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(54) **AIR-CONDITIONING APPARATUS**

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(52) **U.S. Cl.**

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(57) **ABSTRACT**

An air-conditioning apparatus includes: an outdoor unit including a compressor and an outdoor heat exchanger, and configured to generate cooling energy or heating energy; an indoor unit including an indoor heat exchanger, and configured to perform an air-conditioning operation with the cooling energy or the heating energy that is generated by the outdoor unit; a refrigerant pipe provided between the outdoor unit and the indoor unit, and forming a refrigerant circuit in which refrigerant circulates; and a shut-off valve provided at the refrigerant pipe, and configured to be closed when a refrigerant leak is detected. The shut-off valve includes a service port communicating with the refrigerant pipe.

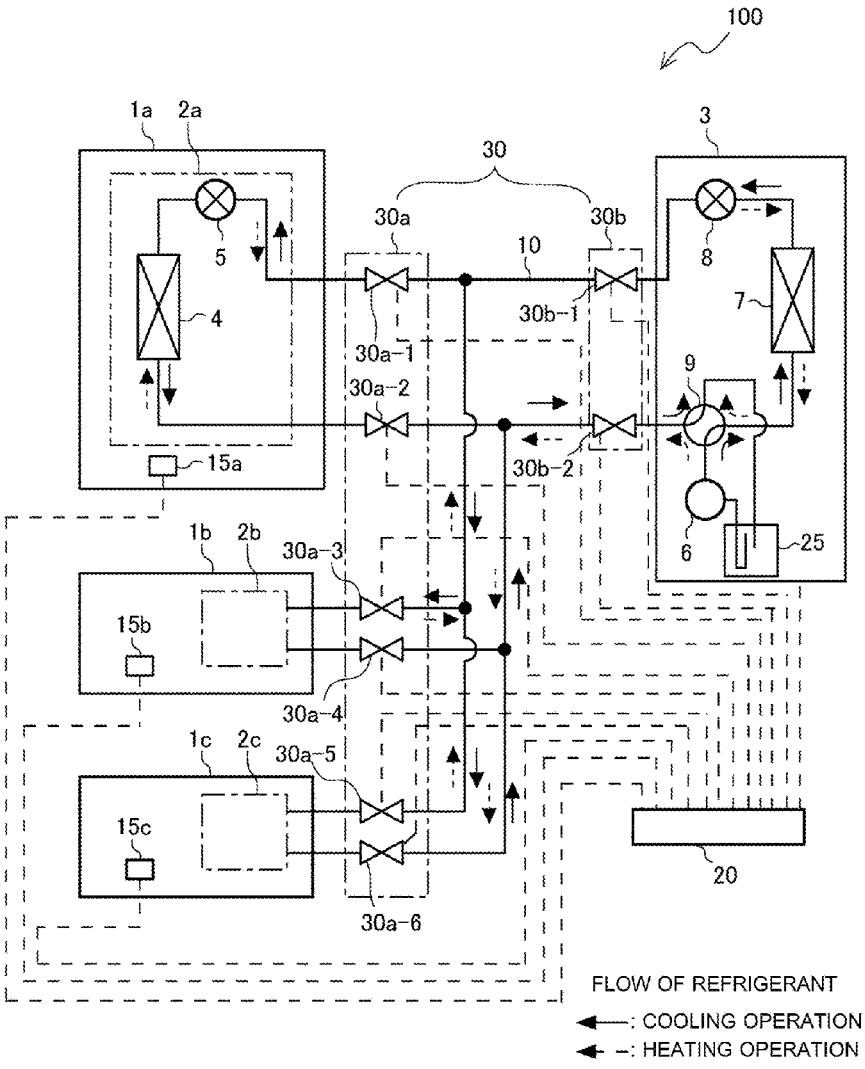


FIG. 1

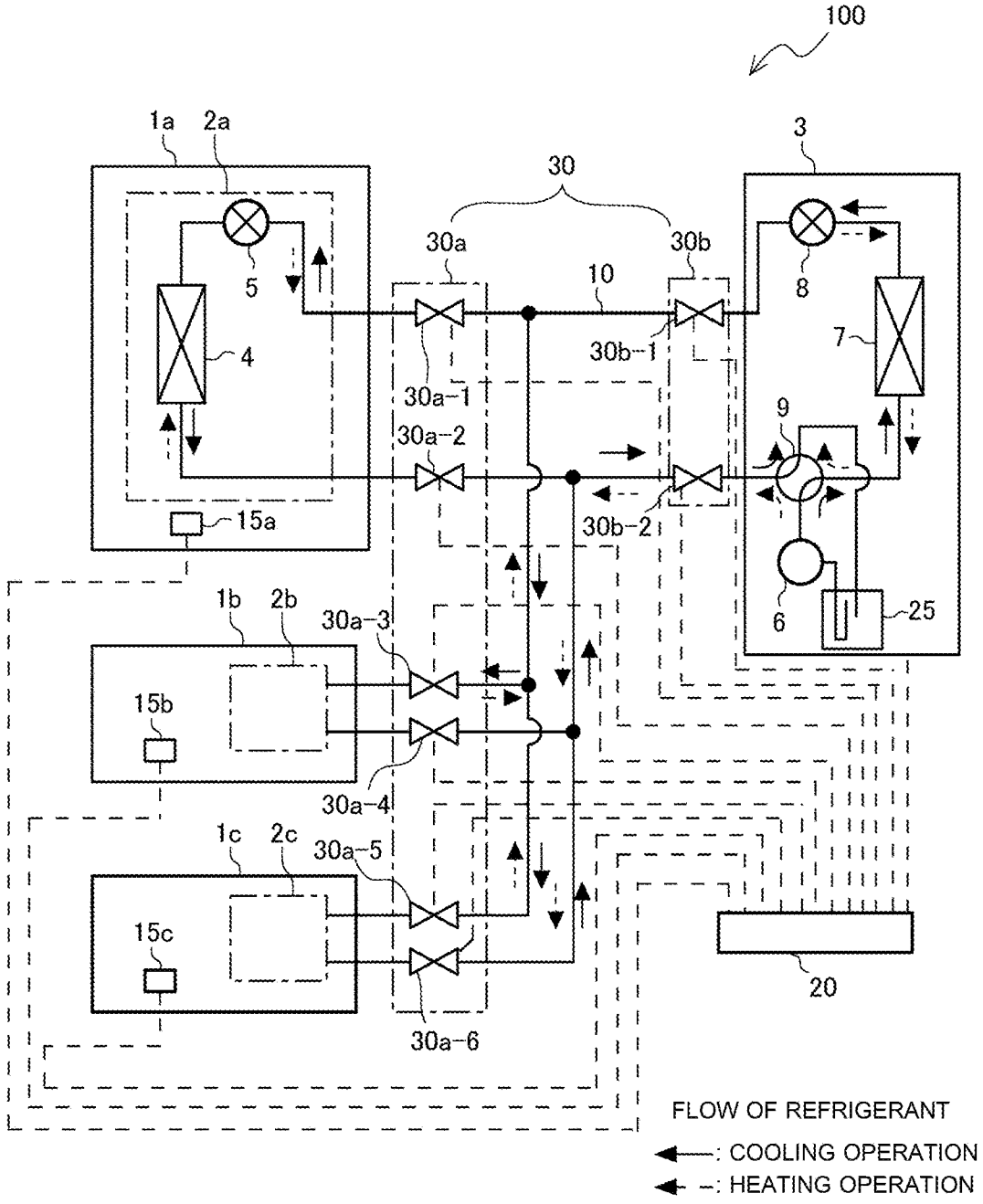

100
1a
2a
3
30
30a
30b
10
5
8
4
7
30b-1
30a-1
9
30a-2
30b-2
15a
1b
2b
30a-3
6
25
15b
30a-4
1c
2c
30a-5
15c
20
30a-6
FLOW OF REFRIGERANT
: COOLING OPERATION
: HEATING OPERATION

FIG. 2

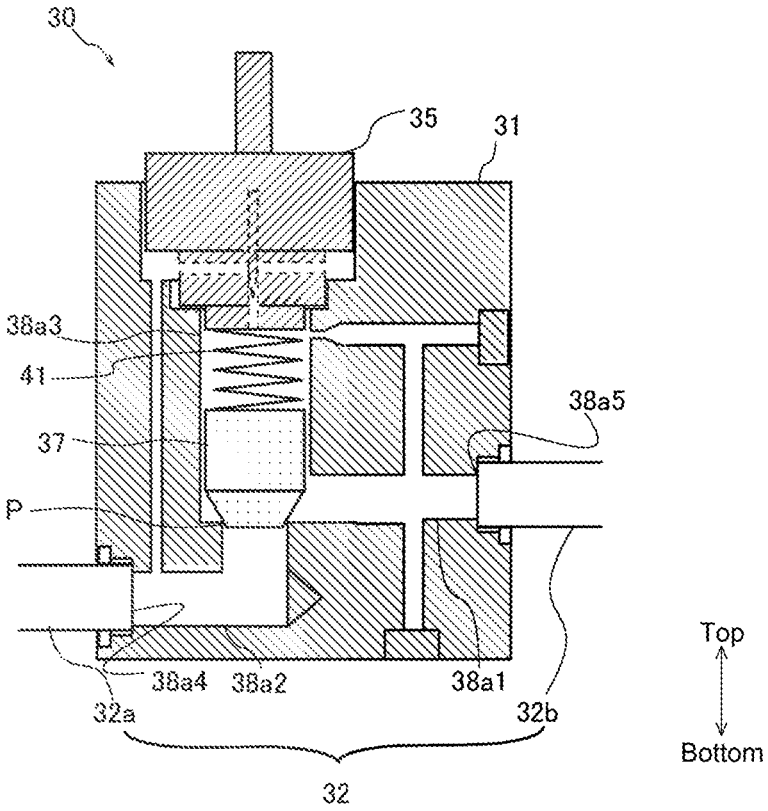


FIG. 3

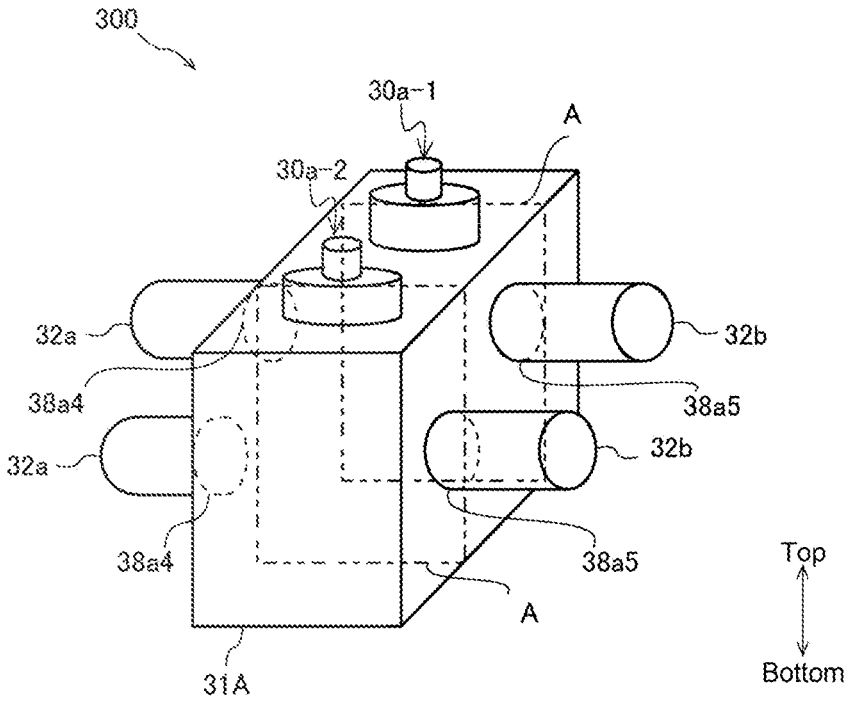

300
30a-1
A
30a-2
32a
32b
38a4
38a5
32a
32b
38a4
38a5
A
31A
Top
Bottom

FIG. 4

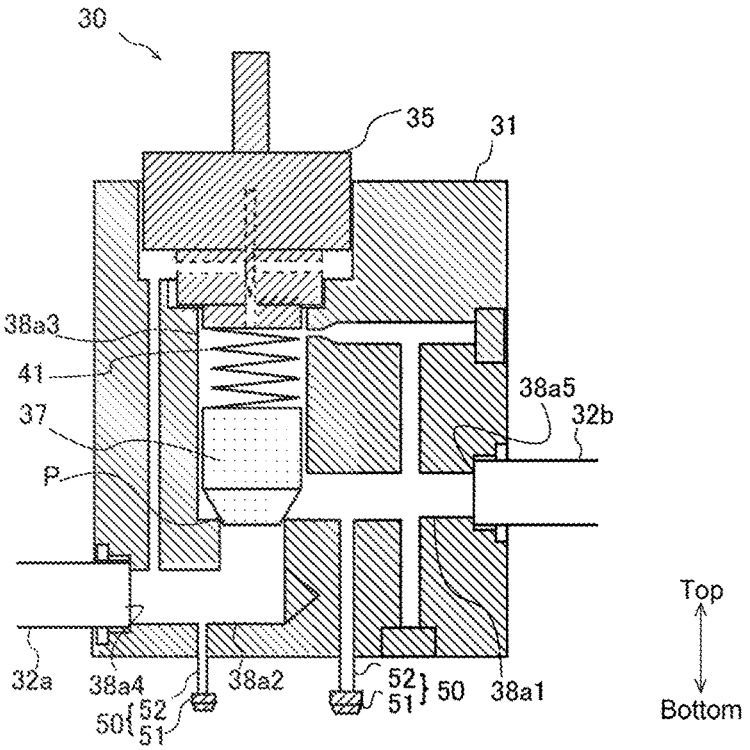

30
35
31
38a3
41
37
P
38a5
32b
32a
38a4
38a2
52
51
50
38a1
Top
Bottom

FIG. 5

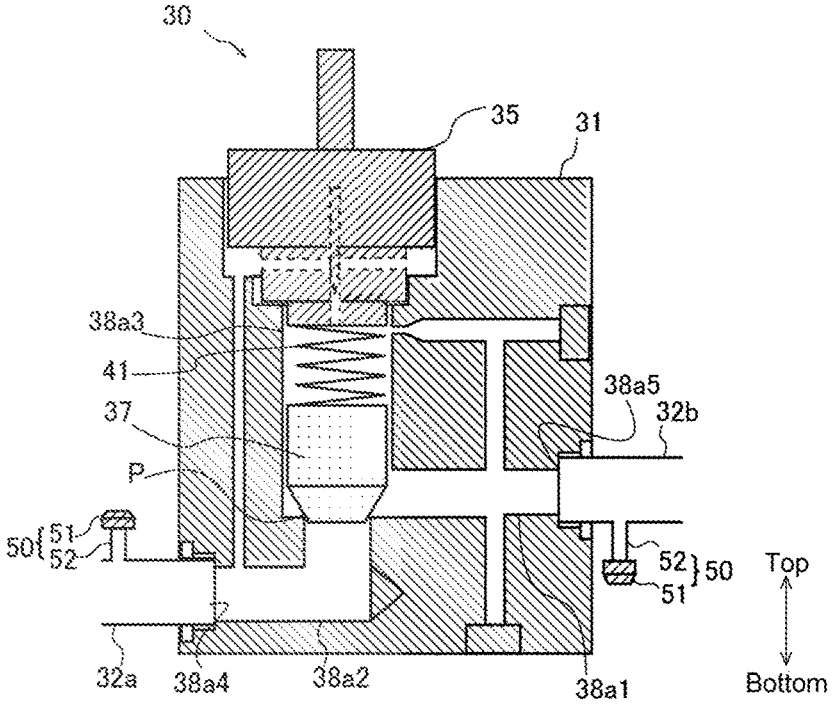

30
35
31
38a3
41
37
P
38a5
32b
50
51
52
32a
38a4
38a2
38a1
Top
Bottom

FIG. 6

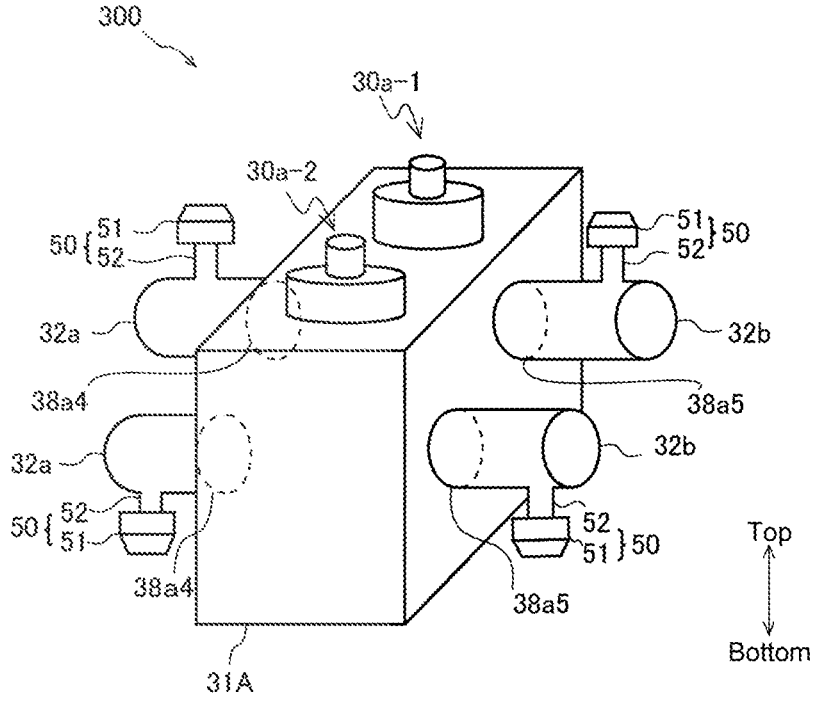

300
30a-1
30a-2
50
51
52
32a
32b
38a4
38a5
Top
Bottom
31A

FIG. 7

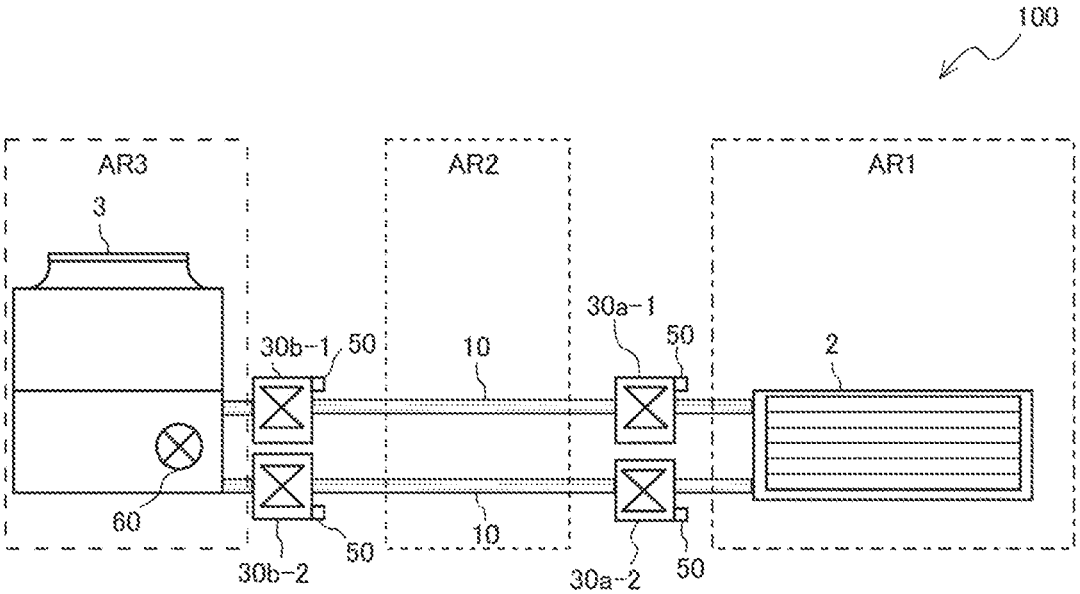

100
AR3
AR2
AR1
3
30b-1
50
10
30a-1
2
60
30b-2
30a-2

FIG. 8

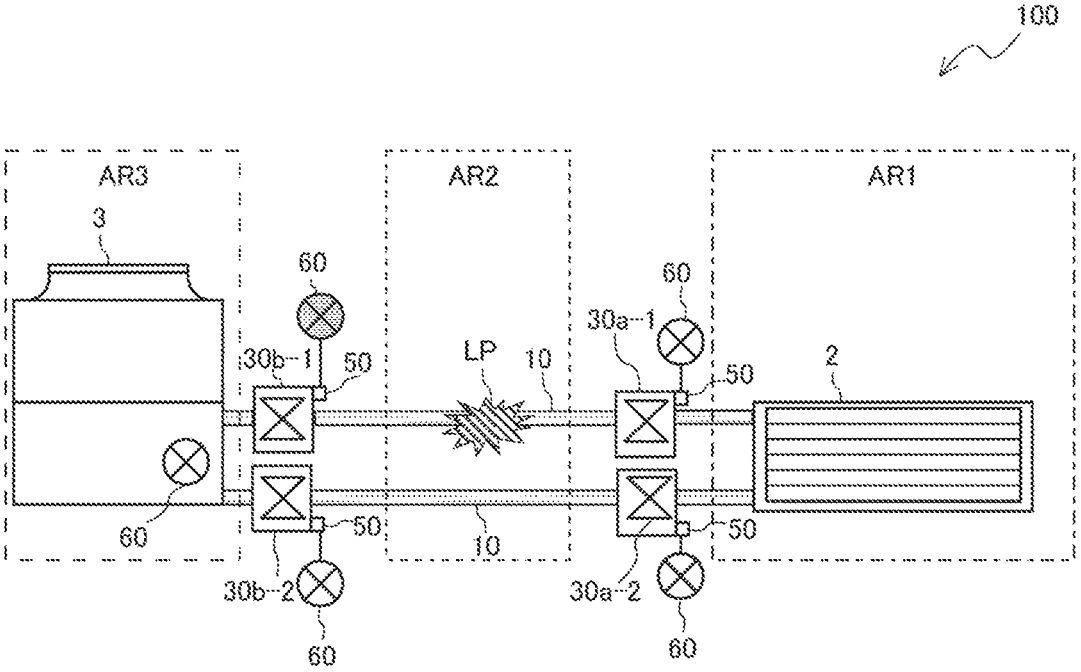
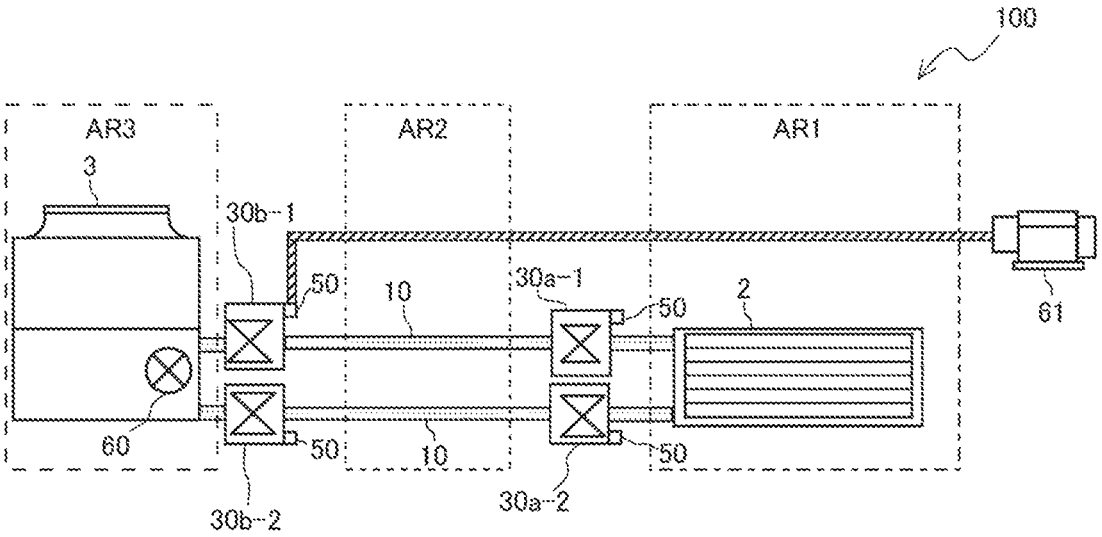

100
AR3
AR2
AR1
3
60
30b-1
50
LP
10
30a-1
2
60
30b-2
30a-2

FIG. 9


100
AR3
AR2
AR1
3
30b-1
50
10
30a-1
2
61
60
30b-2
30a-2

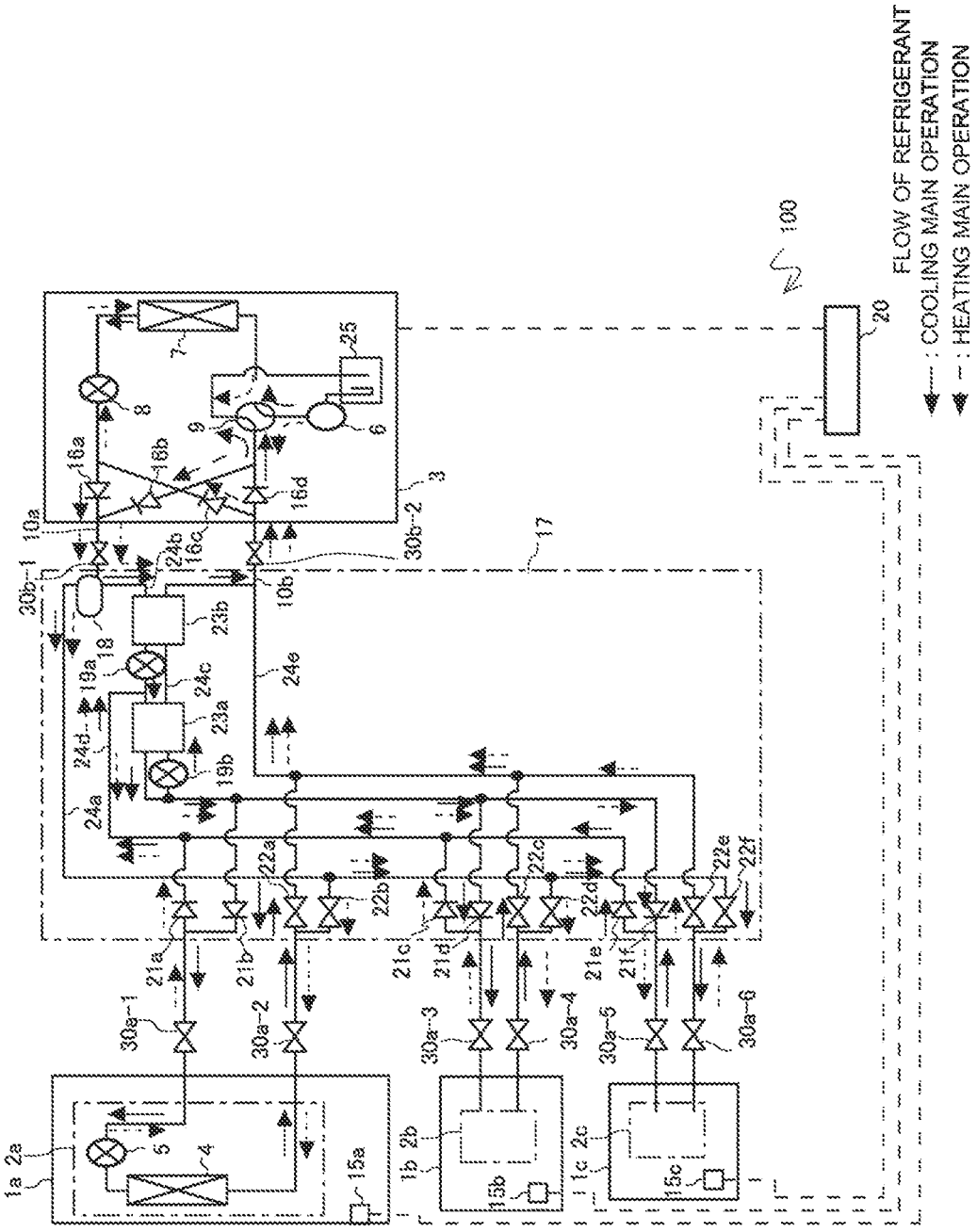
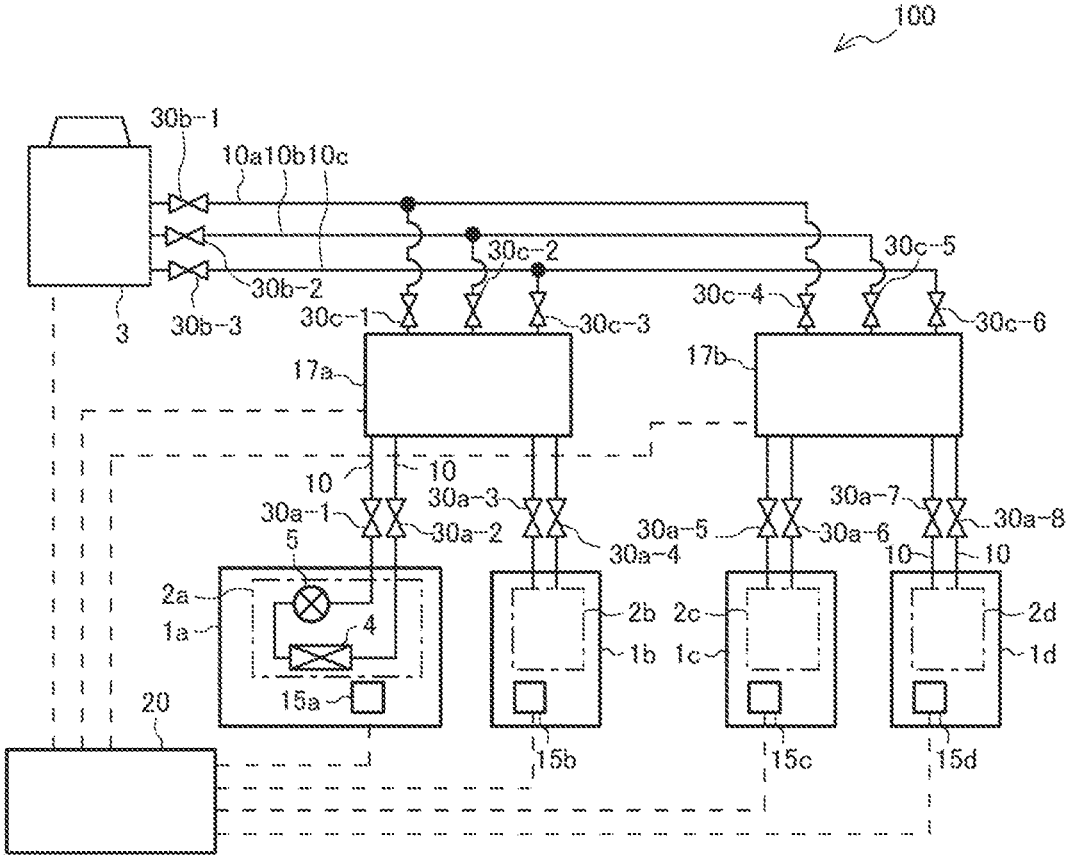

FLOW OF REFRIGERANT
: COOLING MAIN OPERATION
: HEATING MAIN OPERATION
100
20
3
17
1a 2a
1b 2b
1c 2c
4
5
6
7
8
9
10a
10b
15a
15b
15c
16a
16b
16c
16d
18
19a
19b
21a
21b
21c
21d
21e
21f
22a
22b
22c
22d
22e
22f
23a
23b
24a
24b
24c
24d
24e
25
30a-1
30a-2
30a-3
30a-4
30a-5
30a-6
30b-1
30b-2

FIG. 10

FIG. 11


100
30b-1
10a10b10c
30c-2
30c-5
30b-2
30c-4
3
30b-3
30c-1
30c-3
30c-6
17a
17b
10
10
30a-1
30a-3
30a-7
30a-8
30a-2
30a-5
30a-6
30a-4
5
10
10
2a
2b
2c
2d
1a
4
1b
1c
1d
15a
20
15b
15c
15d

AIR-CONDITIONING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a U.S. national stage application of PCT/JP2021/046919 filed on Dec. 20, 2021, the contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to an air-conditioning apparatus including a shut-off valve.

BACKGROUND

[0003] Patent Literature 1 discloses an air-conditioning apparatus that closes, when detecting a leak of refrigerant, a solenoid valve and a shut-off valve in order to reduce further occurrence of the refrigerant leak. To be more specific, the air-conditioning apparatus according to Patent Literature 1 includes an electromagnetic expansion valve and a shut-off valve that are provided in the following manner. The electromagnetic expansion valve is provided in a refrigerant circuit that is located between an outdoor heat exchanger and an indoor heat exchanger such that no compressor is interposed between the outdoor heat exchanger and the indoor heat exchanger. The shut-off valve is provided in a refrigerant circuit that is located between an outdoor heat exchanger and an indoor heat exchanger, with a compressor interposed between the outdoor heat exchanger and the indoor heat exchanger. Patent Literature 1 proposes use of a controller that closes the electromagnetic expansion valve to cause refrigerant to collect on an outdoor heat exchanger side, when a leak of refrigerant is detected, and then closes the shut-off valve.

PATENT LITERATURE

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2000-97527

[0005] In some cases, if refrigerant leaks from an air-conditioning apparatus, further occurrence of such a refrigerant leak is reduced using, for example, the controller described in Patent Literature 1, the air-conditioning apparatus is stopped, and a component of the air-conditioning apparatus is then repaired or replaced by a new one. In this case, it is necessary to find a location at which the refrigerant leak occurs. Furthermore, in the case of repairing or replacing a component of the air-conditioning apparatus, in some cases, the refrigerant is drawn out from the air-conditioning apparatus, the component is repaired or replaced by a new one, and refrigerant is then re-filled into the air-conditioning apparatus. This, however, causes the following problem related to the maintainability of the air-conditioning apparatus: refrigerant pipes have no part that allows connection of external equipment such as, a temperature sensor, a pressure sensor, a pump for drawing the refrigerant, a pump for re-filing refrigerant, and a vacuum pump. Inevitably, it takes time to, for example, find a location where a refrigerant leak occur, draw out refrigerant, and re-fill refrigerant.

SUMMARY

[0006] The present disclosure is applied in view of the above circumstances, and relates to an air-conditioning apparatus that is improved in maintainability.

[0007] An air-conditioning apparatus according to an embodiment of the present disclosure includes: an outdoor unit including a compressor and an outdoor heat exchanger, and configured to generate cooling energy or heating energy; an indoor unit including an indoor heat exchanger, and configured to perform an air-conditioning operation with the cooling energy or the heating energy that is generated by the outdoor unit; a refrigerant pipe provided between the outdoor unit and the indoor unit, and forming a refrigerant circuit in which refrigerant circulates; and a shut-off valve provided at the refrigerant pipe, and configured to be closed when a refrigerant leak is detected. The shut-off valve includes a service port communicating with the refrigerant pipe.

[0008] The air-conditioning apparatus according to an embodiment of the present disclosure includes a shut-off valve having a service port communicating with a refrigerant pipe. It is therefore possible to connect external equipment with the refrigerant pipe by attaching the external equipment to the service port. Thus, maintenance can be performed on the air-conditioning apparatus, with the external equipment attached to the service port, whereby the maintainability of the air-conditioning apparatus can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. **1** is a schematic view illustrating an example of a circuit configuration of an air-conditioning apparatus according to Embodiment 1.

[0010] FIG. **2** is a schematic view illustrating a section of a shut-off valve of the air-conditioning apparatus according to Embodiment 1.

[0011] FIG. **3** is a perspective view illustrating an example of the configuration of the appearance of a shut-off valve unit of the air-conditioning apparatus according to Embodiment 1.

[0012] FIG. **4** is a sectional view schematically illustrating an example of the shut-off valve having a service port in Embodiment 1

[0013] FIG. **5** is a sectional view schematically illustrating another example of the shut-off valve having the service port in Embodiment 1.

[0014] FIG. **6** is a perspective view illustrating an example of the configuration of the shut-off valve unit **300** including the service port **50** in Embodiment 1.

[0015] FIG. **7** is a schematic view illustrating an example in which the air-conditioning apparatus according to Embodiment 1 is provided with plural shut-off valves.

[0016] FIG. **8** is a schematic view illustrating the case where a refrigerant leak occurs in the air-conditioning apparatus as illustrated in FIG. **7**.

[0017] FIG. **9** is a schematic view illustrating an example in which external equipment is connected to the service ports as illustrated in FIG. **7**.

[0018] FIG. **10** is a schematic view illustrating an example of a circuit configuration of an air-conditioning apparatus according to Embodiment 2.

[0019] FIG. **11** is a schematic view illustrating an example of a circuit configuration of an air-conditioning apparatus according to Embodiment 3.

DETAILED DESCRIPTION

[0020] Air-conditioning apparatuses according to the embodiments will be described below with reference to the drawings. Descriptions of the present disclosure that concern the embodiments described below are not limiting but various modifications can be made without departing from the scope and spirit of the present disclosure. The present disclosure may encompass all possible combinations of configurations as described below regarding the embodiments. The drawings illustrate examples of configurations of the air-conditioning apparatuses, and do not limit the configurations described in the present disclosure. Although directional terms (for example, "upper" and "lower") are used as appropriate in order that the embodiments be more easily understood, they are not limiting. In addition, in each of the figures in the drawings, components that are the same as or equivalent to those in a previous figure or previous figures are denoted by the same reference signs. The same is true of the entire text of the specification. In each of the figures, relative dimensions, shapes, or other features of components may differ from actual ones.

Embodiment 1

[0021] FIG. **1** is a schematic view illustrating an example of a circuit configuration of an air-conditioning apparatus **100** according to Embodiment 1. The air-conditioning apparatus **100** as illustrated in FIG. **1** includes an outdoor unit **3**, plural indoor units **2***a*, **2***b*, and **2***c*, and a refrigerant flow switching device **9**, and is capable of switching its operation between a cooling operation and a heating operation. Although the air-conditioning apparatus **100** as illustrated in FIG. **1** includes the indoor units **2***a*, **2***b*, and **2***c*, the air-conditioning apparatus **100** may include a single indoor unit. In addition, the air-conditioning apparatus **100** may be configured to perform only the cooling operation or only the heating operation. In this case, the air-conditioning apparatus **100** does not include the refrigerant flow switching device **9** as illustrated in FIG. **1**.

Configuration of Air-Conditioning Apparatus

[0022] As illustrated in FIG. **1**, the air-conditioning apparatus **100** according to Embodiment 1 includes the outdoor unit **3** serving as a heat source unit; the indoor units **2***a*, **2***b*, and **2***c*; and plural shut-off valves **30** provided between the outdoor unit **3** and the indoor units **2***a*, **2***b*, and **2***c*. The shut-off valve **30** includes an indoor-unit-side shut-off valve **30***a* provided close to the indoor units **2**, and an outdoor-unit-side shut-off valve **30***b* provided close to the outdoor unit **3**. The outdoor unit **3**, the outdoor-unit-side shut-off valve **30***b*, the indoor-unit-side shut-off valve **30***a*, and each of the indoor units **2***a*, **2***b*, and **2***c* are connected by refrigerant pipes **10**. As a result, a refrigerant circuit is formed in which refrigerant circulates through the refrigerant pipes **10**. In FIG. **1**, solid arrows each indicate the flow of the refrigerant in the cooling operation, and dashed arrows each indicate the flow of the refrigerant in the heating operation. In the following description, a side toward which the refrigerant moves along the flow direction is referred to as a downstream side. That is, the refrigerant flows from an upstream side toward the downstream side. The refrigerant to be used can be considered to be R32 refrigerant, but is not limited to the R32 refrigerant. The flow of the refrigerant in the cooling operation and that in the heating operation will be described later.

[0023] In the following description, the indoor-unit-side shut-off valve **30***a* and the outdoor-unit-side shut-off valve **30***b* are each simply referred to as "shut-off valve **30**" as appropriate in the case where they do not particularly need to be distinguished from each other. The following description is also made assuming that the term "shut-off valve **30**" is applicable to both a single shut-off valve **30** and plural shut-off valves **30**.

Indoor-Unit-Side Shut-Off Valve

[0024] The air-conditioning apparatus **100** includes indoor-unit-side shut-off valves **30***a* that are provided at respective refrigerant pipes **10**, that is, the refrigerant pipe **10** connected to the indoor unit **2***a*, the refrigerant pipe **10** connected to the indoor unit **2***b*, and the refrigerant pipe **10** connected to the indoor unit **2***c*. To be more specific, as illustrated in FIG. **1**, indoor-unit-side shut-off valves **30***a*-**1** and **30***a*-**2** are associated with the indoor unit **2***a*; the indoor-unit-side shut-off valves **30***a*-**3** and **30***a*-**4** are associated with the indoor unit **2***b*; and the indoor-unit-side shut-off valves **30***a*-**5** and **30***a*-**6** are associated with the indoor unit **2***c*. In the following description, the indoor-unit-side shut-off valves **30***a*-**1** to **30***a*-**6** are each simply referred to as "indoor-unit-side shut-off valve **30***a*" as appropriate in the case where they do not particularly need to be distinguished from each other. The following description is also made assuming that the term "indoor-unit-side shut-off valve **30***a*" is applicable to both a single indoor-unit-side shut-off valve **30***a* and plural indoor-unit-side shut-off valves **30***a*.

Outdoor-Unit-Side Shut-Off Valve

[0025] The air-conditioning apparatus **100** includes outdoor-unit-side shut-off valves **30***b* provided at respective refrigerant pipes **10** connected to the outdoor unit **3**. To be more specific, as illustrated in FIG. **1**, outdoor-unit-side shut-off valves **30***b*-**1** and **30***b*-**2** are provided at respective refrigerant pipes **10** connected to the outdoor unit **3**. In the following description, the outdoor-unit-side shut-off valve **30***b*-**1** and the outdoor-unit-side shut-off valve **30***b*-**2** are each simply referred to as "outdoor-unit-side shut-off valve **30***b*" as appropriate in the case where they do not particularly need to be distinguished from each other. The following description is also made assuming that the term "outdoor-unit-side shut-off valve **30***b*" is applicable to both a single outdoor-unit-side shut-off valve **30***b* and plural outdoor-unit-side shut-off valves **30***b*.

Outdoor Unit

[0026] As illustrated in FIG. **1**, the outdoor unit **3** includes a compressor **6**, an outdoor heat exchanger **7**, an expansion valve **8**, the refrigerant flow switching device **9**, and an accumulator **25**. The compressor **6** compresses refrigerant to change it into high-temperature and high-pressure refrigerant, and discharges the high-temperature and high-pressure refrigerant.

[0027] The outdoor heat exchanger **7** causes heat exchange to be performed between the refrigerant and air (hereinafter referred to as "outdoor air" as appropriate) supplied by an air-sending device such as a fan (not illus-

trated). Specifically, in the cooling operation, the outdoor heat exchanger **7** serves as a condenser that transfers the heat of the refrigerant to the outdoor air to thereby condense the refrigerant. In the heating operation, the outdoor heat exchanger **7** serves as an evaporator that evaporates the refrigerant to thereby cool the outdoor air with the heat of vaporization.

[0028] The refrigerant flow switching device **9** is, for example, a four-way valve. The refrigerant flow switching device **9** is capable of switching the operation of the air-conditioning apparatus **100** between the cooling operation and the heating operation by switching the flow direction of the refrigerant between plural flow directions. The refrigerant flow switching device **9** is not limited to the four-way valve but may be a combination of two-way valves, three-way valves, or other valves.

[0029] The accumulator **25** is connected to a suction side of the compressor **6**. By the switching operation of the refrigerant flow switching device **9**, the accumulator **25** is connected to the downstream side of the outdoor heat exchanger **7** in the heating operation. The accumulator **25** is connected to the downstream side of an indoor heat exchanger **4** in the cooling operation. The accumulator **25** is a container that stores surplus refrigerant, and absorbs the difference in refrigerant flow rate between the cooling operation and the heating operation. The outdoor unit **3** may include no accumulator **25**.

[0030] The expansion valve **8** reduces the pressure of refrigerant that flows from the indoor units **2***a*, **2***b*, and **2***c* in the heating operation. In the case where the air-conditioning apparatus **100** is used for the cooling operation only, the outdoor unit **3** may include no expansion valve **8**. In the case where the indoor units **2***a*, **2***b*, and **2***c* include respective expansion valves **5**, as a configuration in which no expansion valve **8** is provided, the expansion valve **5** may be used to fulfill the function of the expansion valve **8**.

Indoor Unit

[0031] The indoor units **2***a*, **2***b*, and **2***c* are installed in spaces **1***a*, **1***b*, and **1***c*, respectively, which are air-conditioning target spaces. The indoor units **2***a*, **2***b*, and **2***c* supply air for cooling or air for heating to the spaces **1***a*, **1***b*, and **1***c*, respectively, using the cooling energy or heating energy of refrigerant that circulates through the refrigerant pipe **10**. The indoor units **2***a*, **2***b*, and **2***c* include respective indoor heat exchangers **4** and respective expansion valves **5**. Although FIG. **1** does not illustrate circuit configurations of the indoor units **2***b* and **2***c* in detail, these circuit configurations are the same as the circuit configuration of the indoor unit **2***a*. In the following description, the indoor units **2***a*, **2***b*, and **2***c* are each simply referred to as "indoor unit **2**" as appropriate in the case where they do not particularly be distinguished from each other. Furthermore, the following description is also made assuming that the term "indoor unit **2**" is applicable to both a single indoor unit **2** and plural indoor units **2**.

[0032] The indoor heat exchanger **4** in each of the indoor units **2***a*, **2***b*, and **2***c* causes heat exchange to be performed between air supplied by an air-sending device such as a fan (not illustrated) and refrigerant, thereby obtaining air for cooling or air for heating, which is to be supplied to an associated one of the spaces **1***a*, **1***b*, and **1***c*. Specifically, when the refrigerant carries cooling energy in the cooling operation, the indoor heat exchanger **4** operates as an evaporator to perform the cooling operation by cooling the air in the associated one of the spaces **1***a*, **1***b*, and **1***c*, which are air-conditioning target spaces. When the refrigerant carries heating energy in the heating operation, the indoor heat exchanger **4** operates as a condenser to perform the heating operation by heating the air in the associated one of the spaces **1***a*, **1***b*, and **1***c*, that is, air-conditioning target spaces.

[0033] The expansion valve **5** in each of the indoor unit **2***a*, **2***b*, and **2***c* reduces the pressure of refrigerant that flows from the indoor-unit-side shut-off valve **30***a* in the cooling operation. In the case where the air-conditioning apparatus **100** is used for the heating operation only, the indoor unit **2** may include no expansion valve **5**. In the case where the outdoor unit **3** includes the expansion valve **8**, preferably, the indoor units **2***a*, **2***b*, and **2***c* should include respective expansion valves **5** for adjustment of the capacities of the respective indoor units **2**. However, in the case where each of these indoor units is designed to include no expansion valve **5**, the expansion valve **8** may be used to fulfill the function of the expansion valve **5**.

Refrigerant Leak Detection Device

[0034] The air-conditioning apparatus **100** includes refrigerant leak detection devices **15***a*, **15***b*, and **15***c* to detect a refrigerant leak in the spaces **1***a*, **1***b*, and **1***c* where the indoor units **2***a*, **2***b*, and **2***c* are provided, respectively. Each of the refrigerant leak detection devices **15***a*, **15***b*, and **15***c* is, for example, a gas sensor configured to detect a refrigerant leak by detecting the concentration of refrigerant or the concentration of oxygen. For example, when it is detected that the concentration of the refrigerant is higher than or equal to a threshold value, it is determined that a refrigerant leak occurs. Furthermore, when the concentration of oxygen reaches a threshold value or less, it is determined that a refrigerant leak occurs. In addition, it may be detected whether a refrigerant leak occurs or not, by detecting both the concentration of refrigerant and the concentration of oxygen. Instead of or in addition to the gas sensor, a pressure sensor that detects a pressure in the refrigerant pipe **10** may be provided as each of the refrigerant leak detection devices **15***a*, **15***b*, and **15***c*. When a refrigerant leak occurs, the pressure in the refrigerant pipe **10** drops. Thus, a value detected by the pressure sensor can be used as information for determining whether a refrigerant leak occurs or not. Although the pressure in the refrigerant pipe **10** varies depending on the operating state of the air-conditioning apparatus **100**, it is possible to detect the possibility that a refrigerant leak will occur, by using a pressure in a specific operating state as a reference value. In the following description, the refrigerant leak detection devices **15***a*, **15***b*, and **15***c* are simply referred to as "refrigerant leak detection device **15**" as appropriate in the case where they do not particularly need to be distinguished from each other. Furthermore, the following description is also made assuming that the term "refrigerant leak detection device **15**" is applicable to both a single refrigerant leak detection device **15** and plural refrigerant leak detection devices **15**; and the spaces **1***a*, **1***b*, and **1***c* are each simply referred to as "space **1**" as appropriate in the case where they do not particularly need to be distinguished from each other.

[0035] Furthermore, the following description is also made assuming that the term "space **1**" is applicable to both a single space **1** and plural spaces **1**.

Controller

[0036] The air-conditioning apparatus **100** is provided with a controller **20**. The controller **20** is, for example, software to be run on a computing unit such as a microcomputer or a central processing unit (CPU), or hardware such as a circuit device that fulfills various functions. The controller **20** controls the operation of the entire air-conditioning apparatus **100**. A signal line of the shut-off valve **30** is connected to the controller **20**. For example, the controller **20** may perform an opening and closing control of the shut-off valve **30** by switching the state of the shut-off valve **30** between energized and de-energized states. A signal line of the refrigerant leak detection device **15** is connected to the controller **20**. Information detected by the refrigerant leak detection device **15** is input to the controller **20**.

[0037] The controller **20** performs a control when the refrigerant leak detection device **15** detects a refrigerant leak. Dashed lines extended from the controller **20** as illustrated in FIG. **1** represent signal lines that connect the controller **20** to the refrigerant leak detection device **15** and the shut-off valve **30**. Although not illustrated, a power line of each of the shut-off valve **30** and the refrigerant leak detection device **15** is connected to a power supply. When the refrigerant leak detection device **15** detects a refrigerant leak, the controller **20** performs a control to cause the shut-off valve **30** to be in a closed state.

Configuration of Shut-Off Valve

[0038] FIG. **2** is a schematic view illustrating a section of the shut-off valve **30** of the air-conditioning apparatus **100** according to Embodiment 1. The shut-off valve **30** includes a block body **31**, a flow passage **38** through which the refrigerant flows, and a valve body **37**. FIG. **2** is a vertical sectional view illustrating a configuration of the block body **31** of the shut-off valve **30**. As illustrated in FIG. **2**, the block body **31** includes a base **35**, the valve body **37**, a spring **41**, an indoor-unit-side connection pipe **32***a*, and an outdoor-unit-side connection pipe **32***b*. Furthermore, the block body **31** includes a refrigerant passage provided therein. The refrigerant passage includes a first opening **38***a***4**, a main flow passage **38***a***1**, a main-passage communication part **38***a***3**, a main flow passage **38***a***2**, and a second opening **38***a***5**. In the following description, passages provided in the block body **31** are sometimes collectively referred to as flow passage **38**. As for the spring **41**, it suffices that the spring **41** is provided as occasion needed in order to enhance a closing force of the valve body **37**. Accordingly, the shut-off valve **30** may include no spring **41**. The shut-off valves **30** of the air-conditioning apparatus **100** according to Embodiment 1 include service ports **50**. The service ports **50** will be described later with reference to FIGS. **4** to **6**, and are thus not illustrated in FIGS. **2** and **3**.

Base

[0039] As illustrated in FIG. **2**, the base **35** is fit in an opening provided in an upper portion of the block body **31** such that the base **35** is visually observable from the outside of the shut-off valve **30**. The base **35** seals the opening of the block body **31** to prevent a fluid from leaking from the block body **31**.

Valve Body

[0040] The valve body **37** is movable in the flow passage **38** to open and close the flow passage **38**. In Embodiment 1, the valve body **37** is provided in part of the flow passage **38** that extends in an up-down direction. The valve body **37** can be moved up and down. When the air-conditioning apparatus **100** is in the stopped state, the valve bodies **37** of all the shut-off valves **30** are moved down to a closed position P where the valve bodies **37** shuts off the passages **38**. In the case where the air-conditioning apparatus **100** includes plural indoor units **2**, in some cases, one of the indoor units **2** is in operation and another one of the indoor units **2** is in the stopped state. For example, in the air-conditioning apparatus **100** as illustrated in FIG. **1**, in some cases, the indoor units **2***a* and **2***c* are in operation and the indoor unit **2***b* is in the stopped state. In this case, the valve bodies **37** of the indoor-unit-side shut-off valves **30***a*-**3** and **30***a*-**4** connected to the indoor unit **2***b* are moved down to the closed position P where the valve bodies **37** shut off the respective passages **38** in the indoor-unit-side shut-off valves **30***a*-**3** and **30***a*-**4**.

Indoor-Unit-Side Connection Pipe and Outdoor-Unit-Side Connection Pipe

[0041] The indoor-unit-side connection pipe **32***a* is fit in the first opening **38***a***4** provided in the block body **31**. The outdoor-unit-side connection pipe **32***b* is fit in the second opening **38***a***5** provided in the block body **31**. The indoor-unit-side connection pipe **32***a* is connected to the refrigerant pipe **10** connected to the indoor unit **2**. The outdoor-unit-side connection pipe **32***b* is connected to the refrigerant pipe **10** connected to the outdoor unit **3**. The flow passage **38** connecting the indoor-unit-side connection pipe **32***a* and the outdoor-unit-side connection pipe **32***b* is provided in the block body **31**. A fluid can flow through the flow passage **38** from the outdoor-unit-side connection pipe **32***b* toward the indoor-unit-side connection pipe **32***a*, or from the indoor-unit-side connection pipe **32***a* toward the outdoor-unit-side connection pipe **32***b*. The flow passage **38** is shut off when the valve body **37** is moved down to the closed position P. The flow passage **38** is in the open state when the valve body **37** is located above the closed position P.

[0042] In the following description, the indoor-unit-side connection pipe **32***a* and the outdoor-unit-side connection pipe **32***b* are simply referred to as "connection pipe **32**" as appropriate in the case where they do not particularly need to be distinguished from each other. The following description is also made assuming that the term "connection pipe **32**" is applicable to both a single connection pipe **32** and plural connection pipes **32**.

Passage

[0043] As illustrated in FIG. **2**, the flow passage **38** includes the first opening **38***a***4**, the main flow passage **38***a***1**, the main-passage communication part **38***a***3**, the main flow passage **38***a***2**, and the second opening **38***a***5**. The second opening **38***a***5** is connected to the outdoor-unit-side connection pipe **32***b*, and serves as an inlet or outlet for fluid. The main flow passage **38***a***1** is a passage extending substantially horizontally from the second opening **38***a***5**. The main-passage communication part **38***a***3** is a passage located between the main flow passage **38***a***1** and the main flow passage **38***a***2**, and extending upward from an end of the main flow passage **38***a***1**. The main flow passage **38***a***2** is a passage that is L-shaped as a whole. The main flow passage **38***a***2** extends downward from the lower end of the main-

passage communication part **38***a***3**, and further extends substantially horizontally. The main flow passage **38***a***2** is connected at one end to the lower end of the main-passage communication part **38***a***3** as described above, and connected at the other end to the first opening **38***a***4**. The first opening **38***a***4** is connected to the indoor-unit-side connection pipe **32***a*, and serves as an inlet or outlet for fluid. The valve body **37** is moved up and down in the main-passage communication part **38***a***3** to open and close the space between the main flow passage **38***a***1** and the main flow passage **38***a***2**. To avoid complexity of illustration, a reference sign denoting the flow passage **38** is not indicated in FIG. **2**.

[0044] The communication between the main flow passage **38***a***1** and the main flow passage **38***a***2** is shut off when the valve body **37** is located in the closed position P. The closed position P of the valve body **37** corresponds to a position where the main-passage communication part **38***a***3** and the main flow passage **38***a***2** are connected with each other. The main flow passage **38***a***2** is too narrow in width to allow the valve body **37** to move therein. The main flow passage **38***a***2** is connected with the lower end of the main-passage communication part **38***a***3**. Consequently, when the valve body **37** is moved down in the main-passage communication part **38***a***3**, the valve body **37** cannot be further moved down to a position located below the position where the main-passage communication part **38***a***3** and the main flow passage **38***a***2** connect with each other. That is, in this state, the valve body **37** blocks the space between the main-passage communication part **38***a***3** and the main flow passage **38***a***2**. The main flow passage **38***a***1** is connected to the main-passage communication part **38***a***3** at a position located above the closed position P of the valve body **37**. Thus, when the valve body **37** is stopped at the closed position P, the valve body **37** blocks the space between the main flow passage **38***a***1** and the main-passage communication part **38***a***3**.

Operation of Air-Conditioning Apparatus

[0045] Next, it will be described how the air-conditioning apparatus **100** having the above configuration is operated in the cooling operation and in the heating operation, based on the flow of the refrigerant. In the air-conditioning apparatus **100** according to Embodiment 1, all of the indoor units **2***a*, **2***b*, and **2***c* may perform the cooling operation or all of the indoor units **2***a*, **2***b*, and **2***c* may perform the heating operation.

Cooling Operation

[0046] The following description is made regarding the case where the indoor units **2***a*, **2***b*, and **2***c* perform the cooling operation, with reference to the solid arrows indicated in FIG. **1**, assuming that none of the shut-off valves **30** is in the closed state, that is, the shut-off valves **30** allow flow of the refrigerant. When being compressed in the compressor **6**, the refrigerant changes into gas refrigerant, and then flows into the outdoor heat exchanger **7** through the refrigerant flow switching device **9**. The gas refrigerant that has flowed into the outdoor heat exchanger **7** exchanges heat with outdoor air to condense while transferring heat to the outdoor air, and thus change into liquid refrigerant. The liquid refrigerant flows out from the outdoor heat exchanger **7**.

[0047] After flowing out from the outdoor heat exchanger **7**, the liquid refrigerant flows out from the outdoor unit **3**. The liquid refrigerant that has flowed out from the outdoor unit **3** flows into the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b***-1**. The liquid refrigerant that has flowed into the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b***-1** flows through the flow passage **38** of the outdoor-unit-side shut-off valve **30***b***-1**, and flows out from the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b***-1**. The liquid refrigerant that has flowed out from the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b***-1** flows through the refrigerant pipe **10**, and flows into the outdoor-unit-side connection pipe **32***b* of each of the indoor-unit-side shut-off valves **30***a***-1**, **30***a***-3**, and **30***a***-5**. The liquid refrigerant that has flowed into the outdoor-unit-side connection pipe **32***b* of each of the indoor-unit-side shut-off valves **30***a***-1**, **30***a***-3**, and **30***a***-5** flows through the flow passage **38** of that indoor-unit-side shut-off valve, and flows out from the indoor-unit-side connection pipe **32***a* of the indoor-unit-side shut-off valve.

[0048] The liquid refrigerant that has flowed out from each of the indoor-unit-side shut-off valves **30***a***-1**, **30***a***-3**, and **30***a***-5** is reduced in pressure by the expansion valve **5** in an associated one of the indoor units **2***a*, **2***b*, and **2***c*, and then flows into an associated one of the indoor heat exchangers **4**. The refrigerant that has flowed into the indoor heat exchanger **4** exchanges heat with indoor air to receive heat therefrom and evaporate, thereby cooling the indoor air, and thus changes into gas refrigerant. The gas refrigerant flows out from the indoor heat exchanger **4**.

[0049] The gas refrigerant that has flowed out from each of the indoor heat exchangers **4** flows into the indoor-unit-side connection pipe **32***a* of an associated one of the indoor-unit-side shut-off valves **30***a***-2**, **30***a***-4**, and **30***a***-6**. The gas refrigerant that has flowed into the indoor-unit-side connection pipe **32***a* of the above indoor-unit-side shut-off valve flows through the flow passage **38** of the above indoor-unit-side shut-off valve, and flows out from the outdoor-unit-side connection pipe **32***b* of the indoor-unit-side shut-off valve. The gas refrigerant that has flowed out form the outdoor-unit-side connection pipe **32***b* of the indoor-unit-side shut-off valve flows through the refrigerant pipe **10**, and flows into the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b***-2**. The gas refrigerant that has flowed into the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b***-2** flows through the flow passage **38** of the outdoor-unit-side shut-off valve **30***b***-2**, and flows out from the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b***-2**. The gas refrigerant that has flowed out from the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b***-2** flows through the refrigerant pipe **10**, and flows into the outdoor unit **3**.

[0050] The gas refrigerant that has flowed into the outdoor unit **3** returns to the compressor **6** after flowing through the refrigerant flow switching device **9** and the accumulator **25**. In the cooling operation, the circulation of refrigerant as described above is repeated.

Heating Operation

[0051] It will be described how the refrigerant flows in a heating main operation. The description is made regarding

the case where the indoor units **2***a*, **2***b*, and **2***c* perform the heating operation, with reference to the dashed arrows indicated in FIG. **1**, and is made assuming that in this case, none of the shut-off valves **30** is in the closed state, that is, the shut-off valves **30** allow flow of the refrigerant. After being compressed in the compressor **6**, the refrigerant flows through the refrigerant flow switching device **9** and flows out from the outdoor unit **3**.

[0052] The refrigerant that has flowed out from the outdoor unit **3** flows through the refrigerant pipe **10** and flows into the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b*-**2**. The refrigerant that has flowed into the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b*-**2** flows through the flow passage **38** of the outdoor-unit-side shut-off valve **30***b*-**2**, and flows out from the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b*-**2**. The refrigerant that has flowed out from the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b*-**2** flows through the refrigerant pipe **10** and flows into the outdoor-unit-side connection pipe **32***b* of each of the indoor-unit-side shut-off valves **30***a*-**2**, **30***a*-**4**, and **30***a*-**6**.

[0053] The refrigerant that has flowed into the outdoor-unit-side connection pipe **32***b* of each of the indoor-unit-side shut-off valves **30***a*-**2**, **30***a*-**4**, and **30***a*-**6** flows through the flow passage **38** of that indoor-unit-side shut-off valve, and flows out from the indoor-unit-side connection pipe **32***a* of the indoor-unit-side shut-off valve. The refrigerant that has flowed out from the indoor-unit-side connection pipe **32***a* of the indoor-unit-side shut-off valve flows into the indoor heat exchanger **4** in an associated one of the indoor units **2***a* to **2***c*.

[0054] The refrigerant that has flowed into the indoor heat exchanger **4** exchanges heat with indoor air to condense while transferring heat to the indoor air, thereby heating the indoor air, and thus changes into liquid refrigerant. The liquid refrigerant then flows out from the indoor heat exchanger **4**. The liquid refrigerant that has flowed out form the indoor heat exchanger **4** flows through the expansion valve **5** that is provided in an associated one of the indoor units **2***a* to **2***c* and that is in the open state, and then flows into the indoor-unit-side connection pipe **32***a* of an associated one of the indoor-unit-side shut-off valves **30***a*-**1**, **30***a*-**3**, and **30***a*-**5**. The liquid refrigerant that has flowed into the indoor-unit-side connection pipe **32***a* of the above indoor-unit-side shut-off valve flows through the flow passage **38** of the indoor-unit-side shut-off valve, and flows out from the outdoor-unit-side connection pipe **32***b* of the indoor-unit-side shut-off valve.

[0055] The liquid refrigerant that has flowed out from the outdoor-unit-side connection pipe **32***b* flows through the refrigerant pipe **10** and flows into the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b*-**1**. The liquid refrigerant that has flowed into the indoor-unit-side connection pipe **32***a* of the outdoor-unit-side shut-off valve **30***b*-**1** flows through the flow passage **38** of the outdoor-unit-side shut-off valve **30***b*-**1** and flows out from the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b*-**1**. The liquid refrigerant that has flowed out from the outdoor-unit-side connection pipe **32***b* of the outdoor-unit-side shut-off valve **30***b*-**1** flows through the refrigerant pipe **10** and flows into the outdoor unit **3**. The liquid refrigerant that has flowed into the outdoor unit **3** is reduced in pressure by the expansion valve **8** and flows into the outdoor heat exchanger **7**. The refrigerant that has flowed into the outdoor heat exchanger **7** exchanges heat with indoor air to receive heat therefrom and evaporate and thus gasifies, and the refrigerant flows out from the outdoor heat exchanger **7**. The refrigerant that has flowed out from the outdoor heat exchanger **7** flows through the refrigerant flow switching device **9** and the accumulator **25** and returns to the compressor **6**. In the heating operation, the above circulation of the refrigerant is repeated.

Configuration of Shut-Off Valve Unit

[0056] In the air-conditioning apparatus **100** according to Embodiment 1, plural shut-off valves **30** may be formed as a single shut-off valve unit **300**. FIG. **3** is a perspective view illustrating an example of the configuration of the appearance of the shut-off valve unit **300** according to Embodiment 1. FIG. **3** illustrates, for the purpose of explanation, an example in which the indoor-unit-side shut-off valves **30***a*-**1** and **30***a*-**2** as illustrated in FIG. **1** are formed as the shut-off valve unit **300**. The vertical section as illustrated in FIG. **2** corresponds to a portion A indicated by chain double-dashed lines in FIG. **3**. The shut-off valve unit **300** may be formed as a single unit made up of three or more shut-off valves **30**.

[0057] For example, plural shut-off valves **30** connected to the same indoor unit **2** can be provided as a shut-off valve unit **300**. Therefore, in the air-conditioning apparatus **100** as illustrated in FIG. **1**, the indoor-unit-side shut-off valves **30***a*-**1** and **30***a*-**2** connected to the indoor unit **2***a* can be provided as a first shut-off valve unit **300**; the indoor-unit-side shut-off valves **30***a*-**3** and **30***a*-**4** connected to the indoor unit **2***b* can be formed as a second shut-off valve unit **300**; and the indoor-unit-side shut-off valves **30***a*-**5** and **30***a*-**6** connected to the indoor unit **2***c* can be formed as a third shut-off valve unit **300**. The outdoor-unit-side shut-off valves **30***b*-**1** and **30***b*-**2** connected to the outdoor unit **3** can be formed as a single shut-off valve unit **300**.

[0058] As illustrated in FIG. **3**, the shut-off valve unit **300** includes two shut-off valves **30**, that is, the indoor-unit-side shut-off valve **30***a*-**1** and the indoor-unit-side shut-off valve **30***a*-**2**. The block body **31** of the indoor-unit-side shut-off valve **30***a*-**1** and the block body **31** of the indoor-unit-side shut-off valve **30***a*-**2** are formed as a single block body **31**A. The flow passage **38** of the indoor-unit-side shut-off valve **30***a*-**1** and the flow passage **38** of the indoor-unit-side shut-off valve **30***a*-**2** are arranged side by side in the block body **31**A. As illustrated in FIG. **3**, the block body **31**A of the shut-off valve unit **300** has the first opening **38***a***4** and the second opening **38***a***5** of the indoor-unit-side shut-off valve **30***a*-**1** and the first opening **38***a***4** and the second opening **38***a***5** of the indoor-unit-side shut-off valve **30***a*-**2**. With the two first openings **38***a***4**, respective indoor-unit-side connection pipes **32***a* are connected. With the two second openings **38***a***5**, respective outdoor-unit-side connection pipes **32***b* are connected.

Configuration of Service Port

[0059] The shut-off valves **30** of the air-conditioning apparatus **100** according to Embodiment 1 includes the service ports **50**. The service port **50** will be described with reference to FIGS. **4** to **6**. FIGS. **4** and **5** are sectional views each schematically illustrating an example of the shut-off valve **30** including the service port **50** according to Embodiment 1. FIG. **6** is a perspective view illustrating an example of the

configuration of the shut-off valve unit **300** including the service ports **50** in Embodiment 1.

[0060] As illustrated in FIG. **4**, the service port **50** is provided in the block body **31** of the shut-off valve **30** such that the service port **50** communicates with the flow passage **38**. Therefore, the service port **50** communicates with the refrigerant pipe **10** via the flow passage **38**. The service port **50** has a tip **51** and a connection part **52**. The tip **51** can be formed to have an opening that allows external equipment to be inserted from the tip **51** into the service port **50**. When being inserted from the tip **51** of the service port **50**, the external equipment can communicate with the refrigerant pipe **10**. The tip **51** may be shaped to serve as a joint that allows connection of the external equipment. For example, a push-in joint may be provided as the tip **51**. Alternatively, a screwed-threaded joint and a sealing component may be provided as the tip **51**.

[0061] The connection part **52** of the service port **50** has a tubular shape, and connects the tip **51** of the service port **50** and the flow passage **38** of the shut-off valve **30**. Thus, the external equipment inserted from the tip **51** can be moved to the flow passage **38** of the shut-off valve **30** through the connection part **52**.

[0062] FIG. **4** illustrates two service ports **50** that communicates with the first main flow passage **38***a***1** and the main flow passage **38***a***2**, respectively. As described above, a first one of the service ports **50** is provided at a location where the first service port **50** communicates with the main flow passage **38***a***1**, and a second one of the service ports **50** is provided at a location where the second service port **50** communicates with the main flow passage **38***a***2**. As a result, even when the valve body **37** blocks the flow passage **38**, the two service ports **50** can be used to communicate with the indoor-unit-side connection pipe **32***a* and the outdoor-unit-side connection pipe **32***b*. That is, when the external equipment is connected with the two service ports **50**, it can communicate with the refrigerant pipe **10** connected to the indoor unit **2** and the refrigerant pipe **10** connected to the outdoor unit **3**.

[0063] The number of service ports **50** and the installation positions of the service ports **50**, however, are not limited to those as illustrated in FIG. **4**. A single service port **50** may be provided in such a manner as to communicate with some portion of the flow passage **38** provided in the block body **31**. In addition to the two service ports **50** as illustrated in FIG. **4**, another service port **50** may be provided. The service port **50** provided in the flow passage **38** does not necessarily have to protrude from the bottom of the block body **31**. The service port **50** may protrude from the side or top of the block body **31**.

[0064] It is not indispensable that the service port **50** is provided in the block body **31** of the shut-off valve **30**. As illustrated in FIG. **5**, service ports **50** may be provided in the indoor-unit-side connection pipe **32***a* and the outdoor-unit-side connection pipe **32***b*. Furthermore, the service port **50** may be provided in either the indoor-unit-side connection pipe **32***a* or the outdoor-unit-side connection pipe **32***b*. As another example, one service port **50** may be provided in the block body **31**, and another service port **50** may be provided in either the indoor-unit-side connection pipe **32***a* or the outdoor-unit-side connection pipe **32***b*.

[0065] Referring to FIG. **6**, service ports **50** are provided in the indoor-unit-side connection pipes **32***a* and the outdoor-unit-side connection pipes **32***b* of the shut-off valve unit **300**. To be more specific, referring to FIG. **6**, in all the outdoor-unit-side connection pipes **32***b* and the indoor-unit-side connection pipes **32***a*, respective service ports **50** are provided. However, it is not indispensable that the service ports **50** are provided in all the outdoor-unit-side connection pipes **32***b* and the indoor-unit-side connection pipes **32***a* of the shut-off valve unit **300**. A combination of the number of service ports **50** and the locations of the service ports **50** is not limited to those illustrated in FIG. **6**. The number of service ports **50** and the locations of the service port **50** may be combined such that the service port or ports **50** are provided in the following manner: for example, in the service port **50** in the outdoor-unit-side connection pipe **32***b* of the indoor-unit-side shut-off valve **30***a*-**1** and in the indoor-unit-side connection pipe **32***a* of the indoor-unit-side shut-off valve **30***a*-**2**, respective service ports **50** are provided. In addition, the service port **50** may be provided in the block body **31**A in such a manner as to communicate with the flow passage **38**.

[0066] FIGS. **4** to **6** illustrate examples in each of which the service port **50** or the service ports **50** are provided in the block body **31**, the indoor-unit-side connection pipe **32***a*, and/or the outdoor-unit-side connection pipe **32***b*. However, it suffices that the service port or ports **50** are provided in the shut-off valve **30** at such a location as to communicate with the refrigerant pipe **10**, and illustration of the service ports **50** is not limiting. For example, the service port or ports **50** may be provided in the base **35** or the valve body **37**.

Use of Service Port

[0067] External equipment for use in maintenance of the air-conditioning apparatus **100** can be directly connected to the tip **51** of the service port **50**. The maintenance of the air-conditioning apparatus **100** means work such as installation, removal, relocation, repair, modification, and inspection of the air-conditioning apparatus **100**. As external equipment, for example, a pressure sensor, a device for drawing refrigerant, a vacuum pump, and a tank for re-filing refrigerant. Also, as external equipment, a connection hose may be directly connected to the tip **51**. In the case where the external equipment cannot be directly connected to the tip **51**, it suffices that the external equipment is connected to a connection hose connected to the tip **51**. Therefore, in the maintenance of the air-conditioning apparatus **100**, necessary external equipment can be connected via the hose directly connected to the tip **51**. Furthermore, the external equipment can be inserted from the tip **51**, not being directly connected to the tip **51**. By inserting a sensor such as a pressure sensor or a temperature sensor from the tip **51**, and moving the inserted sensor to the refrigerant pipe **10**, it is possible to acquire information on the inside of the refrigerant pipe **10**.

[0068] With reference to FIGS. **7** and **8**, an example of how to use the service port **50** in the maintenance on the air-conditioning apparatus **100** will be described. FIG. **7** is a schematic view illustrating an example in which the air-conditioning apparatus **100** according to Embodiment 1 is provided with plural shut-off valves **30**. FIG. **8** is a schematic view illustrating the case where a refrigerant leak occurs in the air-conditioning apparatus **100** as illustrated in FIG. **7**. It will be described how the service port **50** is used in the case where a refrigerant leak occurs in the air-conditioning apparatus **100** as illustrated in FIG. **7**.

[0069] As illustrated in FIGS. **7** and **8**, at refrigerant pipes **10** that connect the indoor unit **2** and the outdoor unit **3**, the indoor-unit-side shut-off valve **30***a*-**1**, the indoor-unit-side shut-off valve **30***a*-**2**, the outdoor-unit-side shut-off valve **30***b*-**1**, and the outdoor-unit-side shut-off valve **30***b*-**2** are provided, whereby it is possible to divide the inside of the air-conditioning apparatus **100** into a first region AR1, a second region AR2, and a third region AR3, and do a service work on the air-conditioning apparatus **100**. The first region AR1 is a region where the indoor unit **2** is installed. The second region AR2 is a region where the refrigerant pipes **10** connecting the indoor unit **2** and the outdoor unit **3** are provided. The third region AR3 is a region where the outdoor unit **3** is installed. The outdoor unit **3** is provided with a pressure sensor **60**. The second region AR2 can be further divided into a region where the refrigerant pipe **10** that connects the indoor-unit-side shut-off valve **30***a*-**1** and the outdoor-unit-side shut-off valve **30***b*-**1** is provided and a region where the refrigerant pipe **10** that connects the indoor-unit-side shut-off valve **30***a*-**2** and the outdoor-unit-side shut-off valve **30***b*-**2** is provided.

[0070] The indoor-unit-side shut-off valve **30***a*-**1**, the indoor-unit-side shut-off valve **30***a*-**2**, the outdoor-unit-side shut-off valve **30***b*-**1**, and the outdoor-unit-side shut-off valve **30***b*-**2** have respective service ports **50** each of which is provided at a location where the service port **50** communicates with the indoor-unit-side connection pipe **32***a* when the flow passage **38** is blocked by the valve body **37**.

[0071] When a refrigerant leak is detected by the refrigerant leak detection device **15** of the air-conditioning apparatus **100**, each of the shut-off valves **30** are closed. As a result, the first region AR1, the second region AR2, and the third region AR3 are isolated from each other. After a refrigerant leak is detected, when the air-conditioning apparatus **100** is deactivated, and a value of the pressure in the refrigerant pipe **10** is measured by a pressure sensor, in a region where a refrigerant leak does not occur, the value detected by the pressure sensor does not change from the time when the air-conditioning apparatus **100** is deactivated. In contrast, in a region where a refrigerant leak occurs, the value detected by the pressure sensor becomes close to the atmosphere pressure. Therefore, as illustrated in FIG. **8**, to the service ports **50** of the indoor-unit-side shut-off valve **30***a*-**1**, the indoor-unit-side shut-off valve **30***a*-**2**, the outdoor-unit-side shut-off valve **30***b*-**1**, and the outdoor-unit-side shut-off valve **30***b*-**2**, respective pressure sensors **60** are connected in order to detect pressures in the respective regions. It is therefore possible to determine from which of the first region AR1, the second region AR2, and the third region AR3 refrigerant leaks. Although FIG. **7** illustrates an example in which the pressure sensor **60** is connected to the outdoor unit **3** provided in the third region AR3, the pressure sensor **60** may be connected to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1** or the outdoor-unit-side shut-off valve **30***b*-**2** that communicates with the third region AR3.

[0072] FIG. **8** illustrates an example in which refrigerant leaks at a refrigerant leak position LP at the refrigerant pipe **10**. Although in the example illustrated in FIG. **8**, to all of the service ports **50**, respective pressure sensors **60** are connected, it is not indispensable that the pressure sensors **60** are connected to all the service ports **50** simultaneously, and it suffices that the pressure sensors **60** are successively connected to the respective service ports **50** to detect the pressures in the respective regions.

[0073] In the case where refrigerant leaks at the refrigerant leak position LP, the value detected by the pressure sensor **60** connected to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1** is close to the atmospheric pressure. In FIG. **8**, the pressure sensor **60** connected to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1** is indicated in a dotted pattern. At this time, the values detected by the pressure sensors **60** connected to the respective service ports **50** of the indoor-unit-side shut-off valve **30***a*-**1**, the indoor-unit-side shut-off valve **30***a*-**2**, and the outdoor-unit-side shut-off valve **30***b*-**2** are kept constant after deactivation of the air-conditioning apparatus **100**. It is therefore possible to determine that refrigerant leaks from the refrigerant pipe **10** located in the second region AR2 and extending between the indoor-unit-side shut-off valve **30***a*-**1** and the outdoor-unit-side shut-off valve **30***b*-**1**. As a result, in order to determine a location where a refrigerant leak occurs, the first region AR1 and the third region AR3 can be excluded from regions to be checked. It is therefore possible to decrease the number of regions to be checked to determine a location where a refrigerant leak occurs, thereby shortening the time required to determine the location where the refrigerant leaks occurs, and thus improving the maintainability of the air-conditioning apparatus **100**.

[0074] In the case where the refrigerant leak position LP can be determined, the pressure sensor **60** connected to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1** is removed, and then external equipment necessary for repairing the air-conditioning apparatus **100** can be connected to the service port **50**.

[0075] FIG. **9** is a schematic view illustrating an example in which external equipment is connected to the service ports **50** as illustrated in FIG. **7**. Specifically, a vacuum pump **61** is connected as external equipment to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1**. The service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1** is provided at a location where the service port **50** communicates with the indoor-unit-side connection pipe **32***a*. As illustrated in FIG. **9**, the vacuum pump **61** is connected to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1**, with the air-conditioning apparatus **100** being in the deactivated state, whereby the refrigerant pipes **10** located in the second region AR2 and extending between the indoor-unit-side shut-off valve **30***a*-**1** and the outdoor-unit-side shut-off valve **30***b*-**1** can be evacuated.

[0076] The vacuum pump **61** as illustrated in FIG. **9** is connected to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1**, but can also be connected to the service port **50** of any one of the indoor-unit-side shut-off valve **30***a*-**1**, the indoor-unit-side shut-off valve **30***a*-**2**, and the outdoor-unit-side shut-off valve **30***b*-**2**. For example, referring to FIG. **9**, vacuum pumps **61** can be connected to the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**1** and the service port **50** of the outdoor-unit-side shut-off valve **30***b*-**2**, and evacuate the refrigerant pipes **10** located in the second region AR2 at the same time. It is therefore possible to shorten the time required to perform evacuation.

[0077] The air-conditioning apparatus **100** according to Embodiment 1 includes the outdoor unit **3**, the indoor unit **2**, the refrigerant pipes **10**, and the shut-off valves **30**. The outdoor unit **3** includes the compressor **6**, and the outdoor heat exchanger **7**, and generates cooling energy or heating

energy. The indoor unit **2** includes the indoor heat exchanger **4**, and performs an air-conditioning operation with the cooling energy or the heating energy that is generated in the outdoor unit **3**. The refrigerant pipes **10** are provided between the outdoor unit **3** and the indoor unit **2** and included in a refrigerant circuit in which refrigerant circulates. The shut-off valves **30** are provided at the refrigerant pipes **10**, and are closed when it is detected that a refrigerant leak occurs. The shut-off valves **30** each have the service port **50** that communicates with the refrigerant pipe **10**.

[0078] In the above configuration, external equipment can be inserted into the refrigerant pipe **10** via the service port **50**. That is, it is possible to use necessary external equipment via the service port **50** at the time of performing maintenance of the air-conditioning apparatus **100**, and thus possible to improve the maintainability of the air-conditioning apparatus **100**.

[0079] The service ports **50** of the air-conditioning apparatus **100** according to Embodiment 1 each have the tip **51** that can be opened and closed and allows external equipment to be attached to and detached from the tip **51**. The tip **51** is opened when the external equipment is connected to the tip **52**. As a result, a pressure sensor, a device for drawing refrigerant, a vacuum pump, a tank for re-filing refrigerant, and a connection hose can be directly or indirectly connected to the service port **50**.

[0080] The shut-off valves **30** according to Embodiment 1 each include the block body **31** and the valve body **37**. The block body **31** includes the passages **38** that communicate with refrigerant pipes **10**. In the valve body **37**, each of the flow passage **38** is made to be opened or closed. The service port or ports **50** are provided at the block body **31** in such a manner as to communicate with the passages **38**. In this configuration, the service ports **50** are provided in the block body **31** that is sturdier than the pipe. Therefore, even when a load acts on the service port **50**, the effect of the load on the service port **50** may be reduced.

[0081] The shut-off valves **30** according to Embodiment 1 each include the block body **31**, the valve body **37**, and the connection pipes **32**. The block body **31** includes the passages **38** that communicate with the refrigerant pipes **10**. In the valve body **37**, each of the flow passage **38** is made to be opened or closed. The connection pipes **32** are connected to the passages **38**, and protrudes from the block body **31**. The connection pipes **32** are connected to the refrigerant pipes **10**. The service ports **50** are provided at the connection pipes **32**. In the above configuration, the service ports **50** are provided at the connection pipes **32** of the shut-off valves **30**, which are pipes directly connected to the refrigerant pipes **10**. Therefore, when external equipment needs to be inserted all the way into the refrigerant pipe **10**, this insertion can be relatively easily performed. It is therefore possible to further improve the maintainability of the air-conditioning apparatus **100**.

[0082] Furthermore, in Embodiment 1, plural shut-off valves **30** are provided at the refrigerant pipe **10**. The shut-off valves **30** include the indoor-unit-side shut-off valves **30***a* and the outdoor-unit-side shut-off valves **30***b*. The indoor-unit-side shut-off valves **30***a* are located closer to the indoor unit **2** than to the outdoor unit **3**. The outdoor-unit-side shut-off valves **30***b* are located closer to the outdoor unit **3** than to the indoor unit **2**. In the above configuration, a region where the refrigerant pipes **10** located between the indoor-unit-side shut-off valve **30***a* and the outdoor-unit-side shut-off valve **30***b* are provided can be handled as a single region. In addition, in the maintenance of the air-conditioning apparatus **100**, external equipment can be connected to the service port **50** of each of the indoor-unit-side shut-off valve **30***a* and the outdoor-unit-side shut-off valve **30***b*. The maintenance can thus be efficiently performed. It is therefore possible to further improve the maintainability of the air-conditioning apparatus **100**.

[0083] In Embodiment 1, the plural indoor-unit-side shut-off valves **30***a* are provided. The indoor-unit-side shut-off valves **30***a*-**1** and **30***a*-**2** include the indoor-unit-side shut-off valve **30***a*-**1** that is provided at part of the refrigerant pipe **10** through which the refrigerant passes to flow into the indoor unit **2**, and the outdoor-unit-side shut-off valve **30***a*-**2** that is provided at part of the refrigerant pipe **10** through which the refrigerant passes after flowing out from the indoor unit **2**. The plural outdoor-unit-side shut-off valves **30***b* are provided. The outdoor-unit-side shut-off valves **30***b*-**1** and **30***b*-**2** include the outdoor-unit-side shut-off valve **30***b*-**1** that is provided at part of the refrigerant pipe **10** through which the refrigerant passes to flow into the outdoor unit **3**, and the outdoor-unit-side shut-off valve **30***b*-**2** that is provided at part of the refrigerant pipe **10** through which the refrigerant passes after flowing out from the outdoor unit **3**.

[0084] In the above configuration, the inside of the air-conditioning apparatus **100** is divided into the first region AR1 where the indoor unit **2** is installed, the second region AR2 where the refrigerant pipe **10** connecting the indoor unit **2** and the outdoor unit **3** is provided, and the third region AR3 where the outdoor unit **3** is installed, and in this state, the maintenance of the air-conditioning apparatus **100** can be performed. It is therefore possible to perform maintenance on the first to third regions AR1 to AR3 simultaneously, using the service ports **50** associated with these regions. In addition, in the case of offering service to only a region, maintenance can be performed on only the region, using the service port **50** associated with the region. It is therefore possible to shorten the time required for performing maintenance on the air-conditioning apparatus **100**, and further improve the maintainability of the air-conditioning apparatus **100**.

[0085] For example, in air-conditioning apparatuses such as variable refrigerant flow (VRF) systems, the total length of refrigerant pipes connecting an outdoor unit and plural indoor units can be several hundred meters. In the case where the total length of refrigerant pipes is increased, the amount of refrigerant for use in the air-conditioning apparatus is also increased. Therefore, in an air-conditioning apparatus having refrigerant pipes the total length of which is great, in some cases, it takes a long time to determine a location where a refrigerant leak occurs, since it is necessary to check whether the refrigerant leak occurs, over a relatively large region. For this reason, it may sometimes take time to determine a location where a leak occurs. Furthermore, in maintenance, it may sometimes take time to draw back refrigerant, re-fill refrigerant, and evacuate the refrigerant pipes. In this regard, in the air-conditioning apparatus **100** according to Embodiment 1, it is possible to perform maintenance on the first to third regions AR1 to AR3 at the same time, which are provided independently of each other, using the service ports **50**. Accordingly, it is possible to check the first to third regions AR1 to AR3 simultaneously as to whether a refrigerant leak occurs or not. In addition, it is possible to perform an operation for drawing back refrig-

erant, an operation for re-filling refrigerant, and an operation for evacuation, on the first to third regions AR1 to AR3, at the same time. Furthermore, it is also possible to perform different maintenance operations on the regions at the same time. The maintainability of the air-conditioning apparatus **100** is thus further improved.

Embodiment 2

[0086] The shut-off valves **30** and the air-conditioning apparatus **100** according to Embodiment 2 will be described. In the air-conditioning apparatus **100** according to Embodiment 2, the outdoor unit **3** includes plural check valves **16***a*, **16***b*, **16***c*, and **16***d*; and a relay unit **17** is installed between the outdoor unit **3** and plural indoor units **2**. In this regard, the air-conditioning apparatus **100** according to Embodiment 2 is different in configuration from the air-conditioning apparatus **100** according to Embodiment 1. It should be noted that regarding Embodiment 2, components that are the same as those in Embodiment 1 will be denoted by the same reference signs and their description will thus be omitted.

[0087] FIG. **10** is a schematic view illustrating an example of a circuit configuration of the air-conditioning apparatus **100** according to Embodiment 2. As illustrated in FIG. **10**, the air-conditioning apparatus **100** according to Embodiment 2 is a two-pipe type air-conditioning apparatus **100** in which two pipes are provided as refrigerant pipes **10** located between the outdoor unit **3** and the relay unit **17**. The outdoor-unit-side shut-off valves **30***b*-**1** and **30**-*b***2** are provided at the refrigerant pipes **10** between the outdoor unit **3** and the relay unit **17**.

[0088] As illustrated in FIG. **10**, the air-conditioning apparatus **100** includes the indoor-unit-side shut-off valves **30***a*-**1**, **30***a*-**2**, **30***a*-**3**, **30***a*-**4**, **30***a*-**5**, and **30***a*-**6** associated with the indoor units **2***a*, **2***b*, and **2***c*. The shut-off valves **30** according to Embodiment 2 are the same as those in Embodiment 1, and their descriptions will thus be omitted. In FIG. **10**, illustration of dashed lines indicating connection between the controller **20** and the shut-off valve **30** is omitted.

Configuration of Air-Conditioning Apparatus

[0089] In the air-conditioning apparatus **100** according to Embodiment 2, it is possible to activate an indoor unit that performs the cooling operation and an indoor unit that performs the heating operation at the same time. In the entire air-conditioning apparatus, when a cooling load on the indoor unit that performs the cooling operation exceeds a heating load on the indoor unit that performs the heating operation, a cooling main operation is performed. In contrast, when the heating load on the indoor unit that performs the heating operation exceeds the cooling load on the indoor unit that performs the cooling operation, a heating main operation is performed. When the cooling main operation is performed as the cooling load exceeds the heating load, for example, the number of indoor units that perform the cooling operation is larger than that of indoor units that perform the heating operation. In contrast, when the heating main operation is performed as the heating load exceeds the cooling load, the number of indoor units that perform the heating operation is larger than that of indoor units that perform the cooling operation.

[0090] In FIG. **10**, as an example of the flow of the refrigerant in the cooling main operation, solid arrows indicate the flow of the refrigerant in the case where the indoor units **2***a* and **2***b* perform the cooling operation and the indoor unit **2***c* performs the heating operation. Also, in FIG. **10**, as an example of the flow of the refrigerant in the heating main operation, dashed arrows indicate the flow of the refrigerant in the case where the indoor units **2***a* and **2***b* perform the heating operation and the indoor unit **2***c* performs the cooling operation.

[0091] As illustrated in FIG. **10**, the outdoor unit **3** includes plural check valves **16***a*, **16***b*, **16***c*, and **16***d*. The check valves **16***a*, **16***b*, **16***c*, and **16***d* adjust the flow of the refrigerant by preventing backflow of the refrigerant, such that the refrigerant circulates in a single direction.

[0092] The relay unit **17** is provided between the outdoor unit **3** and the indoor-unit-side shut-off valves **30***a*-**1** to **30***a*-**6**. The outdoor unit **3** and the relay unit **17** are connected by refrigerant pipes **10**. The refrigerant pipes **10** between the outdoor unit **3** and the relay unit **17** include a refrigerant-pipe communication part **10***a* and a refrigerant-pipe communication part **10***b*. Refrigerant that flows from the outdoor unit **3** to the relay unit **17** passes through the refrigerant-pipe communication part **10***a*. Refrigerant that flows from the relay unit **17** to the outdoor unit **3** passes through the refrigerant-pipe communication part **10***b*. The outdoor-unit-side shut-off valve **30***b*-**1** is provided at the refrigerant-pipe communication part **10***a*. The outdoor-unit-side shut-off valve **30***b*-**2** is provided at the refrigerant-pipe communication part **10***b*.

[0093] The indoor-unit-side shut-off valves **30***a*-**1** to **30***a*-**6** are provided at the refrigerant pipes **10** between the indoor unit **2** and the relay unit **17**. At the refrigerant pipe **10** extending from the indoor-unit-side shut-off valve **30***a*-**1**, check valves **21***a* and **21***b* are provided. At the refrigerant pipe **10** extending from the indoor-unit-side shut-off valve **30***a*-**3**, check valves **21***c* and **21***d* are provided. At the refrigerant pipe **10** extending from the indoor-unit-side shut-off valve **30***a*-**5**, check valves **21***e* and **21***f* are provided. The indoor-unit-side shut-off valve **30***a* is located closer to an associated one of the indoor units **2** than to the relay unit **17**. Accordingly, the indoor-unit-side shut-off valve **30***a*-**1** and the indoor-unit-side shut-off valve **30***a*-**2** are located closer to the indoor unit **2***a* than to the relay unit **17**. The indoor-unit-side shut-off valve **30***a*-**3** and the indoor-unit-side shut-off valve **30***a*-**4** are located closer to the indoor unit **2***b* than to the relay unit **17**. The indoor-unit-side shut-off valve **30***a*-**5** and the indoor-unit-side shut-off valve **30***a*-**6** are located closer to the indoor unit **2***c* than to the relay unit **17**.

[0094] As illustrated in FIG. **10**, at the refrigerant pipe **10** extending from the indoor-unit-side shut-off valve **30***a*-**2**, on-off valves **22***a* and **22***b* are provided. At the refrigerant pipe **10** extending from the indoor-unit-side shut-off valve **30***a*-**4**, on-off valves **22***c* and **22***d* are provided. At the refrigerant pipe **10** extending from the indoor-unit-side shut-off valve **30***a*-**6**, on-off valves **22***e* and **22***f* are provided.

[0095] The indoor-unit-side shut-off valves **30***a*-**1** to **30***a*-**6** and the indoor units **2***a* to **2***c* are the same in configuration as those according to Embodiment 1, and their descriptions will thus be omitted. Although the indoor units **2***b* and **2***c* each include the indoor heat exchanger **4** and the expansion valve **5** as well as the indoor unit **2***a*, illustration of the indoor heat exchangers **4** and the expansion valves **5** of the indoor units **2***b* and **2***c* is thus omitted in FIG. **10**.

[0096] The relay unit **17** includes a gas-liquid separator **18**, heat exchangers **23***a* and **23***b*, expansion valves **19***a* and

19*b*, the check valves 21*a*, 21*b*, 21*c*, 21*d*, 21*e*, and 21*f*, the on-off valves 22*a*, 22*b*, 22*c*, 22*d*, 22*e*, and 22*f*, and pipes 24*a*, 24*b*, 24*c*, and 24*d*. As illustrated in FIG. 10, the outdoor unit 3 and the gas-liquid separator 18 are connected by the refrigerant-pipe communication part 10*a*. The gas-liquid separator 18, the heat exchangers 23*a* and 23*b*, the expansion valves 19*a* and 19*b*, the check valves 21*a* to 21*f*, the on-off valves 22*a* to 22*f*, and the pipes 24*a* to 24*d* in the relay unit 17 will be described later; that is, these components are described in the following description concerning the cooling main operation.

Cooling Main Operation

[0097] The flow of the refrigerant in the cooling main operation will be described below. With reference to the solid arrows in FIG. 10, the following description is made by referring to by way of example the case where the indoor units 2*a* and 2*b* perform the cooling operation and the indoor unit 2*c* performs the heating operation.

[0098] The refrigerant is compressed in the compressor 6 to change into gas refrigerant, and the gas refrigerant passes through the refrigerant flow switching device 9 and flows into the outdoor heat exchanger 7. The gas refrigerant that has flowed into the outdoor heat exchanger 7 exchanges heat with outdoor air to condense while transferring heat to the outdoor air, thereby changing into two-phase gas-liquid refrigerant. The two-phase gas-liquid refrigerant then flows out from the outdoor heat exchanger 7.

[0099] The two-phase gas-liquid refrigerant that has flowed out form the outdoor heat exchanger 7 passes through the expansion valve 8 and the check valve 16*a*, and then flows out from the outdoor unit 3. The two-phase gas-liquid refrigerant that has flowed out from the outdoor unit 3 passes through the refrigerant-pipe communication part 10*a* and the outdoor-unit-side shut-off valve 30*b*-1 and flows into the relay unit 17. The two-phase gas-liquid refrigerant that has flowed into the relay unit 17 flows into the gas-liquid separator 18, and is separated into gas refrigerant and liquid refrigerant. The gas refrigerant flows into the pipe 24*a*, and the liquid refrigerant flows into the pipe 24*b*. With the pipe 24*a* into which the gas refrigerant flows, the on-off valves 22*b*, 22*d*, and 22*f* are connected. With the pipe 24*b* to which the liquid refrigerant flows, the heat exchanger 23*b*, the expansion valve 19*a*, the heat exchanger 23*a*, and the check valves 21*b*, 21*d*, and 21*f* are connected.

[0100] The gas refrigerant that has flowed into the pipe 24*a* flows toward the indoor unit 2*c* which performs the heating operation. To be more specific, the gas refrigerant that has flowed into the pipe 24*a* passes through the on-off valve 22*f* and through the indoor-unit-side shut-off valve 30*a*-6 associated with the indoor unit 2*c*, and then flows into the indoor unit 2*c*. The gas refrigerant that has flowed into the indoor unit 2*c* flows into the indoor heat exchanger 4.

[0101] The gas refrigerant that has flowed into the indoor heat exchanger 4 of the indoor unit 2*c* exchanges heat with indoor air to condense while transferring heat to the indoor air, thereby heating the indoor air. As a result, the gas refrigerant changes into liquid refrigerant, and the liquid refrigerant flows out from the indoor heat exchanger 4. The liquid refrigerant that has flowed out from the indoor heat exchanger 4 is reduced in pressure by the expansion valve 5, and then flows out from the indoor unit 2*c*. The liquid refrigerant that has flowed out from the indoor unit 2*c* passes through the indoor-unit-side shut-off valve 30*a*-5 and flows into the relay unit 17.

[0102] The liquid refrigerant that has flowed into the relay unit 17 passes through the check valve 21*e* and flows into the pipe 24*d*. The pipe 24*d* is connected to the pipe 24*b* located close to the outlet of the expansion valve 19*a*. Therefore, in the pipe 24*b*, the liquid refrigerant that has flowed into the pipe 24*d* joins the liquid refrigerant that has been subjected to separation by the gas-liquid separator 18 and then expanded by the expansion valve 19*a*.

[0103] The liquid refrigerant that has been obtained through separation by the gas-liquid separator 18 and flowed into the pipe 24*b* flows through the heat exchanger 23*b* and the expansion valve 19*a*, and as a result, is subcooled. The subcooled liquid refrigerant joins the liquid refrigerant flowing from the pipe 24*d*. The liquid refrigerant obtained by the above joining is further subcooled in the heat exchanger 23*a*, and then branches off. Branching part of the refrigerant flows from the pipe 24*b* into the pipe 24*c*. Remaining part of the liquid refrigerant that has not flowed into the pipe 24*c* flows through the pipe 24*b* and flows toward one of the indoor unit 2*a* and the indoor unit 2*b* that performs the cooling operation.

[0104] The pipe 24*c* is connected with the expansion valve 19*b* and the heat exchangers 23*a* and 23*b*. The pipe 24*c* is connected with a pipe 24*e* at a location close to the outlet of the heat exchanger 23*b*. Thus, the above branching part of the liquid refrigerant that has flowed into the pipe 24*c* after flowing out from the heat exchanger 23*a* is reduced in pressure in the expansion valve 19*b*, and then flows through the heat exchangers 23*a* and 23*b*. In the heat exchangers 23*a* and 23*b*, the liquid refrigerant exchanges heat with the liquid refrigerant flowing in the pipe 24*b* to receive heat therefrom, thereby subcooling the liquid refrigerant flowing in the pipe 24*b*. After flowing out from the heat exchanger 23*b*, the refrigerant joins the gas refrigerant flowing in the pipe 24*e*. The refrigerant obtained through the above joining then flows through the outdoor-unit-side shut-off valve 30*b*-2 and the refrigerant-pipe communication part 10*b*, and flows into the outdoor unit 3.

[0105] The above remaining part of the liquid refrigerant that has not flowed into the pipe 24*c* after flowing out from the heat exchanger 23*a* flows through the check valve 21*b* or the check valve 21*d*, then flows through the indoor-unit-side shut-off valve 30*a*-1 associated with the indoor unit 2*a* or through the indoor-unit-side shut-off valve 30*a*-3 associated with the indoor unit 2*b*, and flows into the indoor unit 2*a* or the indoor unit 2*b*. The liquid refrigerant that has flowed into the indoor unit 2*a* or the indoor unit 2*b* is reduced in pressure by the expansion valve 5, and then flows into the indoor heat exchanger 4. The liquid refrigerant that has flowed into the indoor heat exchanger 4 exchanges heat with indoor air to receive heat therefrom and evaporate, thereby cooling the indoor air. As a result, the liquid refrigerant changes into gas refrigerant, and the gas refrigerant flows out from the indoor heat exchanger 4.

[0106] The gas refrigerant that has flowed out from the indoor heat exchanger 4 flows through the indoor-unit-side shut-off valve 30*a*-2 or the indoor-unit-side shut-off valve 30*a*-4 and flows into the relay unit 17. The gas refrigerant that has flowed into the relay unit 17 flows through the on-off valve 22*a* or the on-off valve 22*c* and flows into the pipe 24*e*. The gas refrigerant that has flowed into the pipe

24*e* joins the refrigerant flowing in the pipe **24***c*, and the refrigerant obtained through the joining then flows through the outdoor-unit-side shut-off valve **30***b*-**2** and the refrigerant-pipe communication part **10***b* and flows into the outdoor unit **3**.

[0107] The gas refrigerant that has flowed from the relay unit **17** into the outdoor unit **3** through the outdoor-unit-side shut-off valve **30***b*-**2** flows through the check valve **16***d*, the refrigerant flow switching device **9**, and the accumulator **25**, and returns to the compressor **6**. In the cooling main operation, the above circulation of the refrigerant is repeated.

Heating Main Operation

[0108] The flow of the refrigerant in the heating main operation will be described below. With reference to the dashed arrows in FIG. **10**, the following description is made by referring to by way of example the case where the indoor units **2***a* and **2***b* perform the heating operation and the indoor unit **2***c* performs the cooling operation is described below by way of example. It should be noted that the configurations of the gas-liquid separator **18**, the heat exchangers **23***a* and **23***b*, the expansion valves **19***a* and **19***b*, the check valves **21***a* to **21***f*, the on-off valves **22***a* to **22***f*, and the pipes **24***a* to **24***d* in the relay unit **17** are the same as those in the cooling main operation. Therefore, features of the above components that have already been described above will not be re-described.

[0109] Refrigerant compressed in the compressor **6** flows through the refrigerant flow switching device **9** and the check valve **16***b*, flows out from the outdoor unit **3**, then flows through the refrigerant-pipe communication part **10***a* and the outdoor-unit-side shut-off valve **30***b*-**1**, and flows into the relay unit **17**. The refrigerant that has flowed into the relay unit **17** flows into the gas-liquid separator **18** and is separated into gas refrigerant and liquid refrigerant. The gas refrigerant flows into the pipe **24***a*, and the liquid refrigerant flows into the pipe **24***b*.

[0110] The gas refrigerant that has flowed into the pipe **24***a* flows toward one of the indoor unit **2***a* and the indoor unit **2***b* that performs the heating operation. More specifically, the gas refrigerant that has flowed into the pipe **24***a* passes through the on-off valve **22***b* or the on-off valve **22***d*, then flows through the indoor-unit-side shut-off valve **30***a*-**2** associated with the indoor unit **2***a* or through the indoor-unit-side shut-off valve **30***a*-**4** associated with the indoor unit **2***b*, and flows into the indoor unit **2***a* or the indoor unit **2***b*. The gas refrigerant that has flowed into the indoor unit **2***a* or the indoor unit **2***b* flows into the indoor heat exchanger **4**.

[0111] The gas refrigerant that has flowed into the indoor heat exchanger **4** of the indoor unit **2***a* or the indoor unit **2***b* exchanges heat with indoor air to condense while transferring heat to the indoor air, thereby heating the indoor air. As a result, the gas refrigerant changes into liquid refrigerant, and the liquid refrigerant flows out from the indoor heat exchanger **4**. The liquid refrigerant that has flowed out from the indoor heat exchanger **4** is reduced in pressure by the expansion valve **5** of the indoor unit **2***a* or the indoor unit **2***b*, and then flows out from the indoor unit **2***a* or the indoor unit **2***b*. The liquid refrigerant that has flowed out from the indoor unit **2***a* or the indoor unit **2***b* flows through the indoor-unit-side shut-off valve **30***a*-**1** or the indoor-unit-side shut-off valve **30***a*-**3** and flows into the relay unit **17**.

[0112] The liquid refrigerant that has flowed into the relay unit **17** flows through the check valve **21***a* or the check valve **21***c* and flows into the pipe **24***d*. The pipe **24***d* is connected to the pipe **24***b*, and the liquid refrigerant that has flowed into the pipe **24***d* thus joins, in the pipe **24***b*, the liquid refrigerant that has been obtained through separation by the gas-liquid separator **18** and expanded by the expansion valve **19***a*.

[0113] The liquid refrigerant flowing from the pipe **24***d* joins the liquid refrigerant that has flowed into the pipe **24***b* after being obtained through the separation by the gas-liquid separator **18**. The liquid refrigerant obtained through the separation by the gas-liquid separator **18** flows through the heat exchanger **23***b* and the expansion valve **19***a* and is subcooled. The subcooled liquid refrigerant joins the liquid refrigerant flowing from the pipe **24***d*. The liquid refrigerant obtained through the above joining is further subcooled in the heat exchanger **23***a*, and branches off. Then, branching part of the liquid refrigerant flows from the pipe **24***b* into the pipe **24***c*. The pipe **24***c* is connected to the pipe **24***e*, and the above branching part of the liquid refrigerant that has flowed into the pipe **24***c* passes through the expansion valve **19***b* and the heat exchangers **23***a* and **23***b* and then flows into the pipe **24***e*. The refrigerant that has flowed into the pipe **24***e* passes through the outdoor-unit-side shut-off valve **30***b*-**2** and the refrigerant-pipe communication part **10***b* and flows into the outdoor unit **3**.

[0114] Remaining part of the liquid refrigerant that has not flowed into the pipe **24***c* flows through the pipe **24***b* and flows toward the indoor unit **2***c*, which performs the cooling operation. Specifically, the above remaining part of the liquid refrigerant that has not flowed into the pipe **24***c* passes through the check valve **21***f*, then passes through the indoor-unit-side shut-off valve **30***a*-**5** associated with the indoor unit **2***c*, and flows into the indoor unit **2***c*. The liquid refrigerant that has flowed into the indoor unit **2***c* is reduced in pressure by the expansion valve **5** and then flows into the indoor heat exchanger **4**. The liquid refrigerant that has flowed into the indoor heat exchanger **4** exchanges heat with indoor air to receive heat therefrom and evaporate, thereby cooling the indoor air. As a result, the liquid refrigerant changes into gas refrigerant, and the gas refrigerant flows out from the indoor heat exchanger **4**.

[0115] The gas refrigerant that has flowed out form the indoor heat exchanger **4** flows out from the indoor unit **2***c*, passes through the indoor-unit-side shut-off valve **30***a*-**6**, and flows into the relay unit **17**. The gas refrigerant that has flowed into the relay unit **17** passes through the on-off valve **22***e* and flows into the pipe **24***e*. The gas refrigerant that has flowed into the pipe **24***e* joins the refrigerant flowing in the pipe **24***c*, then passes through the outdoor-unit-side shut-off valve **30***b*-**2** and the refrigerant-pipe communication part **10***b*, and flows into the outdoor unit **3**.

[0116] The gas refrigerant that has flowed from the relay unit **17** into the outdoor unit **3** through the outdoor-unit-side shut-off valve **32***b*-**2** passes through the check valve **16***c*, the expansion valve **8**, and the outdoor heat exchanger **7**, and is completely gasified. The completely gasified refrigerant returns to the compressor **6** through the refrigerant flow switching device **9** and the accumulator **25**. In the heating main operation, the above circulation of the refrigerant is repeated.

Operation in Case Where Refrigerant Leak Is Detected

[0117] When it is detected that a refrigerant leak occurs, each of the shut-off valves **30** is closed as described above regarding Embodiment 1. As a result, the region where each

indoor unit **2** is located, the region where the relay unit **17** is located, and the region where the outdoor unit **3** is located are isolated from each other as independent regions. In this state, as described above regarding Embodiment 1, external equipment such as a pressure sensor or a vacuum pump is connected to the shut-off valve **30**, whereby it is possible to determine the location at which the refrigerant leak occurs, and perform maintenance. For example, in the case where a refrigerant leak occurs in the vicinity of the check valve **21***a* that is provided as illustrated in FIG. **10**, a detection value obtained by the pressure sensor connected to the indoor-unit-side shut-off valve **30***a*-**1** is close to the atmospheric pressure. Therefore, at the time of determining the location at which the refrigerant leak occurs, it is possible to shorten the time required for the checking by starting the checking from part of the refrigerant pipe **10** that is close to the indoor-unit-side shut-off valve **30***a*-**1**.

[0118] Furthermore, in the case of drawing the refrigerant from the relay unit **17** in order to prevent an increase in the amount of refrigerant leak, devices for drawing refrigerant are connected to respective indoor-unit side shut-off valves, that is, the indoor-unit-side shut-off valves **30***a*-**1** to **30***a*-**6**, to draw back the refrigerant. By applying this way, it is possible to reduce the amount of time required to draw back the refrigerant. Furthermore, in the case of evacuating the refrigerant pipes **10** after repairing an area where the refrigerant leak occurs, vacuum pumps are connected to plural shut-off valves **30**. Thus, they can be evacuated at the same time. It is therefore possible to reduce the time that is required for maintenance from the time at which refrigerant leaks from the air-conditioning apparatus **100**.

[0119] As described above, in Embodiment 2, the plural indoor units **2** is provided; the relay unit **17** is installed between the outdoor unit **3** and the indoor units **2***a* to **2***c*, and switches the flow passage to be used in the refrigerant circuit between plural flow passages; the outdoor unit **3**, the relay unit **17**, and the indoor units **2***a* to **2***c* are connected by the refrigerant pipes **10**; and for the indoor units **2***a* to **2***c*, the respective indoor-unit-side shut-off valves **30***a* are provided, and each of the indoor-unit-side shut-off valves **30***a* is located closer to an associated one of the indoor units **2** than to the relay unit **17**.

[0120] By virtue of the above configuration, the inside of the air-conditioning apparatus **100** is divided into a region where the outdoor unit **3** is installed, a region located between the relay unit **17** and the indoor unit **2**, a region where the indoor unit **2***a* is installed, a region where the indoor unit **2***b* is installed, and a region where the indoor unit **2***c* is installed, whereby those regions can be subjected to maintenance independently of each other. It is therefore possible to perform maintenance on the above regions simultaneously, and thus reduce the time required for maintenance on the air-conditioning apparatus **100**. Accordingly, the maintainability of the air-conditioning apparatus **100** is improved.

[0121] In existing air-conditioning apparatuses having a relay unit, the total length of refrigerant pipes is great, and the amount of refrigerant to be used is large. Thus, in some cases, it takes time to perform maintenance such as an operation to determine the location at which a refrigerant leak occurs, an operation to draw back refrigerant, an operation to re-fill refrigerant, and an operation to evacuate the refrigerant pipes. In the air-conditioning apparatus **100** according to Embodiment 2, refrigerant pipes **10** branch off in a complicated way in regions located between the relay unit **17** and the indoor units **2**, and the total length of the refrigerant pipes **10** is great. However, in the air-conditioning apparatus **100** according to Embodiment 2, external equipment is connected to the service ports **50** of the indoor-unit-side shut-off valves **30***a*-**1** to **30***a*-**6**, whereby maintenance can be performed simultaneously on the regions located between the relay unit **17** and the indoor units **2**. Therefore, the maintainability of the air-conditioning apparatus **100** is further improved.

Embodiment 3

[0122] The shut-off valves **30** and the air-conditioning apparatus **100** according to Embodiment 3 will be described below. In the air-conditioning apparatus **100** according to Embodiment 3, plural relay units **17** are provided between the outdoor unit **3** and the plural indoor units **2**, and the shut-off valves **30** include relay-unit-side shut-off valves **30***c*. In this regard, the air-conditioning apparatus **100** of Embodiment 3 is different in configuration from the air-conditioning apparatus **100** of Embodiment 1. Regarding Embodiment 3, components that are the same as those in Embodiment 1 and/or Embodiment 2 will be denoted by the same reference signs, and their descriptions will thus be omitted.

[0123] FIG. **11** is a schematic view illustrating an example of a circuit configuration of the air-conditioning apparatus **100** of Embodiment 3. As illustrated in FIG. **11**, the air-conditioning apparatus **100** of Embodiment 3 is a three-pipe air-conditioning apparatus **100** in which three pipes are provided as refrigerant pipes **10** between the outdoor unit **3** and relay units **17***a* and **17***b*. To be more specific, the refrigerant pipes **10** between the outdoor unit **3** and the relay units **17***a* and **17***b* are a refrigerant-pipe communication part **10***a*, a refrigerant-pipe communication part **10***b*, and a refrigerant-pipe communication part **10***c*. It should be noted that in FIG. **11**, detailed illustration of the circuits of the relay unit **17***a*, the relay unit **17***b*, the outdoor unit **3**, and indoor units **2***b*, **2***c*, and **2***d* is omitted, and dashed lines representing connection relationships between the controller **20** and the shut-off valves **30** are omitted. In the following description, the relay unit **17***a* and the relay unit **17***b* are each simply referred to as "relay unit **17**" as appropriate when they do not particularly need to be distinguished from each other. Also, the following description is also made assuming that the term "relay unit **17**" is applicable to both a single relay unit **17** and plural relay units **17**.

[0124] Outdoor-unit-side shut-off valves **30***b*-**1**, **30***b*-**2**, and **30***b*-**3** are provided between the outdoor unit **3** and the relay units **17***a* and **17***b*. The outdoor-unit-side shut-off valve **30***b*-**1** is provided at the refrigerant-pipe communication part **10***a*. The outdoor-unit-side shut-off valve **30***b*-**2** is provided at the refrigerant-pipe communication part **10***b*. The outdoor-unit-side shut-off valve **30***b*-**3** is provided at the refrigerant-pipe communication part **10***c*. The outdoor-unit-side shut-off valves **30***b*-**1** to **30***b*-**3** are located closer to the outdoor unit **3** than to the relay unit **17**.

[0125] The relay-unit-side shut-off valves **30***c* are provided between the outdoor unit **3** and the relay units **17***a* and **17***b*. The relay-unit-side shut-off valves **30***c*, as well as the indoor-unit-side shut-off valves **30***a* and the outdoor-unit-side shut-off valves **30***b*, are similar in configuration to the shut-off valves **30** according to Embodiment 1. In other words, the shut-off valves **30** include the relay-unit-side

shut-off valves **30***c*. As illustrated in FIG. **11**, at the refrigerant pipes **10** between the outdoor unit **3** and the relay units **17***a* and **17***b*, relay-unit-side shut-off valves **30***c*-**1**, **30***c*-**2**, **30***c*-**3**, **30***c*-**4**, **30***c*-**5**, and **30***c*-**6** are provided. In the following description, the relay-unit-side shut-off valves **30***c*-**1** to **30***c*-**6** are simply referred to as "relay-unit-side shut-off valves **30***c*" as appropriate when they do not particularly need to be distinguished from each other, and the following description is also made assuming that the term "relay-unit-side shut-off valve **30***c*" is applicable to both a single relay-unit-side shut-off valve **30***c* and plural relay-unit-side shut-off valves **30***c*.

[0126] The relay-unit-side shut-off valves **30***c*-**1**, **30***c*-**2**, and **30***c*-**3** are associated with the relay unit **17***a*. The relay-unit-side shut-off valves **30***c*-**4**, **30***c*-**5**, and **30***c*-**6** are associated with the relay unit **17***b*. The relay-unit-side shut-off valve **30***c* are each provided at the refrigerant pipe **10** connecting the outdoor unit **3** and the relay unit **17**, at a location close to an associated one of the relay units **17**. That is, the relay-unit-side shut-off valves **30***c*-**1** to **30***c*-**3** are located closer to the relay unit **17***a* than to the outdoor unit **3**. The relay-unit-side shut-off valves **30***c*-**4** to **30***c*-**6** are located closer to the relay unit **17***b* than to the outdoor unit **3**.

[0127] As illustrated in FIG. **11**, the air-conditioning apparatus **100** according to Embodiment 3 includes plural indoor units **2***a*, **2***b*, **2***c*, and **2***d*. The indoor unit **2***a*, **2***b*, **2***c*, and **2***d* are provided in spaces **1***a*, **1***b*, **1***c*, and **1***d*, respectively, which are air-conditioning target spaces. Refrigerant leak detection devices **15***a*, **15***b*, **15***c*, and **15***d* are provided in the spaces **1***a*, **1***b*, **1***c*, and **1***d*, respectively, to detect a refrigerant leak. It should be noted that the refrigerant leak detection devices **15***a* to **15***d* according to Embodiment 3 are the same as the refrigerant leak detection device **15** according to Embodiment 1, and their descriptions will thus be omitted.

[0128] The indoor units **2***a* and **2***b* are connected to the relay unit **17***a*. The indoor units **2***c* and **2***d* are connected to the relay unit **17***b*. The refrigerant pipe **10** between the indoor unit **2***a* and the relay unit **17***a* is provided with the indoor-unit-side shut-off valves **30***a*-**1** and **30***a*-**2**. At refrigerant pipes **10** between the indoor unit **2***b* and the relay unit **17***a*, the indoor-unit-side shut-off valves **30***a*-**3** and **30***a*-**4** are provided. At refrigerant pipes **10** between the indoor unit **2***c* and the relay unit **17***b*, the indoor-unit-side shut-off valves **30***a*-**5** and **30***a*-**6** are provided. At the refrigerant pipes **10** between the indoor unit **2***d* and the relay unit **17***b*, the indoor-unit-side shut-off valves **30***a*-**7** and **30***a*-**8** are provided. The configurations of the shut-off valves **30** according to Embodiment 3 are the same as those according to Embodiment 1, and their descriptions will thus be omitted.

Operation in Case Where Refrigerant Leak Is Detected

[0129] When it is detected that a refrigerant leak occurs, as described regarding Embodiment 1, the shut-off valves **30** are closed. The air-conditioning apparatus **100** according to Embodiment 3 includes the relay-unit-side shut-off valves **30***c*. As a result, regions where the respective indoor units **2** are installed, regions where the respective relay units **17** are installed, regions located between the relay units **17** and the outdoor unit **3**, and a region where the outdoor unit **3** is located are isolated from each other as independent regions. For example, in the case where refrigerant leaks from the refrigerant-pipe communication part **10***a*, a detection value obtained by a pressure sensor connected to any one of the outdoor-unit-side shut-off valve **30***b*-**1**, the relay-unit-side shut-off valve **30***c*-**1**, and the relay-unit-side shut-off valve **30***c*-**4** can be considered to be close to the atmospheric pressure. Therefore, it is possible to shorten the time required for checking to determine part of the refrigerant pipe **10** where the refrigerant leak occurs, by starting the checking from an area close to the shut-off valve **30** connected to the pressure sensor that obtains the detection value close to the atmospheric pressure. It is therefore possible to reduce the time required for the checking.

[0130] In the case of drawing back refrigerant from the refrigerant-pipe communication part **10***a* in order to prevent an increase in the amount of refrigerant leak, the device for drawing refrigerant connected to each of the outdoor-unit-side shut-off valve **30***b*-**1**, the relay-unit-side shut-off valve **30***c*-**1**, and the relay-unit-side shut-off valve **30***c*-**4** to draw back refrigerant. By applying this way, it is possible to shorten the time required to draw back refrigerant. Furthermore, in the case of evacuating the refrigerant-pipe communication part **10***a* after repairing an area where a refrigerant leak occurs, vacuum pumps are connected to the outdoor-unit-side shut-off valve **30***b*-**1**, the relay-unit-side shut-off valve **30***c*-**1**, and the relay-unit-side shut-off valve **30***c*-**4** to enable simultaneous evacuation to be performed. It is therefore possible to reduce the time required for maintenance that is performed after refrigerant leaks from the air-conditioning apparatus **100**. Therefore, the maintainability of the air-conditioning apparatus **100** can be further improved.

[0131] As described above, the shut-off valves **30** according to Embodiment 3 include the plural indoor-unit-side shut-off valves **30***a*, the plural outdoor-unit-side shut-off valves **30***b*, and plural relay-unit-side shut-off valves **30***c*. It is therefore possible to divide the inside of the air-conditioning apparatus **100** according to Embodiment 3 into a region where the indoor unit **2***a* is installed, a region where the indoor unit **2***b* is installed, a region where the indoor unit **2***c* is installed, a region where the indoor unit **2***d* is installed, a region where the relay unit **17***a* is installed, a region where the relay unit **17***b* is installed, and a region located between the outdoor unit **3** and the relay unit **17**. Furthermore, each of the above regions can be subjected to maintenance as an independent region. In existing air-conditioning apparatuses including a relay unit, since the total length of refrigerant pipes is great and the amount of refrigerant to be used is large, in some cases, it takes time to perform maintenance such as an operation to determine the location where a refrigerant leak occurs, an operation to draw back an operation to re-fill refrigerant, and an operation to evacuate refrigerant pipes. In contrast, in the air-conditioning apparatus **100** according to Embodiment 3, it is possible to perform maintenance simultaneously on plural regions as independent regions. It is therefore possible to further improve the maintainability of the air-conditioning apparatus.

1. An air-conditioning apparatus comprising:

an outdoor unit including a compressor and an outdoor heat exchanger, and configured to generate cooling energy or heating energy;

an indoor unit including an indoor heat exchanger, and configured to perform an air-conditioning operation with the cooling energy or the heating energy that is generated by the outdoor unit;

a refrigerant pipe provided between the outdoor unit and the indoor unit, and forming a refrigerant circuit in which refrigerant circulates;

a shut-off valve provided at the refrigerant pipe, and configured to be closed when a refrigerant leak is detected; and

a pressure sensor,

wherein the shut-off valve includes a service port communicating with the refrigerant pipe, and the pressure sensor is connected to the service port.

2. The air-conditioning apparatus of claim **1**, wherein

the service port has a tip that is openable and closable and that allows the pressure sensor to be attached to and detached from the tip, and

the tip is opened when the pressure sensor is connected to the tip.

3. The air-conditioning apparatus of claim **1**, wherein

the shut-off valve includes

a block body including a flow passage that is formed therein to communicate with the refrigerant pipe, and

a valve body to cause the flow passage to be opened or closed, and

the service port is provided at the block body in such a manner as to communicate with the flow passage.

4. The air-conditioning apparatus of claim **1**, wherein

the shut-off valve includes

a block body including a flow passage that is formed in the block body to communicate with the refrigerant pipe,

a valve body configured to cause the flow passage to be opened or closed, and

a connection pipe connected to the flow passage and protruding from the block body,

the connection pipe is connected to the refrigerant pipe, and

the service port is provided at the connection pipe.

5. The air-conditioning apparatus of claim **1**, wherein

a plurality of the shut-off valves are provided at the refrigerant pipe, and

the plurality of shut-off valves include

an indoor-unit-side shut-off valve located closer to the indoor unit than to the outdoor unit, and

an outdoor-unit-side shut-off valve located closer to the outdoor unit than to the indoor unit.

6. The air-conditioning apparatus of claim **5**, wherein

a plurality of the indoor-unit-side shut-off valves are provided,

the plurality of indoor-unit-side shut-off valves include

an indoor-unit-side shut-off valve provided at part of the refrigerant pipe through which the refrigerant passes to flow into the indoor unit, and

an indoor-unit-side shut-off valve provided at part of the refrigerant pipe through which the refrigerant flows after flowing out from the indoor unit,

a plurality of the outdoor-unit-side shut-off valves are provided, and

the plurality of outdoor-unit-side shut-off valves include

an outdoor-unit-side shut-off valve provided at part of the refrigerant pipe through which the refrigerant passes to flow into the outdoor unit, and

an outdoor-unit-side shut-off valve provided at part of the refrigerant pipe through which the refrigerant flows after flowing out from the outdoor unit.

7. The air-conditioning apparatus of claim **5**, wherein

a plurality of the indoor units are provided,

a relay unit is provided between the outdoor unit and the plurality of indoor units, and is configured to switch a flow passage to be used in the refrigerant circuit between plural flow passages,

the outdoor unit, the relay unit, and the plurality of indoor units are connected by the refrigerant pipe,

each of a plurality of the indoor-unit-side shut-off valves is provided for an associated one of the plurality of indoor units, and

the indoor-unit-side shut-off valve is located closer to the associated indoor unit than to the relay unit.

8. The air-conditioning apparatus of claim **7**, wherein

the plurality of shut-off valves include a relay-unit-side shut-off valve provided between the outdoor unit and the relay unit,

the relay-unit-side shut-off valve is located closer to the relay unit than to the outdoor unit, and

the outdoor-unit-side shut-off valve is located closer to the outdoor unit than to the relay unit.

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