) are each configured to block the liquid refrigerant flow path (41) and the gas refrigerant flow path (42) when the refrigerant has leaked in the associated one of the utilization circuits (30a). The cut-off units (50) each include the liquid refrigerant flow path (41), the gas refrigerant flow path (42), a first flow path switching valve (V1), a second flow path switching valve (V2), and a high-pressure introduction circuit (60).

[0047] The first flow path switching valve (V1) is connected to the liquid refrigerant flow path (41). The first flow path switching valve (V1) constitutes a cut-off valve that blocks the liquid refrigerant flow path (41). The second flow path switching valve (V2) is connected to the gas refrigerant flow path (42). The second flow path switching valve (V2) constitutes a cut-off valve that blocks the gas refrigerant flow path (42). The first flow path switching valve (V1) and the second flow path switching valve (V2) are disposed outside the casing of the indoor unit (30).

[0048] The liquid refrigerant flow path (41) includes a first liquid flow path (41a) that is a first flow path and a second liquid flow path (41b) that is a second flow path. The first liquid flow path (41a) is formed in a portion of the liquid refrigerant flow path (41) closer to the heat source circuit (20a). The second liquid flow path (41b) is formed on the side of the utilization circuit (30a) in the liquid refrigerant flow path (41).

[0049] The gas refrigerant flow path (42) includes a first gas flow path (42a) that is a first flow path and a second gas flow path (42b) that is a second flow path. The first gas flow path (42a) is formed in a portion of the gas refrigerant flow path (42) closer to the heat source circuit (20a). The second gas flow path (42b) is formed in a portion of the gas refrigerant flow path (42) closer to the utilization circuit (30a).

[0050] The high-pressure introduction circuit (60) includes a liquid-side introduction path (61), a gas-side introduction path (62), and a main introduction path (63). One end of the liquid-side introduction path (61) is connected to an intermediate portion of the first liquid flow path (41a). The other end of the liquid-side introduction path (61) is connected to one end of the main introduction path (63). One end of the gas-side introduction path (62) is connected to an intermediate portion of the second gas flow path (42b). The other end of the gas-side introduction path (62) is connected to one end of the main introduction path (63). The other end of the main introduction path (63) branches into a first branch introduction section (63a) and a second branch introduction section (63b).

[0051] A first check valve (64), which is a first on-off valve, is connected to the liquid-side introduction path (61). A second check valve (65), which is a second on-off valve, is connected to the gas-side introduction path (62). The first check valve (64) allows the refrigerant to flow from the liquid-side introduction path (61) toward the main introduction path (63) and disallows the refrigerant to flow in the opposite direction. The second check valve (65) allows the refrigerant to flow from the gas-side introduction path (62) toward the main introduction path (63) and disallows the refrigerant to flow in the opposite direction.

[0052] The first flow path switching valve (V1) of this example is configured as a first four-way switching valve (51) of a differential pressure drive type. The second flow path switching valve (V2) of this example is configured as a second four-way switching valve (52) of a differential pressure drive type.

[0053] As shown in FIGS. 1 and 2, four-way switching valves (51, 52) each include a first port (P1), a second port (P2), a third port (P3), and a fourth port (P4).

[0054] As shown in FIGS. 1 and 2, the first port (P1) of the first four-way switching valve (51) is connected to the first liquid flow path (41a). The second port (P2) of the first four-way switching valve (51) is connected to the second liquid flow path (41b). The third port (P3) of the first four-way switching valve (51) communicates with the high-pressure introduction circuit (60). Strictly speaking, the third port (P3) of the first four-way switching valve (51) is connected to the first branch introduction section (63a) of the high-pressure introduction circuit (60). The fourth port (P4) of the first four-way switching valve (51) is closed with a first closing member (53) (see FIG. 2).

[0055] The first port (P1) of the second four-way switching valve (52) is connected to the first gas flow path (42a). The second port (P2) of the second four-way switching valve (52) is connected to the second gas flow path (42b). The third port (P3) of the second four-way switching valve (52) communicates with the high-pressure introduction circuit (60). Strictly speaking, the third port (P3) of the second four-way switching valve (52) is connected to the second branch introduction section (63b) of the high-pressure introduction circuit (60). The fourth port (P4) of the second four-way switching valve (52) is closed with a second closing member (54) (see FIG. 2).

[0056] The four-way switching valves (51, 52) are each switchable between a first state (indicated by the solid lines in FIG. 1) and a second state (indicated by the broken lines in FIG. 1). In the first state, the first port (P1) communicates with the second port (P2), and the third port (P3) communicates with the fourth port (P4). In the second state, the first port (P1) communicates with the third port (P3), and the second port (P2) communicates with the fourth port (P4).

[0057] As shown in FIGS. 2 to 4, the first four-way switching valve (51) has a first low-pressure pipe (55). One end of the first low-pressure pipe (55) is connected to the second port (P2) of the first four-way switching valve (51). The first low-pressure pipe (55) communicates with the utilization circuit (30a) via the second liquid flow path (41b). The other end of the first low-pressure pipe (55) is connected to a pressure chamber inside the first four-way switching valve (51).

[0058] The second four-way switching valve (52) has a second low-pressure pipe (56). One end of the second low-pressure pipe (56) is connected to the second port (P2) of the second four-way switching valve (52). The second low-pressure pipe (56) communicates with the utilization circuit (30a) via the second gas flow path (42b). The other end of the second low-pressure pipe (56) is connected to a pressure chamber inside the second four-way switching valve (52). In each of the four-way switching valves (51, 52) shown in FIGS. 2 to 4, an internal flow path for communicating the four ports (P1, P2, P3, P4) is indicated by broken lines.

[0059] The cut-off unit (50) includes a control unit (57). The control unit (57) includes a microcomputer mounted on a control board and a memory device (specifically, a semiconductor memory) storing software for operating the microcomputer.

-Operation-

[0060] The air conditioner (10) performs a cooling operation and a heating operation. Hereinafter, the cooling operation and the heating operation during a normal operation in which the refrigerant has not leaked will be described with reference to FIG. 1.

<Cooling Operation>

[0061] During the cooling operation, the outdoor four-way switching valve (23) is in the first state, the first four-way switching valve (51) is in the first state, and the second four-way switching valve (52) is in the first state. The outdoor expansion valve (24) is open. The opening degree of the indoor expansion valve (32) is controlled based on the superheat degree of the associated one of the indoor heat exchangers (31). The outdoor fan (22a) and the indoor fans (31a) are actuated. During the cooling operation, performed is a first refrigeration cycle (cooling cycle) in which the refrigerant dissipates heat and is condensed in the outdoor heat exchanger (22), and the refrigerant evaporates in the indoor heat exchangers (31).

[0062] The refrigerant compressed in the compressor (21) dissipates heat and is condensed in the outdoor heat exchanger (22) and passes through the outdoor expansion valve (24). The refrigerant flows from the main liquid pipe (12) into the liquid refrigerant flow path (41), flows through the first port (P1) and the second ports (P2) of the first four-way switching valve (51) in this order, and flows into the associated one of the utilization circuits (30a). In the utilization circuit (30a), the refrigerant is decompressed at the indoor expansion valve (32), and then evaporates in the indoor heat exchanger (31). In the indoor heat exchanger (31), the air is cooled by the evaporating refrigerant. The cooled air is supplied to the indoor space.

[0063] The refrigerant that has evaporated in the indoor heat exchanger (31) flows through the gas refrigerant flow path (42), and flows through the second port (P2) and the first port (P1) of the second four-way switching valve (52) in this order. The flows of the refrigerant merge together in the main gas pipe (16) to be sucked into the compressor (21).

<Heating Operation>

[0064] During the heating operation, the outdoor four-way switching valve (23) is in the second state, the first four-way switching valve (51) is in the first state, and the second four-way switching valve (52) is in the first state. The opening degree of the outdoor expansion valve (24) is controlled based on the superheat degree of the refrigerant flowing out of the outdoor heat exchanger (22). The opening degree of the indoor expansion valve (32) is controlled based on the subcooling degree of the refrigerant flowing out of the indoor heat exchanger (31). The outdoor fan (22a) and the indoor fan (31a) are actuated. During the heating operation, performed is a second refrigeration cycle (heating cycle) in which the refrigerant dissipates heat and is condensed in the indoor heat exchanger (31), and the refrigerant evaporates in the indoor heat exchangers (31).

[0065] The refrigerant that has compressed in the compressor (21) flows from the main gas pipe (16) into the gas refrigerant flow path (42), flows through the first port (P1) and the second port (P2) of the second four-way switching valve (52) in this order, and flows into the associated one of the utilization circuits (30a). In the utilization circuit (30a), the refrigerant dissipates heat and is condensed in the indoor heat exchanger (31). In the indoor heat exchanger (31), the air is heated by the refrigerant dissipating heat. The heated air is supplied to the indoor space.

[0066] The refrigerant that has dissipated heat in the indoor heat exchanger (31) flows through the liquid refrigerant flow path (41), and flows through the second port (P2) and the first port (P1) of the first four-way switching valve (51) in this order. The flows of refrigerant merge in the main liquid pipe (12) to be decompressed in the outdoor expansion valve (24). The decompressed refrigerant flows through the outdoor heat exchanger (22). In the outdoor heat exchanger (22), the refrigerant absorbs heat from the outdoor air to evaporate. The evaporated refrigerant is sucked into the compressor (21).

-Operation of Flow Path Switching Valve During Refrigerant Leakage-

[0067] The first four-way switching valve (51) and the second four-way switching valve (52) of this example are configured to be kept in the above-mentioned first state during the normal operation. Specifically, a spool valve inside each of the four-way switching valves (51, 52) is pressed with a high-pressure refrigerant introduced from the third port (P3) or an urger such as a spring to be positioned such that the first port (P1) communicates with the second port (P2) and the third port (P3) communicates with the fourth port (P4), for example (see FIGS. 2 and 3). This makes the liquid refrigerant flow path (41), the utilization circuit (30a), and the gas refrigerant flow path (42) communicate with one another, and the cooling cycle and the heating operation described above can be performed. A valve seat of the spool valve is preferably made from a resin material with low sliding resistance. The resin material may be, for example, Teflon (registered trademark).

[0068] The high-pressure introduction circuit (60) of this example is configured to introduce the high-pressure refrigerant into the third port (P3) during both cooling operation and heating operation.

[0069] In the cooling operation shown in FIG. 2, the high-pressure liquid refrigerant flows through the liquid refrigerant flow path (41), and the decompressed low-pressure gas refrigerant flows through the gas refrigerant flow path (42). Accordingly, in the high-pressure introduction circuit (60) during the cooling operation, the high-pressure liquid refrigerant in the liquid-side introduction path (61) flows through the first check valve (64) in the open state and is introduced into the third port (P3) of each of the four-way switching valves (51, 52) via the main introduction path (63). At this time, the second check valve (65) is basically in the closed state.

[0070] In the heating operation shown in FIG. 3, the high-pressure gas refrigerant flows through the gas refrigerant flow path (42), and the liquid refrigerant having a pressure slightly lower than that of the gas refrigerant flows through the liquid refrigerant flow path (41). Accordingly, in the high-pressure introduction circuit (60) during the heating operation, the high-pressure gas refrigerant in the gas-side introduction path (62) flows through the second check valve (65) in the open state and is introduced into the third port (P3) of each of the four-way switching valves (51, 52) via the main introduction path (63). At this time, the second check valve (65) is in the closed state or open state.

[0071] In this way, during the cooling operation and the heating operation, the high-pressure refrigerant serving as a drive source of each of the four-way switching valves (51, 52) can be reliably supplied to the third port (P3).

[0072] When the refrigerant leaks in the utilization circuit (30a) of the indoor unit (30) during the cooling operation or the heating operation, the first four-way switching valve (51) and the second four-way switching valve (52) are placed in the second state (see FIG. 4). This operation blocks the liquid refrigerant flow path (41) and the gas refrigerant flow path (42). As a result, the leakage of the refrigerant in the heat source circuit (20a), the main liquid pipe (12), and the main gas pipe (16) from the utilization circuit (30a) to the indoor space may be avoided.

[0073] Specifically, when the refrigerant leakage occurs in the utilization circuit (30a), the internal pressures of the utilization circuit (30a), the liquid refrigerant flow path (41), and the gas refrigerant flow path (42) decrease. In the first four-way switching valve (51), the internal pressure of the first low-pressure pipe (55) decreases with the decrease in the internal pressure of the liquid refrigerant flow path (41). The differential pressure between the pressure of the high-pressure refrigerant introduced from the third port (P3) and the internal pressure of the first low-pressure pipe (55) causes the spool valve to move in the first four-way switching valve (51). As a result, the first four-way switching valve (51) is placed in the second state in which the first port (P1) and the third port (P3) communicate with each other, and the second port (P2) and the fourth port (P4) communicate with each other, as shown in FIG. 4. In this way, the first four-way switching valve (51) blocks the liquid refrigerant flow path (41).

[0074] Likewise, in the second four-way switching valve (52), the internal pressure of the second low-pressure pipe (56) decreases with the decrease in the internal pressure of the gas refrigerant flow path (42). The differential pressure between the pressure of the high-pressure refrigerant introduced from the third port (P3) and the internal pressure of the second low-pressure pipe (56) causes the spool valve to move in the second four-way switching valve (52). As a result, the second four-way switching valve (52) is placed in the second state in which the first port (P1) and the third port (P3) communicate with each other, and the second port (P2) and the fourth port (P4) communicate with each other, as shown in FIG. 4. In this way, the first four-way switching valve (51) blocks the liquid refrigerant flow path (41).

[0075] As described above, each of the four-way switching valves (51, 52) of this embodiment uses the decrease in the internal pressure of the low-pressure pipe (55, 56) to switch to the second state automatically when the refrigerant leaks in the utilization circuit (30a). In this way, the utilization circuit (30a) may be reliably switched to a closed circuit.

[0076] A pilot pipe and a pilot valve of known art may be used in switching the four-way switching valves (51, 52) of a differential pressure drive type from the first state to the second state.

-Another Operation When Refrigerant Leaks-

[0077] When the refrigerant leaks in the utilization circuit (30a), the refrigerant leakage detection sensor (35) detects the leakage. When the indoor controller (33) receives the detection signal from the refrigerant leakage detection sensor (35), a sign indicating the leakage is displayed on a display unit. The display unit may be provided, for example, in the remote control (34) or in a decorative panel of the indoor unit (30). The display unit is switched between displaying a status indicating an abnormality due to the leakage of the refrigerant and displaying a status indicating normality because of no leakage of the refrigerant.

-Advantages of Embodiment-

[0078] The air conditioner of the embodiment includes: a refrigerant circuit (10a) including a heat source circuit (20a) to which a compressor (21) and an outdoor heat exchanger (22) are connected, and a utilization circuit (30a) to which an indoor heat exchanger (31) is connected, and configured to perform a refrigeration cycle; an outdoor unit (20) including the heat source circuit (20a); and an indoor unit (30) provided with the utilization circuit (30a). The refrigerant circuit (10a) further includes: two refrigerant flow paths (41, 42) connected to respective ends of the utilization circuit (30a), and two cut-off valves connected to the respective refrigerant flow paths (41, 42). At least one of the two cut-off valves is configured as a flow path switching valve (V1, V2) configured to switch a flow path so as to block refrigerant flow paths (41, 42) when the refrigerant leaks in the utilization circuit (30a).

[0079] The cut-off valves of the liquid refrigerant flow path (41) and the gas refrigerant flow path (42) are configured as respective flow path switching valves (V1, V2). Due to its structure, the flow path switching valves (V1, V2) each have a relatively wide flow path as compared with an electromagnetic valve or an expansion valve.

This allows a reduction in the pressure loss when the refrigerant passes through the flow path switching valve (V1, V2) during the cooling operation and the heating operation. Therefore, the power consumption of the air conditioner (10) can be reduced. Switching the flow paths of the flow path switching valves (V1, V2) enables the flow of the refrigerant to be blocked.

[0080] In this embodiment, the refrigerant flow paths (41, 42) includes respective first flow paths (41a, 42a) formed on sides of the respective flow path switching valves (V1, V2) closer to the heat source circuit (20a), and respective second flow paths (41b, 42b) formed on sides of the flow path switching valves (V1, V2) closer to the utilization circuit (30a), and the flow path switching valves (V1, V2) are configured as respective four-way switching valves (51, 52) each having a first port (P1) connected to associated one of the first flow paths (41a, 42a), a second port (P2) connected to associated one of the second flow paths (41b, 42b), a third port (P3), and a fourth port (P4).

[0081] The flow path switching valves (V1, V2) are configured as the respective four-way switching valves (51, 52). Due to its structure, the four-way switching valves (51, 52) each have a relatively wide flow path as compared to an electromagnetic valve or an expansion valve. This allows a reduction in the pressure loss when the refrigerant passes through the flow path switching valves (V1, V2) during the cooling operation and the heating operation. Therefore, the power consumption of the air conditioner (10) can be reduced. As described above, the four-way switching valves (51, 52) are connected to a pipe having an outer diameter of 12.7 mm or 15.9 mm. In general, the outdoor four-way switching valve (23) of the multiple-type air conditioner (10) may be connected to a pile having the same outer diameter. In the embodiment, the same kind of valve as the outdoor four-way switching valve (23) may be used as the four-way switching valves (51, 52). This allows a reduction in the amount of the refrigerant leaking when the valve is in the closed state, as compared to the case in which the electromagnetic valve or the expansion valve is used as the cut-off valve and is connected to the pipe having the outer diameter of 12.7 mm or 15.9 mm.

[0082] In this embodiment, the refrigerant circuit (10a) further includes a high-pressure introduction circuit (60) configured to introduce a high-pressure refrigerant in the first flow paths (41a, 42a) into the third port (P3), and the four-way switching valves (51, 52) are of a differential pressure drive type, using the high-pressure refrigerant introduced into the third port (P3) as a drive source.

[0083] The high-pressure refrigerant in the first flow paths (41a, 42a) is introduced into the third port (P3) of the four-way switching valves (51, 52). The pressure of the high-pressure refrigerant is used to switch the states of the four-way switching valves (51, 52). This allows the refrigerant flow paths (41, 42) to be blocked without using another drive source such as an electric motor.

[0084] In the embodiment, the refrigerant circuit (10a) is configured to perform a first refrigeration cycle (cooling cycle) in which the outdoor heat exchanger (22) serves as a radiator and the indoor heat exchanger (31) serves as an evaporator, and a second refrigeration cycle (heating cycle) in which the indoor heat exchanger (31) serves as a radiator and the outdoor heat exchanger (22) serves as an evaporator, and the high-pressure introduction circuit (60) is configured to introduce the high-pressure refrigerant in the first flow path (41a, 42a) having higher pressure out of the first flow paths (41a, 42a) at least into the third port (P3).

[0085] In this configuration, the high-pressure refrigerant can be reliably introduced into the third port (P3) of the four-way switching valve (51, 52) during both cooling operation and heating operation. This allows the four-way switching valve (51, 52) to be reliably switched using the pressure of the high-pressure refrigerant.

[0086] In the embodiment, the high-pressure introduction circuit (60) includes a liquid-side introduction path (61) for allowing the first liquid flow path (41a) of the liquid refrigerant flow path (41) and the third port (P3) to communicate with each other, and a gas-side introduction path (62) for allowing the first gas flow path (42a) of the gas refrigerant flow path (42) and the third port (P3) communicate with each other, the liquid-side introduction path (61) is provided with a first check valve (64) that is open during the first refrigeration cycle, and the gas-side introduction path (62) is provided with a second check valve (65) that is open during the second refrigeration cycle.

[0087] In this configuration, when the pressure in the liquid refrigerant flow path (41) increases during the first refrigeration cycle (cooling cycle), the first check valve (64) is open to introduce the high-pressure refrigerant into the third port (P3). When the pressure in the gas refrigerant flow path (42) increases during the second refrigeration cycle (heating cycle), the second check valve (65) is open to introduce the high-pressure refrigerant into the third port (P3).

[0088] In this embodiment, the four-way switching valves (51, 52) each have the fourth port (P4) in a closed state, the four-way switching valves (51, 52) in the first state each make the first port (P1) and the second port (P2) communicate with each other, and the third port (P3) and the fourth port (P4) communicate with each other, and the four-way switching valves (51, 52) in a second state each make the first port (P1) and the third port (P3) communicate with each other, and the second port (P2) and the fourth port (P4) communicate with each other.

[0089] In this configuration, when the four-way switching valves (51, 52) are in the first state, the first port (P1) and the second port (P2) communicate with each other, and the refrigerant flow paths (41, 42) are conductive. In this state, the cooling operation and the heating operation are performed. When the four-way switching valves (51, 52) are in the second state, the second port (P2) and the fourth port (P4) in the closed state communicate with each other. In this state, the liquid refrigerant flow path

(41) and the gas refrigerant flow path (42) are blocked, and the utilization circuit (30a) is disconnected from the refrigerant circuit (10a).

[0090] In this embodiment, the four-way switching valves (51, 52) includes respective low-pressure pipes (55, 56) that communicate with the utilization circuit (30a), and are switched to the second state by differential pressures between the high-pressure refrigerant and internal pressures of the low-pressure pipes (55, 56).

[0091] When the refrigerant leaks in the utilization circuit (30a), the internal pressure of the utilization circuit (30a) decreases. Accordingly, the internal pressures of the low-pressure pipes (55, 56) decrease. At the four-way switching valves (51, 52), the differential pressures between the high-pressure refrigerant and the internal pressures of the low-pressure pipes (55, 56) increase, and the four-way switching valves (51, 52) are switched from the first state to the second state. The four-way switching valves (51, 52) are switched to the second state automatically when the refrigerant leaks in the utilization circuit (30a).

[0092] In this embodiment, the flow path switching valve (V1, V2) is connected to at least the gas refrigerant flow path (42) out of the two refrigerant flow paths (41, 42). The pipe diameter of the gas refrigerant flow path (42) is larger than the pipe diameter of the liquid refrigerant flow path (41). Therefore, the flow path switching valve (V1, V2) provided in the gas refrigerant flow path (42) enables effective reduction in the increase in pressure loss caused by a shield valve.

<First Variation>

[0093] In the foregoing embodiment, the first check valve (64), which is a first on-off valve, is provided in the liquid-side introduction path (61) of the high-pressure introduction circuit (60). The second check valve (65), which is a second on-off valve, is provided in the gas-side introduction path (62) of the high-pressure introduction circuit (60). In the first variation, instead of the first check valve (64), the first on-off valve is configured as a first electromagnetic on-off valve, and instead of the second check valve (65), the second on-off valve is configured as a second electromagnetic on-off valve. The first electromagnetic on-off valve is open during the first refrigeration cycle (cooling cycle) and is closed during the second refrigeration cycle (heating cycle). The second electromagnetic on-off valve is closed during the first refrigeration cycle (cooling cycle) and is closed during the second refrigeration cycle (heating cycle). Thus, similarly to the foregoing embodiment, the high-pressure refrigerant is allowed to be reliably introduced into the third port (P3) of the four-way switching valve (51, 52) during both cooling operation and heating operation.

<Second Variation>

[0094] FIGS. 5A and 5B illustrate a second variation, in which the configuration of the cut-off unit (50) is different from that of the foregoing embodiment. The cut-off valve of the cut-off unit (50) is configured as three-way switching valves (71, 72). The three-way switching valves (71, 72) of this example are so-called rotary valves of an electric rotary type.

[0095] The first three-way switching valve (71) is connected to the liquid refrigerant flow path (41). The second three-way switching valve (72) is connected to the gas refrigerant flow path (42). The three-way switching valves (71, 72) each have a first port (P1), a second port (P2), and a third port (P3).

[0096] The first port (P1) of the first three-way switching valve (71) is connected to the first liquid flow path (41a). The second port (P2) of the first three-way switching valve (71) is connected to the second liquid flow path (41b). The third port (P3) of the first three-way switching valve (71) is closed with a third closing member (83). The first port (P1) of the second three-way switching valve (72) is connected to the first gas flow path (42a). The second port (P2) of the second three-way switching valve (72) is connected to the second gas flow path (42b). The third port (P3) of the second three-way switching valve (72) is closed with a fourth closing member (84).

[0097] The three-way switching valves (71, 72) each include an electric motor (75), a rotating portion (76) rotationally driven by the electric motor (75), and a case (78) housing the rotating portion (76). In the case (78), the first port (P1), the second port (P2), and the third port (P3) are formed. In the rotating portion (76), an internal flow path (77) is formed. The internal flow path (77) of this example is formed to have a substantially L-shaped cross section when cut in the direction perpendicular to the axis thereof.

[0098] Three-way switching valves (71, 72) are each switched between a first state in which the refrigerant flow path (41, 42) is conductive and a second state in which the refrigerant flow path (41, 42) is blocked.

[0099] During the normal operation (cooling operation and heating operation) shown in FIG. 5A, the control unit (57) controls the three-way switching valves (71, 72) into the first state. The control unit (57) controls the electric motor (75) to place the three-way switching valves (71, 72) in the first state. The rotating portion (76) of each of the three-way switching valves (71, 72) in the first state is placed at a rotational angle position at which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77). This allows the refrigerant to flow through the liquid refrigerant flow path (41) and the gas refrigerant flow path (42) during the cooling operation and the heating operation.

[0100] When the refrigerant leaks in the utilization circuit (30a), and the refrigerant leakage detection sensor (35) detects the leakage, a signal is output from the indoor controller (33) to the control unit (57). As shown in FIG. 5B, when the control unit (57) receives the signal, it switches the three-way switching valves (71, 72) to the second state. The control unit (57) controls the electric motor (75) to place the three-way switching valves (71, 72) in the second state. The rotating portion (76) of each of the three-way switching valves (71, 72) in the second state is placed at a rotational angle position at which the first port (P1) and the third port (P3) communicate with each other via the internal flow path (77). This causes the second port (P2) to be substantially closed when the refrigerant leaks, thereby disconnecting the utilization circuit (30a) from the refrigerant circuit (10a).

[0101] In the second variation, the flow path switching valves (V1, V2) are of an electric rotary-type and each have a first port (P1) connected to associated one of the first flow paths (41a, 42a), a second port (P2) connected to associated one of the second flow paths (41b, 42b), a rotating portion (76) in which an internal flow path (77) is formed, and an electric motor (75) configured to rotatably drive the rotating portion (76), and the rotating portion (76) of the flow path switching valve (V1, V2) can be placed at a rotational angle position of the first state in which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77), and placed at a rotational angle position of the second state in which the first port (P1) and the second port (P2) are closed.

[0102] The electric rotary-type flow path switching valves (V1, V2) each have a relatively wide flow path as compared to an electromagnetic valve or a motor-operated valve. This allows a reduction in the pressure loss in the cut-off valve.

[0103] In the second variation, the refrigerant flow paths (41, 42) include respective first flow paths (41a, 42a) formed on sides of the respective flow path switching valves (V1, V2) closer to the heat source circuit (20a), and respective second flow paths (41b, 42b) formed on sides of the flow path switching valves (V1, V2) closer to the utilization circuit (30a), and the flow path switching valves (V1, V2) are configured as three-way switching valves (71, 72) of an electric rotary type and each have a third port (P3) in a closed state, and the rotating portion (76) of each of the three-way switching valves (71, 72) in the first state is placed at a rotational angle position at which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77), and the rotating portion (76) of each of the three-way switching valves (71, 72) in the second state is placed at a rotational angle position at which one of the first port (P1) or the second port (P2) communicates with the third port (P3) via the internal flow path (77), and the other one of the first port (P1) or the second port (P2) is closed with the rotating portion (76).

[0104] With this configuration, the three-way switching valves (71, 72) are each switchable between a state in which the refrigerant flow path (41, 42) is conductive and a state in which the refrigerant flow path (41, 42) is blocked.

[0105] Alternatively, the three-way switching valves (71,72) may each be configured such that, in the second state, the first port (P1) and the closed third port (P3) communicate with each other, and the second port (P2) is closed with a surface of the rotating portion (76). This configuration allows the refrigerant to flow through the refrigerant flow paths (41, 42) during the cooling operation and the heating operation, and allows the utilization circuit (30a) to be disconnected from the refrigerant circuit (10a) when the refrigerant leaks.

<Third Variation>

[0106] FIGS. 6A and 6B illustrate a third variation, in which the configuration of the cut-off unit (50) is different from that of the foregoing embodiment. The cut-off valve of the cut-off unit (50) is configured as two-way switching valves (81, 82). The two-way switching valves (81, 82) of the present example are so-called rotary valves of an electric rotary type.

[0107] The first two-way switching valve (81) is connected to the liquid refrigerant flow path (41). The second two-way switching valve (82) is connected to the gas refrigerant flow path (42). The two-way switching valves (81, 82) each have a first port (P1) and a second port (P2).

[0108] The first port (P1) of the first two-way switching valve (81) is connected to the first liquid flow path (41a). The second port (P2) of the first two-way switching valve (81) is connected to the second liquid flow path (41b). The first port (P1) of the second two-way switching valve (82) is connected to the first gas flow path (42a). The second port (P2) of the second two-way switching valve (82) is connected to the second gas flow path (42b). The third port (P3) of the second two-way switching valve (82) is closed with the fourth closing member (84).

[0109] The two-way switching valves (81, 82) each include an electric motor (75), a rotating portion (76) rotationally driven by the electric motor (75), and a case (78) housing the rotating portion (76). In the case (78), the first port (P1) and the second port (P2) are formed. In the rotating portion (76), an internal flow path (77) is formed. The internal flow path (77) of this example is formed to have a linear cross section when cut in the direction perpendicular to the axis thereof.

[0110] The two-way switching valves (81, 82) are each switched between a first state in which the refrigerant flow path (41, 42) is conductive and a second state in which the refrigerant flow path (41, 42) is blocked.

[0111] During the normal operation (cooling operation and heating operation) shown in FIG. 6A, the control unit (57) controls the two-way switching valves (81, 82) into the first state. The control unit (57) controls the electric motor (75) to place the two-way switching valves (81, 82) in the first state. The rotating portion (76) of each of the two-way switching valves (81, 82) in the first state is placed at a rotational angle position at which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77). This allows the refrigerant to flow through the liquid refrigerant flow path (41) and the gas refrigerant flow path (42) during the cooling operation and the heating operation.

[0112] When the refrigerant leaks in the utilization circuit (30a), and the refrigerant leakage detection sensor (35) detects the leakage, a signal is output from the indoor controller (33) to the control unit (57). As shown in FIG. 6B, when receiving this signal, the control unit (57) switches the two-way switching valves (81, 82) to the second state. The control unit (57) controls the electric motor (75) to place the two-way switching valves (81, 82) in the second state. The rotating portion (76) of each of the two-way switching valves (81, 82) in the second state is placed at a rotational angle position at which the first port (P1) and the second port (P2) are closed with the rotating portion (76). In this example, the internal flow path (77) is orthogonal to the first port (P1) and the second port (P2). Thus, the first port (P1) and the second port (P2) are closed with a surface of the rotating portion (76) when the refrigerant leaks. The utilization circuit (30a) is disconnected from the refrigerant circuit (10a).

[0113] The two-way switching valves may each be a ball valve applicable to a water pipe or the like.

<Fourth Variation>

[0114] The electric rotary-type flow path switching valve may be a four-way switching valve having four ports. In this case, two ports of the four-way switching valve are closed with a closing member, for example. The four-way switching valve switches between a first state in which the first port (P1) and the second port (P2) communicate with each other and a state in which the second port (P2) is closed.

<<Other Embodiments>>

[0115] As shown in FIG. 7, in the air conditioner (10), a plurality of indoor units (30) may be connected in parallel to a pair of refrigerant flow paths (41, 42). Strictly speaking, a plurality of utilization circuits (30a) may be connected in parallel to the pair of the liquid refrigerant flow path (41) and the gas refrigerant flow path (42).

[0116] As shown in FIG. 8, the air conditioner (10) may be configured such that the heat source circuit (20a) of one outdoor unit (20) and the utilization circuit (30a) of one indoor unit (30) are connected to each other via the liquid connection pipe (11) and the gas connection pipe (15). In other words, the air conditioner (10) may be of a so-called pair type. In this configuration, the liquid connection pipe (11) constitutes the liquid-side refrigerant flow path (41) on a liquid side, and the gas connection pipe (15) constitutes the refrigerant flow path (42) on a gas side.

[0117] The indoor unit (30) is not limited to a ceiling-mounted type, and may be of another type such as a wall-mounted type or a floor-mounted type.

[0118] The flow path switching valves (V1, V2) of the above-described embodiments and variations may be combined in any pattern. For example, the flow path switching valve of the present disclosure may be adopted in only one of the two refrigerant flow paths (41, 42), and an electromagnetic valve or an expansion valve may be adopted in the other.

<Refrigerant>

[0119] The refrigerants used in the refrigerant circuit (10a) of the air conditioner (10) of the embodiment, the variations, and the other embodiments are flammable refrigerants. The flammable refrigerant includes refrigerants falling under Class 3 (highly flammable), Class 2 (less flammable), and Subclass 2L (mildly flammable) in the standards of ASHRAE34 Designation and safety classification of refrigerant in the United States or the standards of ISO817 Refrigerants- Designation and safety classification. FIG. 9 shows specific examples of the refrigerants used in the embodiment and the variations. In FIG. 9, "ASHRAE Number" indicates the ASHRAE number of each refrigerant defined in ISO 817, "Component" indicates the ASHRAE number of each substance contained in the refrigerant, "mass%" indicates the concentration of each substance contained in the refrigerant by mass%, and "Alternative" indicates the name of an alternative to the substance of the refrigerant which is often replaced by the alternative. The refrigerant used in the present embodiment is R32. The examples of the refrigerants shown in FIG. 9 are characterized by having a higher density than air.

[0120] While the embodiments and the variations thereof have been described above, it will be understood that various changes in form and details may be made without departing from the spirit and scope of the claims. The embodiment, the variations thereof, and the other embodiments may be combined and replaced with each other without deteriorating intended functions of the present disclosure. The expressions of "first," "second," and "third" described above are used to distinguish the terms to which these expressions are given, and do not limit the number and order of the terms.

INDUSTRIAL APPLICABILITY

[0121] The present disclosure is useful for an air conditioner and a flow path switching valve.

DESCRIPTION OF REFERENCE CHARACTERS

[0122]

10	Air Conditioner
10a	Refrigerant Circuit
20	Outdoor Unit (Heat Source Unit)
20a	Heat Source Circuit
21	Compressor
22	Outdoor Heat Exchanger (Heat Source Heat Exchanger)
30	Indoor Unit (Utilization Unit)
30a	Utilization Circuit

31	Indoor Heat Exchanger (Utilization Heat Exchanger)
41	Refrigerant Flow Path
42	Refrigerant Flow Path
41a, 42a	First Flow Path
41b, 42b	Second Flow Path
51, 52	Four-way Switching Valve
55, 56	Low-pressure Pipe
60	High-pressure Introduction Circuit
61	Liquid-side Introduction Path
62	Gas-side Introduction Path
62	Gas-side Introduction Path
64	First Check Valve (First On-off Valve)
65	Second Check Valve (Second On-off Valve)
71, 72	Three-way Switching Valve
75	Electric Motor
76	Rotating Portion
77	Internal Flow Path
V1, V2	Flow Path Switching Valve

Claims

1. An air conditioner comprising:

a refrigerant circuit (10a) that includes a heat source circuit (20a) to which a compressor (21) and a heat source heat exchanger (22) are connected, and includes a utilization circuit (30a) to which a utilization heat exchanger (31) is connected, and that is configured to perform a refrigeration cycle,
the refrigerant circuit (10a) further including: two refrigerant flow paths (41, 42) connected to respective ends of the utilization circuit (30a), and two cut-off valves connected to the respective refrigerant flow paths (41, 42), wherein
at least one of the cut-off valves is configured as a flow path switching valve (V1, V2) configured to switch a flow path so as to block the refrigerant flow paths (41, 42) when a refrigerant leaks in the utilization circuit (30a).

2. The air conditioner of claim 1, wherein

the refrigerant flow paths (41, 42) include respective first flow paths (41a, 42a) formed between the flow path switching valve (V1, V2) and the heat source circuit (20a), and respective second flow paths (41b, 42b) formed between the flow path switching valve (V1, V2) and the utilization circuit (30a), and
the flow path switching valve (V1, V2) is configured as a four-way switching valve (51, 52) having a first port (P1) connected to associated one of the first flow paths (41a, 42a), a second port (P2) connected to associated one of the second flow paths (41b, 42b), a third port (P3), and a fourth port (P4).

3. The air conditioner of claim 2, wherein

the refrigerant circuit (10a) further includes a high-pressure introduction circuit (60) configured to introduce a high-pressure refrigerant in the first flow paths (41a, 42a) into the third port (P3), and
the four-way switching valve (51, 52) is of a differential pressure drive type using the high-pressure refrigerant introduced into the third port (P3) as a drive source.

4. The air conditioner of claim 3, wherein

the refrigerant circuit (10a) is configured to perform a first refrigeration cycle in which the heat source heat exchanger (22) serves as a radiator and the utilization heat exchanger (31) serves as an evaporator, and a second refrigeration cycle in which the utilization heat exchanger (31) serves as a radiator and the heat source heat exchanger (22) serves as an evaporator, and
the high-pressure introduction circuit (60) is configured to introduce at least the high-pressure refrigerant in the first flow path (41a, 42a) having higher pressure out of the two first flow paths (41a, 42a) of the refrigerant flow paths (41, 42) into the third port (P3).

5. The air conditioner of claim 4, wherein

the high-pressure introduction circuit (60) includes

a liquid-side introduction path (61) for allowing the first flow path (41a, 42a) of the refrigerant flow path (41) on a liquid side to communicate with the third port (P3),
a gas-side introduction path (62) for allowing the first flow path (41a, 42a) of the refrigerant flow path (42) on a gas side to communicate with the third port (P3), and

the liquid-side introduction path (61) is provided with a first on-off valve (64) that is open during the first refrigeration cycle, and
the gas-side introduction path (62) is provided with a second on-off valve (65) that is open during the second refrigeration cycle.

6. The air conditioner of any one of claims 3 to 5, wherein

the four-way switching valve (51, 52) has a fourth port (P4) that is closed,
the four-way switching valve (51, 52) in a first

state makes the first port (P1) and the second port (P2) communicate with each other, and the third port (P3) and the fourth port (P4) communicate with each other, and

the four-way switching valve (51, 52) in a second state makes the first port (P1) and the third port (P3) communicate with each other, and the second port (P2) and the fourth port (P4) communicate with each other.

7. The air conditioner of any one of claims 2 to 6, wherein

the four-way switching valve (51, 52) includes a low-pressure pipe (55, 56) that communicates with the utilization circuit (30a), and is switched to a second state by differential pressure between the high-pressure refrigerant and internal pressure of the low-pressure pipe (55, 56).

8. The air conditioner of claim 1, wherein

the refrigerant flow paths (41, 42) include respective first flow paths (41a, 42a) formed between the flow path switching valve (V1, V2) and the heat source circuit (20a), and respective second flow paths (41b, 42b) formed between the flow path switching valve (V1, V2) and the utilization circuit (30a),

the flow path switching valve (V1, V2) is of an electric rotary-type and has a first port (P1) connected to associated one of the first flow paths (41a, 42a), a second port (P2) connected to associated one of the second flow paths (41b, 42b), a rotating portion (76) in which an internal flow path (77) is formed, and an electric motor (75) configured to rotatably drive the rotating portion (76), and

the rotating portion (76) of the flow path switching valve (V1, V2) is placed at a rotational angle position of a first state in which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77), and is placed at a rotational angle position of a second state in which the first port (P1) and the second port (P2) are closed.

9. The air-conditioning system of claim 8, wherein

the flow path switching valve (V1, V2) is configured as a three-way switching valve (71, 72) of an electric rotary type and has a third port (P3) that is closed, and

the rotating portion (76) of the three-way switching valve (71, 72) in the first state is placed at a rotational angle position at which the first port (P1) and the second port (P2) communicate with each other via the internal flow path (77), and

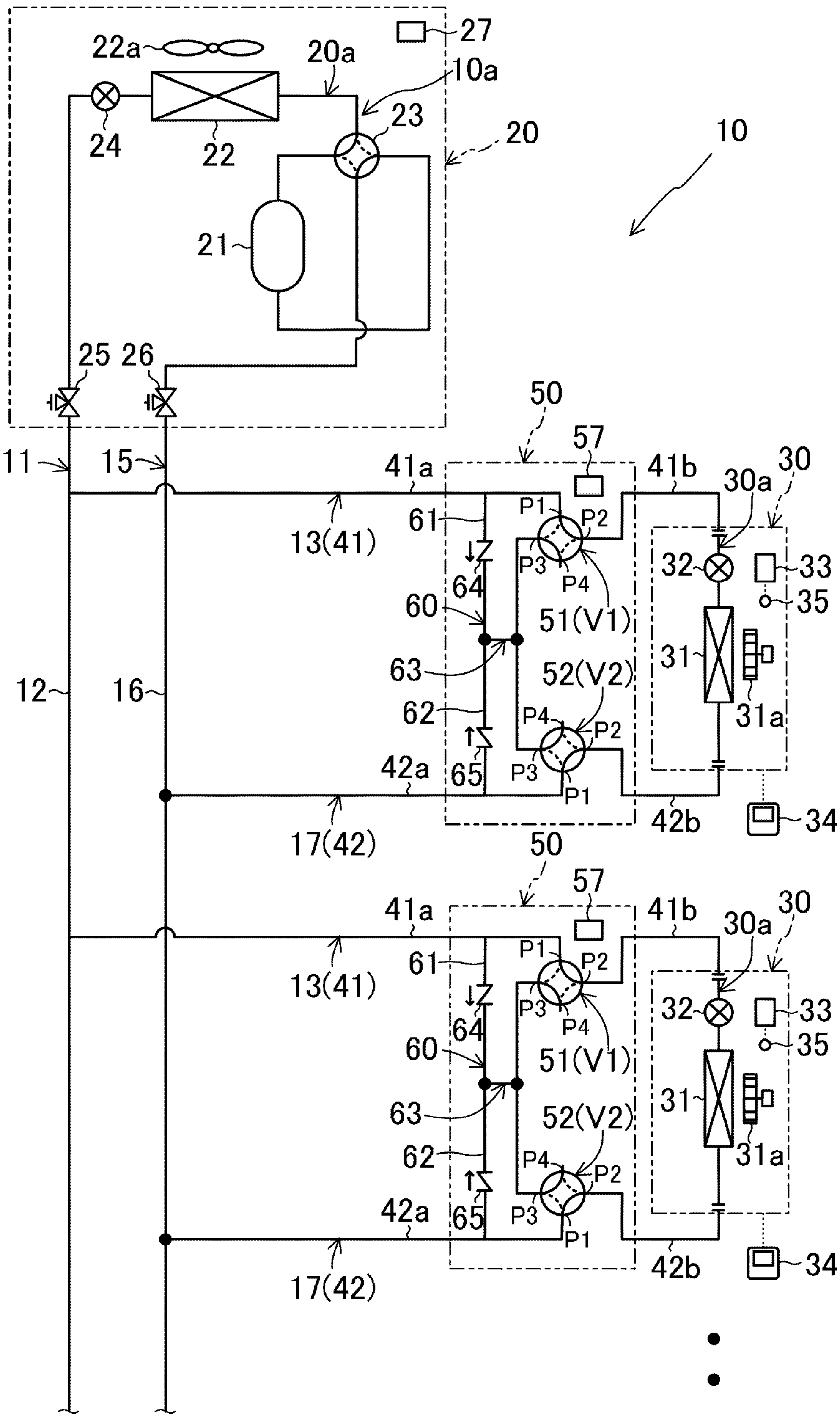
the rotating portion (76) of the three-way switching valve (71, 72) in the second state is placed at a rotational angle position at which one of the first port (P1) or the second port (P2) communicates with the third port (P3) via the internal flow path (77), and the other one of the first port (P1) or the second port (P2) is closed with the rotating portion (76).

10. The air conditioner of any one of claims 1 to 9, wherein

the flow path switching valve (V1, V2) is connected to at least the refrigerant flow path (42) on a gas side, out of the two refrigerant flow paths (41, 42).

11. A flow path switching valve that is a flow path switching valve (V1, V2) connected to a refrigerant flow path (41, 42) of the air conditioner (10) of any one of claims 1 to 10.

FIG.1



22a
20a
10a
27
23
24
22
20
10
21
25 26
50
57
11
15
41a
41b
30a
30
61
P1
P2
13(41)
P3
P4
32
33
35
64
60
51(V1)
31
63
52(V2)
12
16
62
31a
P4
P2
65
P3
P1
42a
17(42)
42b
34

FIG.2

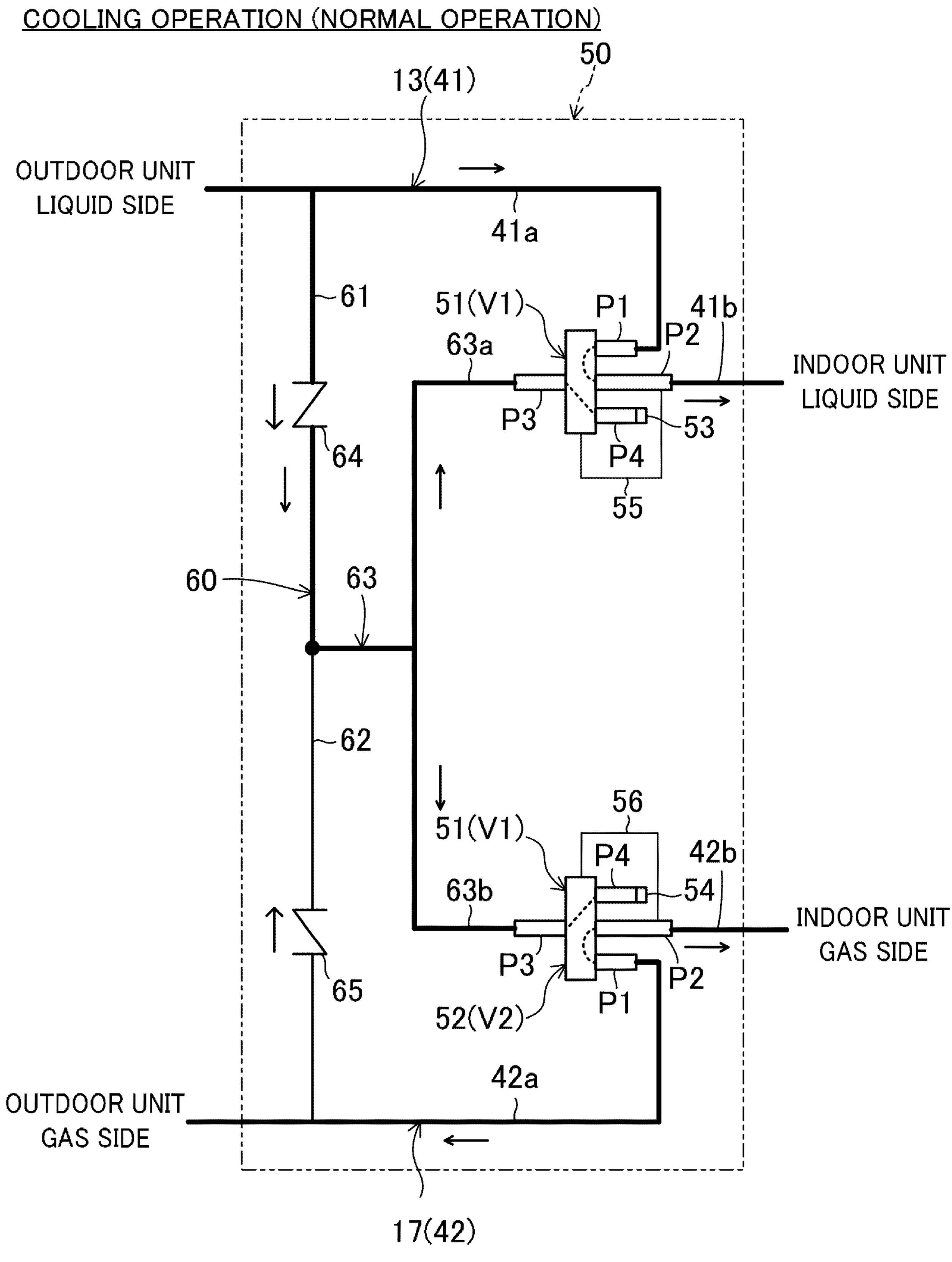

COOLING OPERATION (NORMAL OPERATION)
50
13(41)
OUTDOOR UNIT
LIQUID SIDE
41a
61
51(V1)
P1
41b
P2
63a
INDOOR UNIT
LIQUID SIDE
P3
53
64
P4
55
60
63
62
56
51(V1)
P4
42b
63b
54
INDOOR UNIT
GAS SIDE
P3
65
P2
P1
52(V2)
42a
OUTDOOR UNIT
GAS SIDE
17(42)

FIG.3

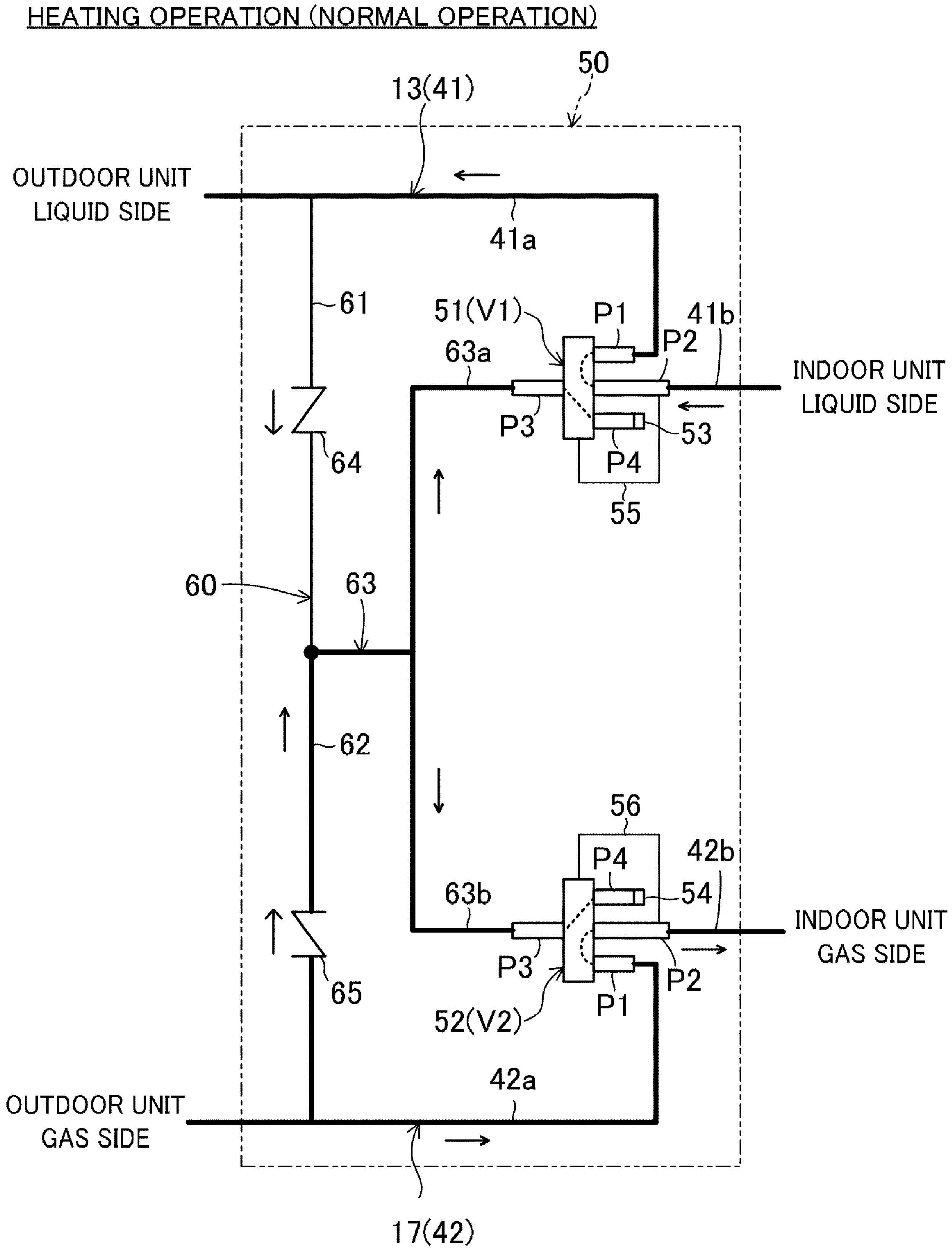

HEATING OPERATION (NORMAL OPERATION)
50
13(41)
OUTDOOR UNIT
LIQUID SIDE
41a
61
51(V1)
P1
41b
P2
63a
INDOOR UNIT
LIQUID SIDE
P3
53
P4
64
55
60
63
62
56
P4
42b
54
63b
INDOOR UNIT
GAS SIDE
P3
P2
65
P1
52(V2)
42a
OUTDOOR UNIT
GAS SIDE
17(42)

FIG.4

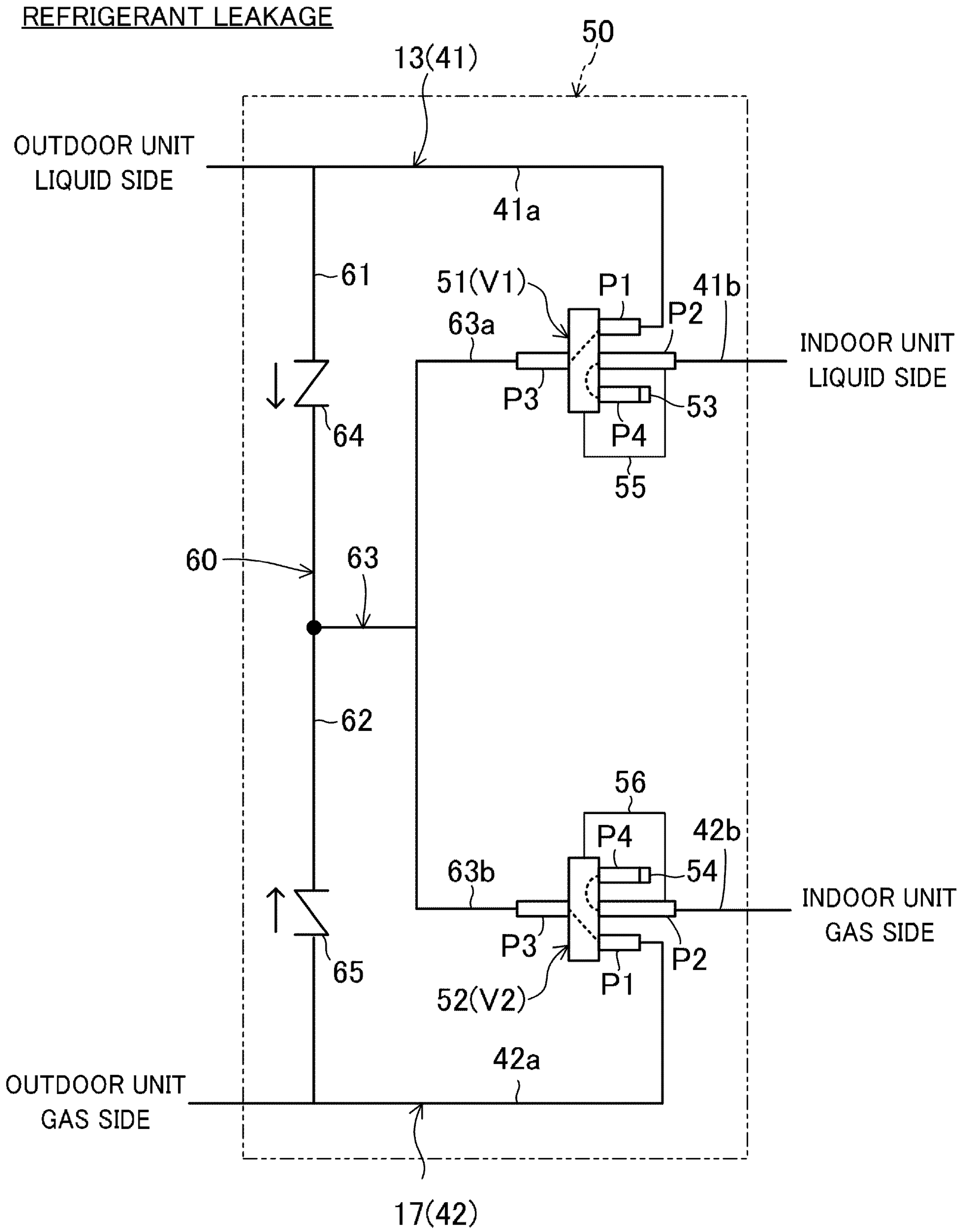

REFRIGERANT LEAKAGE
50
13(41)
OUTDOOR UNIT
LIQUID SIDE
41a
61
51(V1)
P1
41b
P2
63a
INDOOR UNIT
LIQUID SIDE
P3
53
64
P4
55
60
63
62
56
P4
42b
63b
54
INDOOR UNIT
GAS SIDE
P3
P2
65
P1
52(V2)
42a
OUTDOOR UNIT
GAS SIDE
17(42)

FIG.5A

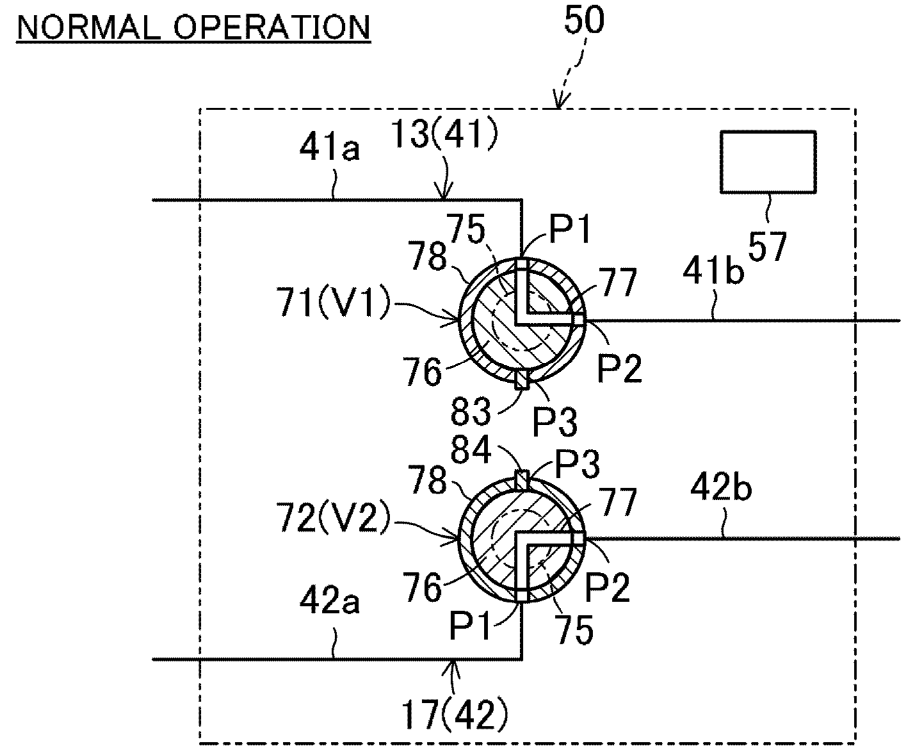

NORMAL OPERATION
50
41a
13(41)
57
75
P1
78
77
41b
71(V1)
76
P2
83
P3
84
P3
78
77
42b
72(V2)
76
P2
42a
P1
75
17(42)

FIG.5B

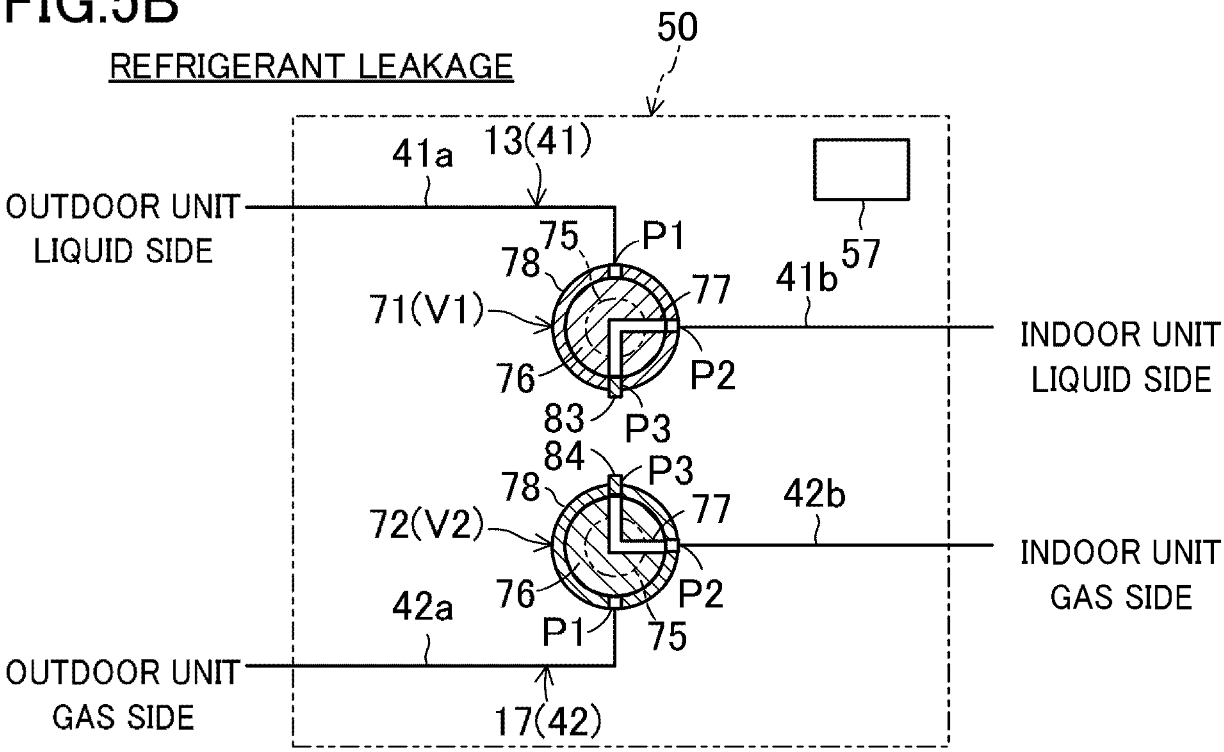

REFRIGERANT LEAKAGE
50
41a
13(41)
OUTDOOR UNIT
LIQUID SIDE
57
75
P1
78
77
41b
71(V1)
INDOOR UNIT
LIQUID SIDE
76
P2
83
P3
84
P3
78
77
42b
72(V2)
INDOOR UNIT
GAS SIDE
76
P2
42a
P1
75
OUTDOOR UNIT
GAS SIDE
17(42)

FIG.6A

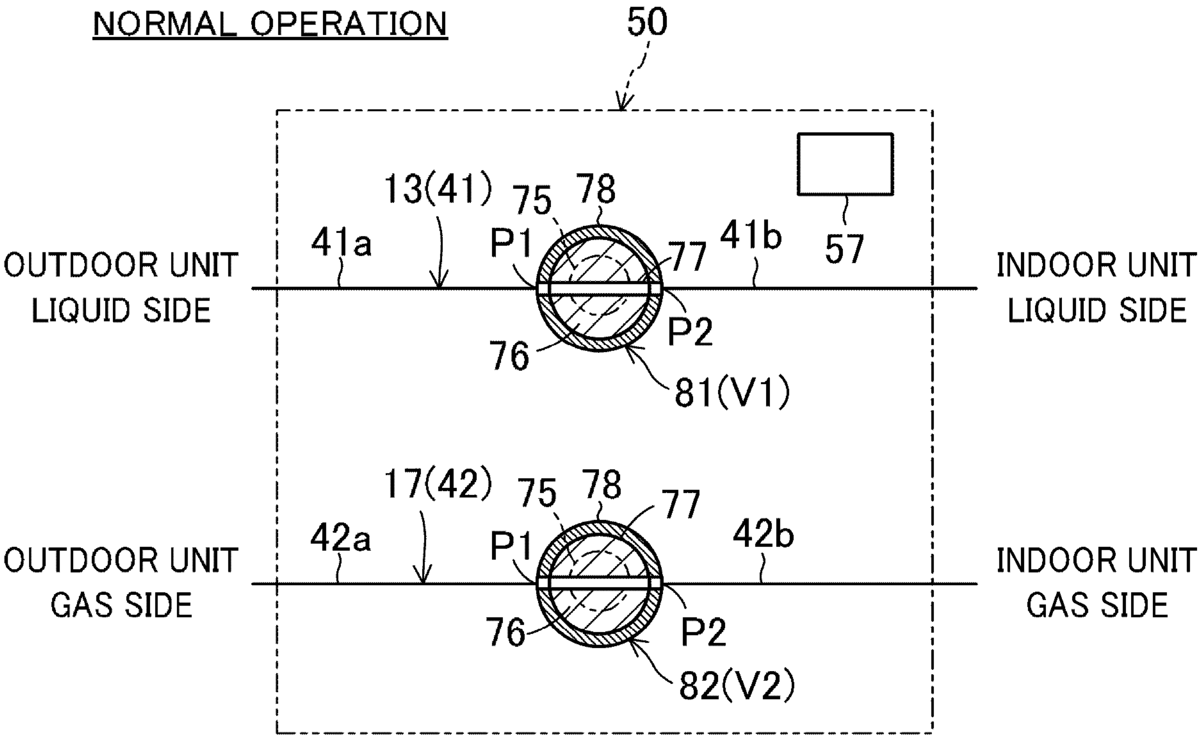

NORMAL OPERATION
50
13(41)
75
78
41a
P1
77
41b
57
OUTDOOR UNIT
LIQUID SIDE
INDOOR UNIT
LIQUID SIDE
P2
76
81(V1)
17(42)
75
78
77
42a
42b
P1
OUTDOOR UNIT
GAS SIDE
INDOOR UNIT
GAS SIDE
76
P2
82(V2)

FIG.6B

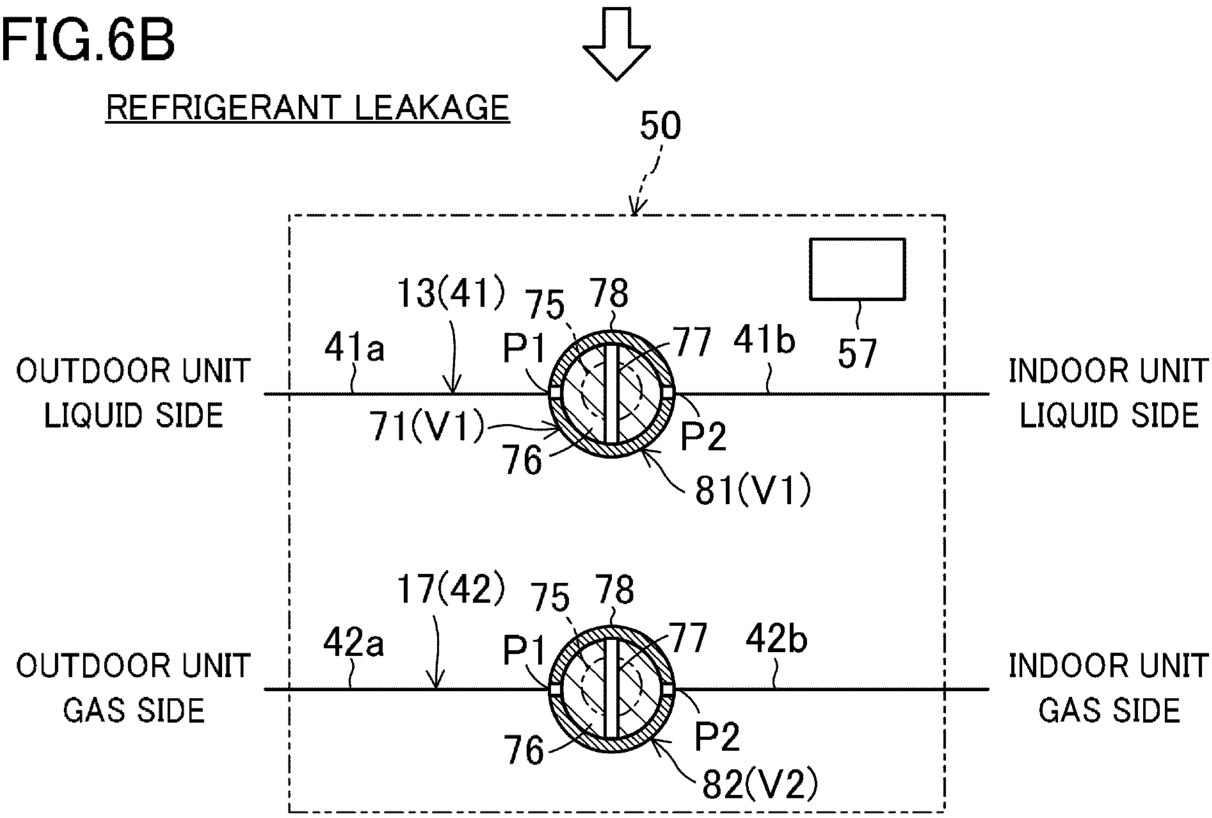

REFRIGERANT LEAKAGE
50
13(41)
75
78
41a
P1
77
41b
57
OUTDOOR UNIT
LIQUID SIDE
INDOOR UNIT
LIQUID SIDE
71(V1)
P2
76
81(V1)
17(42)
75
78
42a
P1
77
42b
OUTDOOR UNIT
GAS SIDE
INDOOR UNIT
GAS SIDE
P2
76
82(V2)

FIG.7

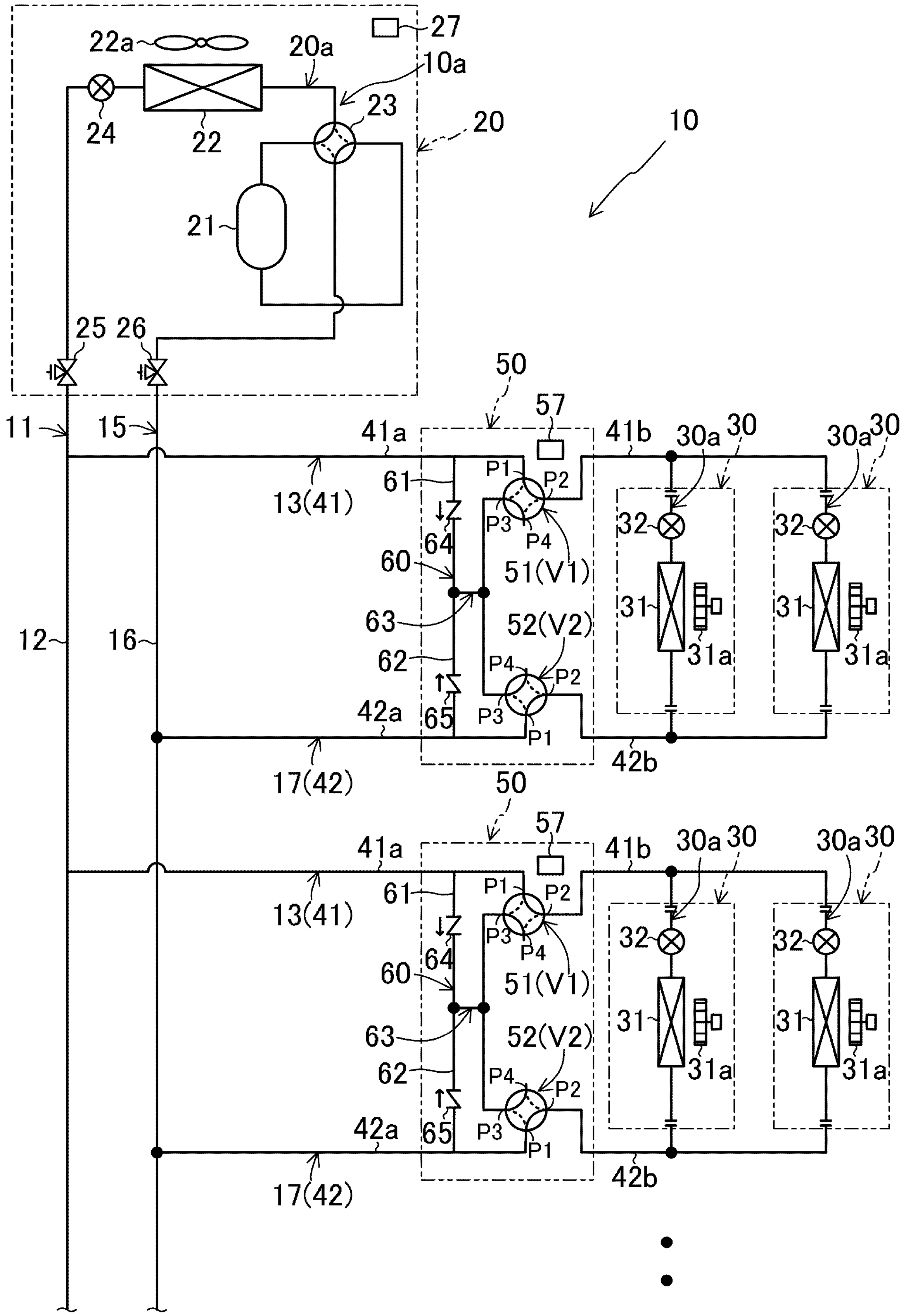

27
22a
20a
10a
23
24
22
20
10
21
25 26
50
57
11
15
41a
41b
30a 30
30a 30
61
P1
P2
13(41)
P3
32
32
64
P4
60
51(V1)
63
31
31
52(V2)
31a
31a
12
16
62
P4
P2
65
P3
42a
P1
17(42)
42b
50
57
41a
41b
30a 30
30a 30
61
P1
P2
13(41)
P3
32
32
64
P4
60
51(V1)
63
31
31
52(V2)
31a
31a
62
P4
P2
65
P3
42a
P1
17(42)
42b

FIG.8

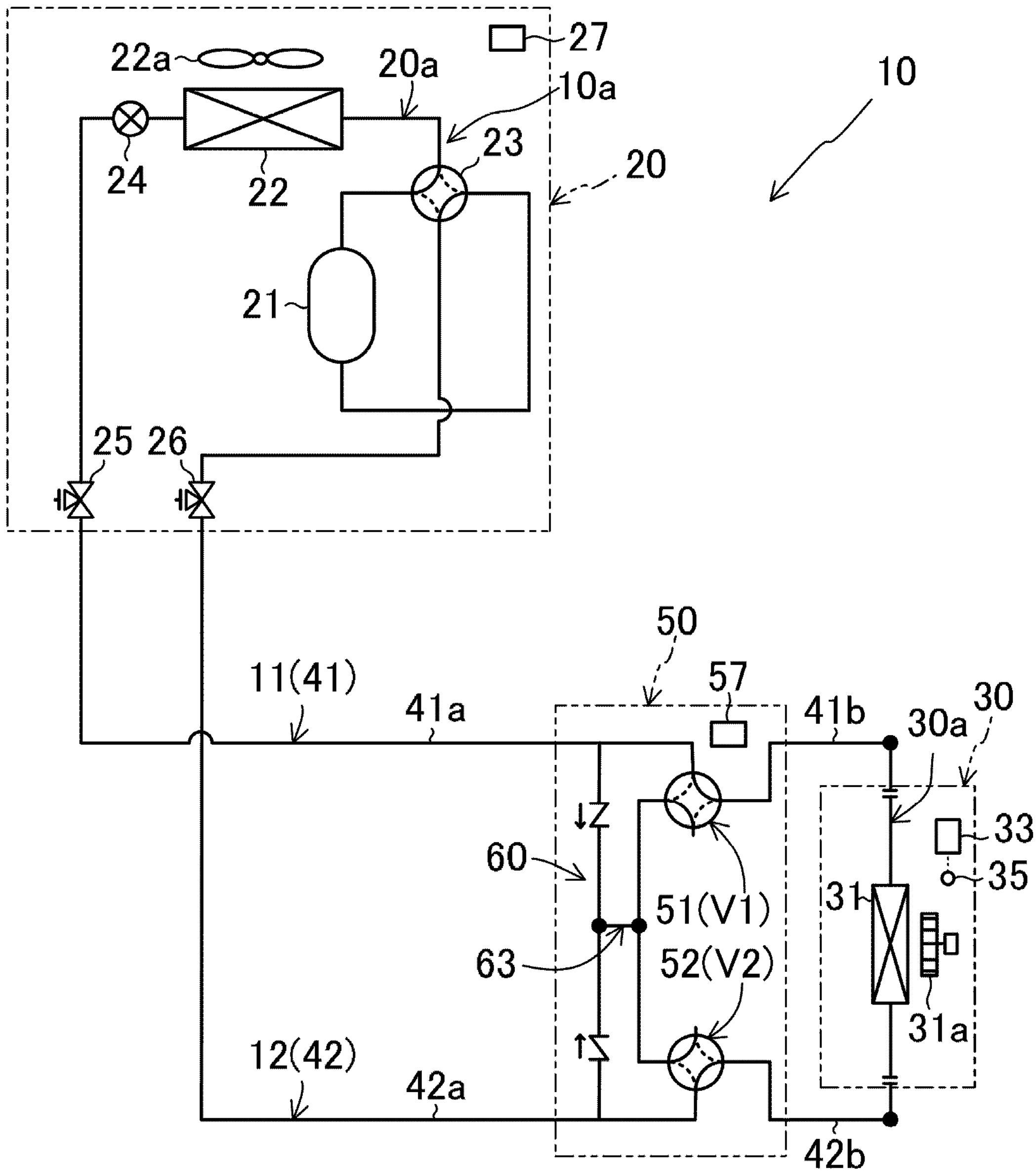

27
22a
20a
10a
10
23
24
22
20
21
25 26
50
57
11(41)
41a
41b
30a
30
33
60
35
31
51(V1)
63
52(V2)
31a
12(42)
42a
42b

FIG.9

ASHRAE Number	COMPONENT	MASS%	Alternative
R1234yf	R1234yf	(100)	R134a
R1234ze(E)	R1234ze(E)	(100)	R134a
	R1234yf/R134a/R152a	(82/7/11)	R134a
R516A	R1234yf/R134a/R152a	(77.5/8.5/14.0)	R134a
R445A	R744/R134a/R1234ze(E)	(6.0/9.0/85.0)	R134a
R444A	R32/R152a/R1234ze(E)	(12/5/83)	R134a
	R32/R125/R1234yf	(15/25/60)	R22/407
R454C	R32/R1234yf	(21.5/78.5)	R22/407
	R32/R152a/R1234ze(E)	(45/20/35)	R22/407
R444B	R32/R152a/R1234ze(E)	(41.5/48.5/10)	R22/407
	R744/R32/R1234ze(E)	(7/30/63)	R22/407
R454A	R32/R1234yf	(35/65)	R404A
R454A	R32/R1234yf	(35/65)	R404A
R454C	R32/R1234yf	(21.5/78.5)	R404A
	R32/R1234yf/R152a/R1234ze(E)	(40/20/10/30)	R404A
R455A	R744/R32/R1234yf	(3.0/21.5/75.5)	R404A
	R32/R1234yf/R134a	(28/51/21)	R404A
	R32/R1234yf/R152a	(35/55/10)	R404A
	R32/R1234yf	(29/71)	R404A
	R-32/R290/R1234yf	(21.0/7.9/71.1)	R404A
R457A	R32/R1234yf/R152a	(18/70/12)	R404A
R459B	R32/R1234yf/R1234ze(E)	(21/69/10)	R404A
	R32/R134a	(50/50)	R404A
	R32/R1234yf	(40/60)	R410A
R452B	R32/R125/R1234yf	(67/7/26)	R410A
	R32/R1234yf	(72.5/27.5)	R410A
R454B	R32/R1234yf	(68.9/31.1)	R410A
	R32/R125/R1234ze(E)	(68/15/17)	R410A
R447B	R32/R125/R1234ze(E)	(68/8/24)	R410A
R32	R32	(100)	R410A
R447A	R32/R1234ze(E)/R125	(68/28.5/3.5)	R410A
	R32/R1234yf/R1234ze(E)	(73/15/12)	R410A
	R32/R1234ze(E)	(72/27)	R410A
R446A	R32/R1234ze(E)/Butane	(68/29/3)	R410A
	R32/R1234yf/R134a	(50/40/10)	R410A
R459A	R32/R1234yf/R1234ze(E)	(68/26/6)	R410A
	R1123/R32	(32/68)	R410A
	R1123/R32	(40/60)	R410A
	R1123/R32	(45/55)	R410A
	R1123/R32/R1234yf	(19/55/26)	R410A
	R1123/R32/R1234yf	(40/44/16)	R410A
	R1123	(100)	R410A
	R744/R32/R1234ze(E)	(6/60/34)	R410A
	R32/R134a/R1234ze	(76/6/18)	R410A
	R32/R152a	(95/5)	R410A
	R32/R134a	(95/5)	R410A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/045808

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F24F11/36(2018.01)i, F24F11/86(2018.01)i, F25B41/04(2006.01)i, F25B49/02(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)
Int. Cl. F24F11/36, F24F11/86, F25B41/04, F25B49/02

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	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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.
A	JP 2010-7998 A (DAIKIN INDUSTRIES, LTD.) 14 January 2010, paragraphs [0040]-[0124], fig. 1-10 (Family: none)	1-11
A	JP 2015-117894 A (HITACHI APPLIANCES, INC.) 25 June 2015, entire text, all drawings (Family: none)	1-11
A	JP 11-182895 A (MITSUBISHI ELECTRIC CORP.) 06 July 1999, entire text, all drawings (Family: none)	1-11
A	JP 62-141469 A (DAIKIN INDUSTRIES, LTD.) 24 June 1987, entire text, all drawings (Family: none)	1-11

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

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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
13.12.2019	24.12.2019

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

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/045808

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-127519 A (PANASONIC CORP.) 05 July 2012, entire text, all drawings (Family: none)	1-11

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

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Patent documents cited in the description

- JP 2012013339 A **[0003]**