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(54) SWITCHING APPARATUS AND AIR CONDITIONING APPARATUS

(57) There is provided a switching device or the like that is capable of efficiently performing operations such as the cutting off of a refrigerant and that is easy to maintain, design, and manufacture at low cost even if the switching device is included in, for example, an air-conditioning apparatus including a plurality of indoor units.

A plurality of shut-off valves 10 and 11 for individually stopping the flow of a refrigerant are provided in a plurality of pipes 6, 7, and others for making a refrigerant circulate between a heat source unit A and a plurality of indoor units C to E. The shut-off valves 10 and 11 are integrated into pairs. A number of pairs of the shut-off valves 10c to 10e and 11c to 11e corresponding to the number of indoor units are grouped together.

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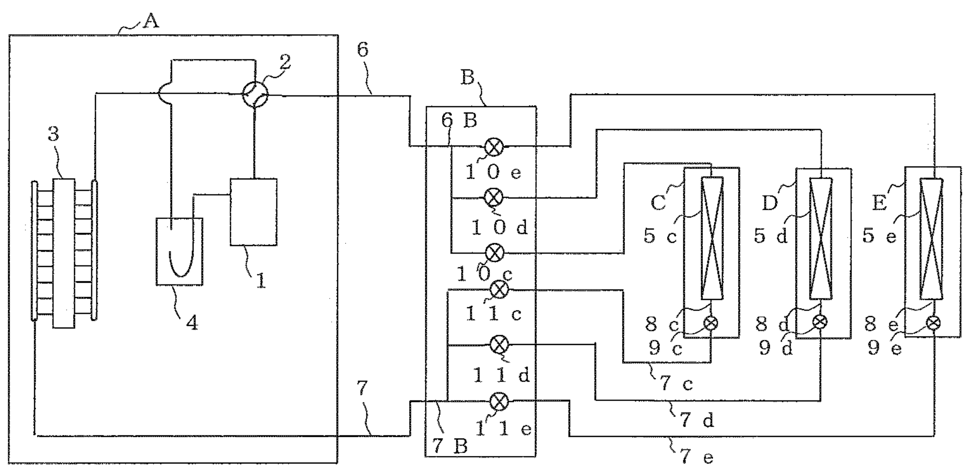

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Description

Technical Field

[0001] The present invention relates to switching devices for switching between allowing and not allowing refrigerants to flow through pipes and to air-conditioning apparatuses employing refrigeration cycles. More specifically, the present invention relates to a switching device or the like that cuts off the refrigerant in times of refrigerant leakage in an air-conditioning apparatus.

Background Art

[0002] In an air-conditioning apparatus (refrigeration cycle apparatus), for example, a compressor, a four-way valve, an outdoor-unit-side heat exchanger, an expansion valve, and an indoor-unit-side heat exchanger are sequentially connected to one another with refrigerant pipes, whereby a refrigerant circuit (refrigeration cycle) through which a refrigerant is made to circulate is provided. When the refrigerant is evaporated or is condensed, heat is transferred to and from air or the like, which is a subject of heat exchange. Utilizing this, an air-conditioning operation, a cooling operation, and the like are performed while the pressure of the refrigerant flowing through the pipes is varied.

[0003] In general, in such an air-conditioning apparatus, the refrigerant is confined in and is made to circulate through devices (means) and pipes included in the refrigerant circuit. Nevertheless, the refrigerant may leak to the outside of the circuit caused by some reason such as connection failure or aging deterioration. If the refrigerant leaks, desired air conditioning cannot be achieved. Moreover, there may be cases such as the refrigerant catching fire. Such a situation is not good for one's health. In light of this, an air-conditioning apparatus has been proposed that includes a refrigerant leakage sensor for detecting the leakage of a refrigerant from an indoor-side heat exchanger to the outside and a pair of solenoid valves for cutting off the flow of the refrigerant that are each provided at positions of the refrigerant circuit on the refrigerant inlet and outlet sides of the indoor-side heat exchanger. If the refrigerant leakage sensor detects any refrigerant leakage, refrigerant-collecting means causes the apparatus to perform a cooling operation. In that case, the on-off valve provided on a side in which the refrigerant that is in a liquid state (a liquid refrigerant) flows (the refrigerant may be a two-phase gas-liquid refrigerant) is first closed. Subsequently, after a predetermined period of time has elapsed, the other on-off valve provided on a side in which the refrigerant that is in a gas state (a gas refrigerant) flows (the refrigerant may be a two-phase gas-liquid refrigerant) is closed (see Patent Literature 1, for example).

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 6-180166

Summary of Invention

Technical Problem

[0005] For example, in the air-conditioning apparatus disclosed in Patent Literature 1, the on-off valves provided before and after the indoor-unit-side heat exchanger are independent of each other. For example, in a case of a multisystem that includes a plurality of indoor units connected in parallel, such on-off valves are provided to each of the indoor units thus becoming dispersed and rendering the apparatus to become large. Consequently, cost of the apparatus is increased. Moreover, the ease of maintenance is hindered. In particular, if refrigerant leakage from an indoor unit is detected, it takes some time to recover those indoor units at its initial stage.

[0006] In addition, the apparatus does not include any means for performing checking of airtightness, for vacuuming, for adding the refrigerant, and so forth between each of the on-off valves and the indoor unit. Therefore, in the case of a multisystem in which a plurality of indoor units are connected, the indoor units cannot be recovered individually, for example. Hence, the system as a whole needs to be stopped. During the stoppage, any operations concerning air conditioning cannot be performed.

[0007] The invention is made to solve the above existing problems and to provide a switching device or the like that is capable of efficiently performing operations such as the cutting off of a refrigerant and that is easy to maintain, design, and manufacture at a low cost even if the switching device is included in, for example, an air-conditioning apparatus with a plurality of indoor units.

Solution to Problem

[0008] A switching device according to the invention includes a plurality of shut-off valves that each cut off the flow of a refrigerant and that are provided in a plurality of pipes between a heat source unit and a plurality of indoor units, the pipes making the refrigerant circulate. The shut-off valves are integrated into pairs. A number of pairs of the shut-off valves corresponding to the number of indoor units are grouped together.

Advantageous Effects of Invention

[0009] According to the invention, the shut-off valves provided in correspondence with the plurality of pipes connecting the heat source unit and the indoor units are integrated into pairs, and the pairs corresponding in number to the number of indoor units are grouped together. Therefore, a small switching device can be obtained. Furthermore, such a switching device can be obtained at a low manufacturing cost, contributing to cost reduction. Furthermore, the integration and grouping facilitates the connection of the indoor units and the respective pairs of the shut-off valves. Furthermore, the ease of maintenance (serviceability) can be improved.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 illustrates a switching device B according to Embodiment 1 of the invention.
[Fig. 2] Fig. 2 illustrates a section of the switching device B.
[Fig. 3] Fig. 3 illustrates an air-conditioning apparatus including the switching device B.
[Fig. 4] Fig. 4 illustrates the flow of a refrigerant in a cooling operation.
[Fig. 5] Fig. 5 illustrates the flow of the refrigerant in a heating operation.
[Fig. 6] Fig. 6 illustrates a section of a switching device B according to Embodiment 2 of the invention.
[Fig. 7] Fig. 7 illustrates a configuration of a refrigerant-leakage-monitoring system according to Embodiment 4 of the invention.
[Fig. 8] Fig. 8 is a flowchart concerning refrigerant-leakage monitoring according to Embodiment 4.

Description of Embodiments

[0011] Embodiments of the invention will now be described with reference to the drawings. In the drawings, the same or equivalent means and the like are denoted by the same reference numerals. In describing means illustrated in a certain drawing, if any description of the means has been given when referring to any other drawings, description thereof for that drawing is omitted or simplified accordingly. If there is no particular need to distinguish or specify such means and the like, suffixes may be omitted.

Embodiment 1

[0012] Fig. 1 includes diagrams illustrating a switching device B according to Embodiment 1 of the invention in which a plurality of shut-off valves are integrated and grouped together. Figs. 1 (a) and 1 (b) illustrate the switching device B seen from different directions. In Fig. 1, solenoid coils (not illustrated) functioning as actuators that open and close shut-off valves 10 and 11 with the use of electromagnetic forces are not illustrated.

[0013] As illustrated in Fig. 1, in the switching device B, each of the shut-off valves 10 and a corresponding one of the shut-off valves 11 are paired as an integral body, and a plurality of pairs are grouped together. Fig. 1 illustrates a combination including three pairs of shut-off valves, namely, shut-off valves 10c to 10e paired to shut-off valves 11c to 11e, respectively. The shut-off valves 10 each control communication between pipes through which a refrigerant flows in a gas state (hereinafter including a two-phase gas-liquid state), and allow or stop the passage of the refrigerant flowing therethrough. The shut-off valves 11 each control communication between pipes through which the refrigerant flows in a liquid state (hereinafter including a two-phase gas-liquid state), and allow or stop the passage of the refrigerant flowing therethrough. Configurations and so forth of the shut-off valves 10 and the shut-off valves 11 will be described separately below.

[0014] A pipe 6B and a pipe 7B are provided to connect the switching device B to a first connection pipe 6 and a second connection pipe 7, respectively, which will be described separately below. Pipes 6c to 6e are each connected to a corresponding one of the shut-off valves 10c to 10e at one end thereof and to a corresponding one of indoor units C, D, and E, which will be described separately below, at the other end thereof. Pipes 7c to 7e are each connected to a corresponding one of the shut-off valves 11c to 11e at one end thereof and to a corresponding one of the indoor units C, D, and E, described separately below, at the other end thereof.

[0015] Fig. 2 illustrates a section Z-Z1 of the switching device B illustrated in Fig. 1. Fig. 2 illustrates a state where the electric coils are not energized. Here, a configuration of the shut-off valve 11e will be described mainly. The shut-off valve 11e allows the pipe 7B that is connected to the first connection pipe 7 and the pipe 7e that is connected to the indoor unit E to communicate with each other when a corresponding one of the solenoid coils is energized.

[0016] The shut-off valve 11e includes, between the pipe 7B and the pipe 7e, a main valve chamber 17b that forms a space in which a main valve 21 b can move. A valve seat 18b having a hole 22b is provided at the boundary between the main valve chamber 17b and the pipe 7e. A lid body 19b is screwed to a main body with its female screw portion, whereby the space in the main valve chamber 17b and a space on the outside are isolated (parted) from each other.

[0017] The main valve 21 b slides along the wall of the main valve chamber 17b due to changes in the pressure in the main valve chamber 17b, thereby opening and closing the hole 22b of the valve seat 18b. The lid body 19b includes a sub-valve chamber 24b that communicates with the main valve chamber 17b via a first communication port 23. The sub-valve chamber 24b provides a space that allows a sub-valve 28b to slide and move therein. The sub-valve 28b opens and closes a pilot hole 27b provided at a lid-body port 26b.

[0018] A second communication port 29b that allows the sub-valve chamber 24b and the pipe 7e to communicate with each other includes a main-body port 30b and the lid-body port 26b. The lid-body port 26b is provided in the lid body 19b and communicates with the main-body port 30b. The lid body 19b is screwed and fixed to the main body, whereby a cylindrical space 31 b is provided between the main body and the lid body 19b. Therefore, the lid-body port 26b may be provided at any circumferential position.

[0019] The lid body 19b is provided as a component (see Fig. 2) including a case 33b that houses the sub-valve 28b and a spring 32b. The case 33b is brazed to an opening of the sub-valve chamber 24. The lid body is assembled with an O-ring 34b for sealing the main valve chamber 17b.

[0020] The solenoid coil for applying suction to the sub-valve 28b is attached to the case 33b separately from and independent of the main body. The O-ring 34b is provided for isolating a space 35b provided between the main valve 21 b and the lid body 19b from the space 31 b. The first communication port 23b extends parallel to the main valve 21 b. A clearance (gap) necessary for the sliding is provided between the main valve chamber 17b and the main valve 21 b.

[0021] The shut-off valve 10e allows the pipe 6B, which is connected to the first connection pipe 6 at the one end thereof, and the 6e, which is connected to the indoor unit E at the other end thereof, to communicate with each other when the solenoid valve coil is energized. The configuration of the shut-off valve 10e, functions of means included therein, and so forth are basically the same as those of the shut-off valve 11e, and individual means corresponding thereto are each denoted with a suffix a instead of a suffix b.

[0022] Operations of the shut-off valves 10 and 11 will now be described. Herein, the shut-off valve 11e is taken as a representative and will be described with reference to Fig. 2. When the solenoid coil is not energized, the pilot hole 27b of the lid-body port 26b is sealed by the spring 32b, as illustrated in Fig. 2. Here, let the pressures in a space 36b provided in the pipe 7B, the space 35b provided in the main valve chamber 17b, and a space 37b provided in the pipe 7e be denoted by P1, P2, and P3, respectively. In this state, the relationship among the pressures is expressed by $P1 \approx P2 > P3$. Furthermore, the main valve 21 b seals the hole 22b of the valve seat 18b, thereby cutting off a flow path that allows the pipe 7B and the pipe 7e to communicate with each other.

[0023] When the solenoid coil is energized, the solenoid coil generates an electromagnetic force. The electromagnetic force causes the sub-valve 28b to move toward the upper side of the case 33b, whereby the pilot hole 27b of the lid-body port 26b is opened. Therefore, the space 35b in the main valve chamber 17b that is nearer to the first communication port 23b communicates with the space 37b in the pipe 7e via the first communication port 23b, the sub-valve chamber 24b, the lid-body port 26b, the space 31 b, and the main-body port 30b. The relationship among the pressures in this state is expressed by $P1 > P2 \approx P3$. The difference between the pressure P1 in the space 36b provided in the pipe 7B and the pressure P2 in the space 35b nearer to the first communication port 23b causes the main valve 21 b to move toward the lid body 19. Therefore, the hole 22b of the valve seat 18b is opened, and the pipe 7B and the pipe 7e communicate with each other. Hence, by energizing the solenoid valve coil according to need, a specific flow path is provided. Thus, the flow is controllable.

[0024] Fig. 3 illustrates a configuration of an air-conditioning apparatus including the switching device B. Embodiment 1 concerns a case where the air-conditioning apparatus including the switching device B is a refrigeration cycle apparatus as illustrated in Fig. 3. In Fig. 3, the air-conditioning apparatus according to Embodiment 1 includes a refrigerant circuit in which a heat source unit A is connected to the indoor units C, D, and E with pipes. The switching device B illustrated in Figs. 1 and 2 is provided between the heat source unit A and the indoor units C, D, and E.

[0025] The heat source unit A and the switching device B are connected to each other with the first connection pipe 6 and the second connection pipe 7. The refrigerant flows in a gas state through the first connection pipe 6. The refrigerant flows in a liquid state through the second connection pipe 7. To reduce the resistance in the flow path, the first connection pipe 6 has a larger diameter than the second connection pipe 7. The switching device B is connected to the indoor units C, D, and E with indoor-side first connection pipes 6c to 6e, respectively, and with indoor-side second connection pipes 7c to 7e, respectively.

[0026] The heat source unit A according to Embodiment 1 includes a compressor 1, a four-way valve 2, a heat-source-side heat exchanger (outdoor heat exchanger) 3, and an accumulator 4. The compressor 1 compresses the refrigerant suctioned thereinto and discharges the refrigerant. The compressor 1 is not particularly limited to but may be configured such that the capacity of the compressor 1 (the amount of refrigerant to be discharged per unit hour) is changeable by arbitrarily changing the operating frequency by using, for example, an inverter circuit or the like. The four-way valve 2 is a valve for switching the flow of the refrigerant between, for example, a cooling operation and a heating operation. The heat-source-side heat exchanger 3 exchanges heat between the refrigerant and air (outside air). For example, in the heating operation, the heat-source-side heat exchanger 3 functions as an evaporator, in which heat is exchanged between a low-pressure refrigerant that has flowed from the second connection pipe 7 and air, whereby the refrigerant is evaporated and gasified. In the cooling operation, the heat-source-side heat exchanger 3 functions as a condenser, in which heat is exchanged between the refrigerant that has flowed from the four-way valve 2 and that is compressed by the compressor 1 and air, whereby the refrigerant is condensed and liquefied. The accumulator 4 is means that store, for example, excessive refrigerant in a liquid state.

[0027] The indoor units C, D, and E include flow control devices 9 (9c to 9e), respectively, and use-side heat exchangers (indoor heat exchangers) 5 (5c to 5e), respectively. In the indoor units C, D, and E, the flow control devices 9 and the use-side heat exchangers 5 are connected to each other with connection pipes 8 (8c to 8e), respectively. The flow control devices 9 control the pressure of the refrigerant in the respective use-side heat exchangers 5 by changing the opening degrees thereof. The use-side heat exchangers 5 each exchange heat between the refrigerant and air. For example, in the cooling operation, the use-side heat exchanger 5 functions as an evaporator, in which heat is exchanged between the refrigerant controlled to have a low pressure by a corresponding one of the flow control devices 9 and air. In the heating operation, the use-side heat exchanger 5 functions as a condenser, in which heat is exchanged between the refrigerant that has flowed from the first connection pipe 6 and air.

[0028] Fig. 4 illustrates the flow of the refrigerant in the air-conditioning apparatus in the cooling operation. An operation of the air-conditioning apparatus configured as illustrated in Fig. 3 will now be described on the basis of the flow of the refrigerant in the refrigerant circuit. Here, it is assumed that the indoor units C, D, and E are in cooling operation, and the shut-off valves 10 and 11 are open. First, a case of the cooling operation will be described with reference to Fig. 4. The flow of the refrigerant in the cooling operation is represented by solid-line arrows in Fig. 4.

[0029] A gas refrigerant having a high temperature and a high pressure compressed by and discharged from the compressor 1 flows through the four-way valve 2 into the heat-source-side heat exchanger 3, where the gas refrigerant exchanges its heat with air, water, or the like, thereby being condensed and liquefied into, for example, a two-phase gas-liquid refrigerant having a high temperature and a high pressure. Then, the refrigerant flows out of the heat source unit A.

[0030] Subsequently, the refrigerant flows through the second connection pipe 7, the shut-off valves 11c to 11e of the switching device B, and the indoor-unit second connection pipes 7c to 7e into the indoor units C, D, and E. After the refrigerant undergoes pressure reduction in the flow control devices 9c to 9e and becomes low in pressure, the refrigerant flows through the use-side heat exchangers 5c to 5e, where the refrigerant is evaporated and gasified, and cools, for example, air in the rooms that are an object of heat exchange. In this case, for example, controllers (not illustrated) that control the indoor units control the opening degrees of the flow control devices 9c to 9e in accordance with the degrees of superheat of the refrigerant at the outlets of the use-side heat exchangers 5c to 5e.

[0031] The refrigerant gasified by flowing through the use-side heat exchangers 5c to 5e flows through the indoor first connection pipes 6c to 6e, the solenoid valves 10c to 10e of the switching device B, and the first connection pipe 6 into the heat source unit A. Subsequently, the refrigerant flows through the four-way valve 2 and the accumulator 4 and is suctioned into the compressor 1, where the refrigerant is compressed and is discharged as described above. Thus, the refrigerant circulates.

[0032] Fig. 5 illustrates the flow of the refrigerant in the air-conditioning apparatus in the heating operation. Here, it is assumed that the indoor units C, D, and E are in heating operation. The flow of the refrigerant in the heating operation is represented by solid-line arrows in Fig. 5.

[0033] The gas refrigerant having a high temperature and a high pressure compressed by and discharged from the compressor 1 flows through the four-way valve 2 out of the heat source unit A. Subsequently, the refrigerant flows through the first connection pipe 6, the shut-off valves 10c to 10e of the switching device B, and the indoor-unit first connection pipes 6c to 6e into the indoor units C, D, and E.

[0034] The refrigerant that has flowed into the indoor units C, D, and E flows through the use-side heat exchangers 5c to 5e, where the refrigerant is condensed and liquefied, and heats, for example, air in the rooms that is an object of heat exchange. In this case, for example, the controllers that control the indoor units control the opening degrees of the flow control devices 9c to 9e in accordance with the degrees of subcooling of the refrigerant at the outlets of the use-side heat exchangers 5c to 5e. Then, the refrigerant undergoes pressure reduction in the flow control devices 9c to 9e becoming low in pressure and flows out of the indoor units C, D, and E.

[0035] Subsequently, the refrigerant flows through the second connection pipe 7, the shut-off valves 11c to 11e of the switching device B, and the indoor-unit second connection pipes 7c to 7e into the heat source unit A. The refrigerant that has flowed into the heat source unit A exchanges its heat with air, water, or the like, whereby the refrigerant is evaporated and gasified. Subsequently, the refrigerant flows through the four-way valve 2 and the accumulator 4 and is suctioned into the compressor 1, where the refrigerant is condensed and is discharged as described above. Thus, the refrigerant circulates.

[0036] As described above, according to Embodiment 1, a refrigerant circuit is provided in which the heat source unit A and the indoor units C, D, and E are connected to each other with the pipes 6, 7, and others. The switching device B is incorporated into the refrigerant circuit such that the shut-off valves 10 and 11 that cut off the flow of the refrigerant are integrated into pairs and are grouped together in accordance with the number of indoor units. Therefore, refrigerant leakage into rooms can be suppressed with a small and simple configuration, and a low-cost product can be provided. Since the pairs of the shut-off valves 10 and 11 corresponding in number to the number of indoor units are provided, only indoor units concerning refrigerant leakage can be separated from the refrigerant circuit. Therefore, there is no need to stop operations of all indoor units. Moreover, since the shut-off valves 10 and 11 are integrated as the switching device B, the ease of service and maintenance is high and disassembling and the like is easy. Furthermore, since such work can be performed smoothly, working time can be reduced. Accordingly, the downtime of the indoor units concerning refrigerant leakage can be reduced, realizing quick recovery. Consequently, the life increases. In addition, since the shut-off valves 10 and 11 are integrated into pairs and are grouped together, manufacturing (production) efficiency can be increased.

[0037] While Embodiment 1 concerns a case where the switching device B includes three pairs of the shut-off valves 10 and 11, the number of pairs is not necessarily limited to three and any other number of pairs also produces the same advantageous effects. Moreover, an apparatus including a plurality of heat-source-side heat exchangers 3 also produces the same advantageous effects. Furthermore, an apparatus including the heat-source-side heat exchanger 3 and an ice thermal storage tank or a water thermal storage tank (including a hot-water type) that are provided in series or in parallel also produces the same advantageous effects.

Embodiment 2

[0038] Fig. 6 illustrates a switching device B according to Embodiment 2 of the invention. The switching device B according to Embodiment 2 includes connecting portions Fa provided in correspondence with the pipes 6c to 6e and connecting portions Fb provided in correspondence with the pipes 7c to 7e. In Fig. 6, one of the connecting portions Fa communicates with the pipe 6e and allows a fluid (a gas or a liquid) to flow to and from the outside of the refrigerant circuit. Furthermore, one of the connecting portions Fb communicates with the pipe 7e and allows a fluid to flow to and from the outside of the refrigerant circuit.

[0039] In Embodiment 2, the connecting portions Fa and Fb are provided to the pipes 6c to 6e and 7c to 7e, respectively, of the switching device B that are provided in correspondence with the indoor units C to E, and a fluid is allowed to flow to and from the outside of the refrigerant circuit. Furthermore, checking of airtightness, vacuuming, addition of the refrigerant, and so forth are made possible. Thus, an air-conditioning apparatus is provided in which, for example, maintenance of any indoor units for which refrigerant leakage is detected can be easily performed in a short time while the air-conditioning operations of the other indoor units are continued.

[0040] As illustrated in Fig. 6, each connecting portion Fb includes a pipe 12b, a joint 13b, a cap 14b, a valve 15b, and a convex-shaped member 16b. As illustrated in Fig. 6, the pipe 12b is connected to the pipe 7e by brazing. The pipe 12b is in communication with the pipe 7e. The joint 13b includes the valve 15b, which has the convex-shaped member 16b inserted therein. One end of the joint 13b is connected to the pipe 12b by brazing. The other end of the joint 13b has a male screw portion, onto which the cap 14b is screwed such that the other end of the joint 13b is not in contact with the convex-shaped member 16b. Basically, for example, the convex-shaped member 16b functions as a stopper that isolates the outside. When the convex-shaped member 16b is pushed from the outside via a hole (not illustrated) provided in the cap 14b, the connecting portion Fb is opened and allows a fluid to flow to and from the outside.

[0041] Each connecting portion Fa includes a pipe 12a connected to the pipe 7e by brazing. The configuration of the connecting portion Fa, functions of means included therein, and so forth are basically the same as those of the connecting portion Fb, and individual means are each denoted with a suffix a.

[0042] Referring to Fig. 6, the following description concerns a measure using the connecting portions Fa and Fb that is to be taken in a case where the refrigerant has leaked in a certain indoor unit (the indoor unit E in the case of Fig. 6). For example, if it is determined that the refrigerant has leaked in the indoor unit E, the shut-off valves 10e and 11e are closed and the indoor unit E is isolated from the flow path (circulation cycle) of the refrigerant. Subsequently, checking is performed locating the part of the indoor unit E where the refrigerant has leaked. In this process, in Embodiment 2, an inert gas such as nitrogen is enclosed from the outside via one of or both of the connecting portions Fa and Fb. Thus, the part causing the refrigerant leakage can be located. After the part causing the refrigerant leakage is located, the inert gas is suctioned and is collected via one of or both of the connecting portions Fa and Fb.

[0043] After maintenance work is performed to the part and the like that has caused the leakage, the connecting portions Fa and Fb are connected to a vacuum pump. Thus, vacuuming can be performed. Furthermore, by connecting each of the connecting portions Fa and Fb to a refrigerant cylinder with a refrigerant hose, a specific amount of refrigerant can be supplied thereinto. Such a measure may be performed not only in times of refrigerant leakage but also in times of inspection and the like.

[0044] As described above, in the switching device B according to Embodiment 2, the connecting portions Fa and Fb are provided in correspondence with the shut-off valves 10 and 11 such that a fluid is allowed to flow to and from the outside. Therefore, for example, the occurrence of any refrigerant leakage, the location of the leakage, and so forth can be checked by supplying inert gas into the indoor unit that is isolated from the refrigerant circuit with the shut-off valves 10 and 11, while the other indoor units are allowed to perform air conditioning. In addition, vacuuming by suction, addition of the refrigerant, and so forth can be performed via the connecting portions Fa and Fb. Hence, the ease of service and maintenance is high, and users in the rooms do not feel uncomfortable. Moreover, the indoor unit can be recovered quickly.

Embodiment 3

[0045] In Embodiment 3, an operation of the switching device B performed when a certain indoor unit has caused refrigerant leakage will be described with reference to Fig. 3. The following description concerns a case where refrigerant leakage has occurred in a room installed with the indoor unit E.

[0046] First, a case of the cooling operation will be described. In the cooling operation, the refrigerant flows into the indoor unit E in a liquid state. Therefore, the shut-off valve 11e is closed, and the flow of the refrigerant that is about to flow into the indoor unit E is stopped. Then, after a predetermined period of time has elapsed, the shut-off valve 10e is closed. With such a time lag between the closing of the shut-off valve 10e and the closing of the shut-off valve 11e, the reduction in the amount of refrigerant flowing through the refrigerant circuit is suppressed, and the influence of the refrigerant leakage to the operation is reduced. Further, the amount of refrigerant leaking to the room can be reduced. Here, the predetermined period of time is a time period that is sufficient for the refrigerant to flow out of the indoor unit E, although the time period varies depending on the size of the indoor unit E (the distance over which the refrigerant flows, and so forth).

[0047] Next, a case of the heating operation will be described. In the heating operation, the refrigerant flows into the indoor unit E in a gas state. Therefore, the shut-off valve 10e is closed, and the flow of the refrigerant that is about to flow into the indoor unit E is stopped. Then, after a predetermined period of time has elapsed, the shut-off valve 11e is closed. The reduction in the amount of refrigerant flowing through the refrigerant circuit is suppressed, and the influence of the refrigerant leakage to the operation is reduced. Further, the amount of refrigerant leaking to the room can be reduced. Here, the predetermined period of time may be different from the predetermined period of time employed in the case of the cooling operation described above.

[0048] As described above, according to Embodiment 3, a refrigerant circuit is provided in which the heat source unit A and the indoor units C to E are connected to each other with the pipes 6, 7, and others. The switching device B is incorporated into the refrigerant circuit such that the shut-off valves 10 and 11 that cut off the flow of the refrigerant are integrated into pairs and are grouped together in accordance with the number of indoor units. Therefore, refrigerant leakage into rooms can be suppressed with a small and simple configuration. Hence, while the safety is enhanced by suppressing the reduction in the density of oxygen in the rooms, a low-cost product can be provided. While Embodiment 3 concerns a case where refrigerant leakage has occurred in one indoor unit, the same advantageous effects are produced in a case where, for example, refrigerant leakage occurs in a plurality of indoor units.

Embodiment 4

[0049] Fig. 7 illustrates a configuration of a leakage monitoring system provided in an air-conditioning apparatus according to Embodiment 4 of the invention. In Fig. 7, refrigerant leakage sensors 39c to 39e are provided in rooms installed with the indoor units C to E, respectively, and detect the state of the refrigerant in the rooms. If, for example, it is determined that the density of the refrigerant has reached a predetermined value or higher, it is regarded that refrigerant leakage has been detected. Then, a leakage signal notifying the refrigerant leakage state is issued.

[0050] A heat-source-unit control device 41 controls means included in the heat source unit A. Particularly in Embodiment 4, the heat-source-unit control device 41 includes communication means for performing communication with other devices included in the air-conditioning apparatus and is capable of communication of various kinds of signals. The heat-source-unit control device 41 also includes recording means (a memory) and thus records data on refrigerant leakage. Indoor-unit control devices 42c to 42e control means included in the respective indoor units C to E. In Embodiment 4, the indoor-unit control devices 42c to 42e are capable of communicating with the heat-source-unit control device 41 through various kinds of signals. The indoor-unit control devices 42c to 42e also perform processing for letting display means of remote controllers 43c to 43e to display operating states and so forth.

[0051] An interface device 40 transmits, to the switching device B via control lines, signals concerning the closing (cutting off of the refrigerant, hereinafter the signals are referred to as closing signals) transmitted from the heat-source-unit control device 41. Thus, the interface device 40 makes the solenoid coils of shut-off valves 10 and 11 that are to be closed be energized. In this case, the interface device 40 is connected to communication lines connecting the heat-source-unit communication device 41 and the indoor-unit communication devices 42c to 42e and is thus capable of communicating therewith over a common communication system. Hence, the probability of failure occurring only to communication concerning refrigerant leakage is reduced.

[0052] The remote controllers 43c to 43e are input means that allow the users to input instructions to the indoor units C to E. The remote controllers 43c to 43e, including the display means, display operating states and so forth in accordance with the signals from the indoor units C to E. In Embodiment 4, the remote controllers 43c to 43e display information on refrigerant leakage in accordance with the signals.

[0053] Fig. 8 is a flowchart concerning the leakage monitoring according to Embodiment 4. In Embodiment 4, a case where the refrigerant leakage sensor 39c has detected refrigerant leakage will be described. For example, if the refrigerant leakage sensor 39c provided in the room detects a refrigerant density higher than or equal to a predetermined value (step S1), a leakage signal is transmitted from the refrigerant leakage sensor 39c to the indoor-unit control device 42c of the indoor unit C.

[0054] The indoor-unit control device 42c receives the leakage signal from the refrigerant leakage sensor 39c. Subsequently, the indoor-unit control device 42c makes, for example, the display means of the remote controller 43c to display information on the leakage (step S2), and transmits, to the heat-source-unit control device 41, a refrigerant-leakage-information signal based on the leakage signal received. In this step, if, for example, any sound can be generated, an alert or the like may be issued.

[0055] When the heat-source-unit control device 41 receives the refrigerant-leakage-information signal, the heat-source-unit control device 41 records data on the leakage in the recording means provided in the heat-source-unit control device 41 (step S3). Although the data is stored in the storage means in this case, a signal may be transmitted, for example, to a superordinate device (for example, a centralized controller or the like). Subsequently, the heat-source-unit control device 41 transmits to the interface device 40 a closing signal for closing the shut-off valves 10c and 11e corresponding to the indoor unit C.

[0056] The interface device 40 transmits the closing signal to the switching device B. In the switching device B, the solenoid coils corresponding to the shut-off valves 10c and 11c are energized, and the shut-off valves 10c and 11c are closed (step S4). In this step, operations of the switching device B and the operations of the shut-off valves 10 and 11 that conduct the measure, which are performed in accordance with the closing signal, are the same as those described in Embodiments 1 and 3.

[0057] As described above, in the system according to Embodiment 4, for example, the interface device 40 that transmits instruction signals to the switching device B is connected to communication control lines that normally connect and allow communication between the heat source unit A and the indoor units C to E, and the communication thereamong is achieved over a common communication system. Therefore, the occurrence of communication failure is prevented. Hence, a stabilized operation is achieved, and the occurrence of refrigerant leakage to the rooms is suppressed. While Embodiment 4 concerns a case where instructions to the interface device 40 are made by the heat source unit A, the invention is not limited thereto. For example, instruction signals may be directly transmitted to the interface device 40 from the indoor units C to E. While Fig. 7 illustrates a configuration in which the interface device 40 and the heat source unit A are separate from each other, the interface device 40 may be, for example, included in the heat source unit A.

Industrial Applicability

[0058] The above embodiments concern a case where the switching device B is included in an air-conditioning apparatus. The invention is not limited to such an apparatus and is also applicable to any other refrigeration cycle apparatuses such as a refrigeration apparatus, a heat pump apparatus, and the like, each including a refrigerant circuit in which a refrigerant circulates through pipes. Reference Signs List

[0059] A heat source unit, B switching device, C to E indoor unit, Fa, Fb connecting portion, 1 compressor, 2 four-way valve, 3 heat-source-side heat exchanger, 4 accumulator, 5c use-side heat exchanger of indoor unit C, 5d use-side heat exchanger of indoor unit D, 5e use-side heat exchanger of indoor unit E, 6 first connection pipe, 6c, 6d, 6e indoor-side first connection pipe, 7 second connection pipe, 7c, 7d, 7e indoor-side second connection pipe, 8c, 8d, 8e connection pipe, 9 flow control device, 10, 10c, 10d, 10e, 11, 11c, 11d, 11e shut-off valve, 12a, 12b pipe, 13a, 13b joint, 14a, 14b cap, 15a, 15b valve, 16a, 16b convex-shaped member, 17a, 17b main valve chamber, 18a, 18b valve seat, 19, 19b lid body, 20a, 20b main-body port, 21 a, 21 b main valve, 22a, 22b hole, 23a, 23b case, 24a, 24b sub-valve chamber, 26a, 26b lid-body port, 27a, 27b pilot hole, 28a, 28b sub-valve, 29a, 29b second communication port, 30a, 30b main-body port, 31 a, 31 b, 35a, 35b, 36a, 36b space, 32a, 32b spring, 33a, 33b case, 34a, 34b O-ring, 39c to 39e refrigerant leakage sensor, 40 interface device, 41 heat-source-unit control device, 42c to 42e indoor-unit control device, 43c to 43e remote controller

Claims

1. A switching device, comprising:

   a plurality of shut-off valves integrally formed into pairs, the shut-off valves being provided in a plurality of pipes that connect a heat source unit and indoor units so as to circulate a refrigerant, the shut-off valves each cutting off a flow of the refrigerant based on an instruction,
   wherein a number of pairs of the shut-off valves corresponding to the number of indoor units are grouped together.

2. The switching device of claim 1, further comprising a connecting portion provided in a connection between a shut-off valve of each pair and a pipe on a side of the corresponding indoor unit, the connecting portion being capable of flowing a fluid into or out from the pipe.

3. An air-conditioning apparatus in which a heat source unit that includes a compressor, a four-way valve, and a heat-source-side heat exchanger and indoor units that each include a flow control device and a use-side heat exchanger are connected to each other with pipes and in which a refrigerant circuit per-

forms cooling and heating while a path through which a refrigerant circulates is switched by the four-way valve, the air-conditioning apparatus comprising:

the switching device of claim 1 or 2, connected in the pipes provided between the heat source unit and the plurality of indoor units.

4. The air-conditioning apparatus of claim 3, further comprising
refrigerant-leakage-detecting means that transmits a leakage signal when detecting refrigerant leakage from any of the indoor units provided in an air-conditioned space; and
an interface device that transmits an open-close signal to the switching device, the open-close signal requesting to close the corresponding shut-off valve on the basis of the leakage signal.

5. The air-conditioning apparatus of claim 4, wherein transmission of the signals concerning the refrigerant leakage is performed over a communication system that is used between the heat source unit and the indoor units.

6. The air-conditioning apparatus of claim 4 or 5, wherein
the indoor units each further include a controller including display means that displays a state of the corresponding indoor unit, and
when the leakage signal from the refrigerant-leakage-detecting means is received, information on the leakage is displayed on the display means of the corresponding controller.

7. The air-conditioning apparatus of any one of claims 4 to 6, wherein the heat source unit includes recording means that records information on the leakage when receiving the leakage signal from the refrigerant-leakage-detecting means.

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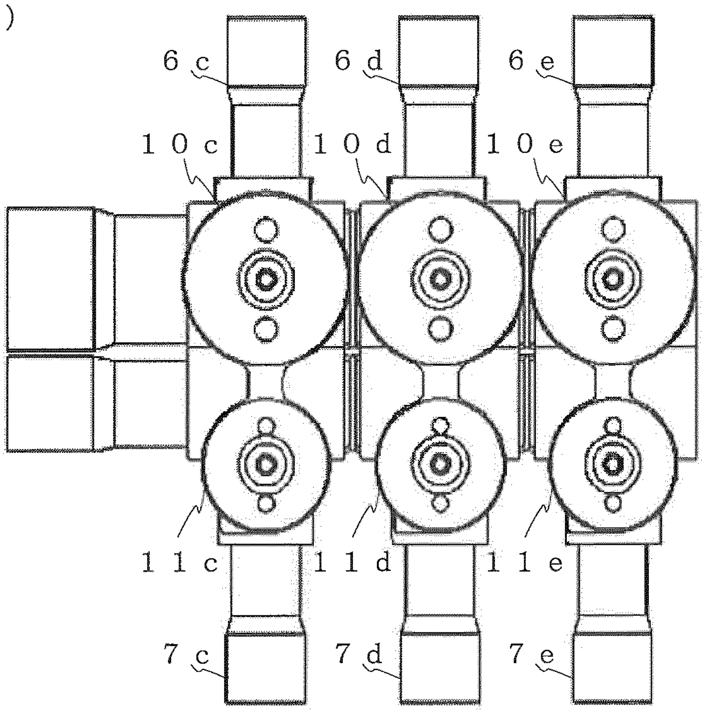
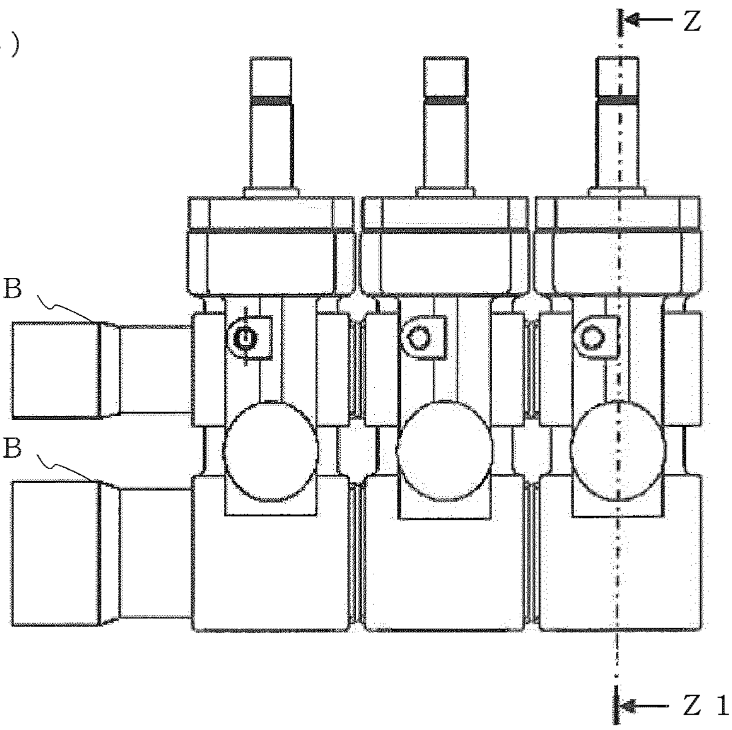
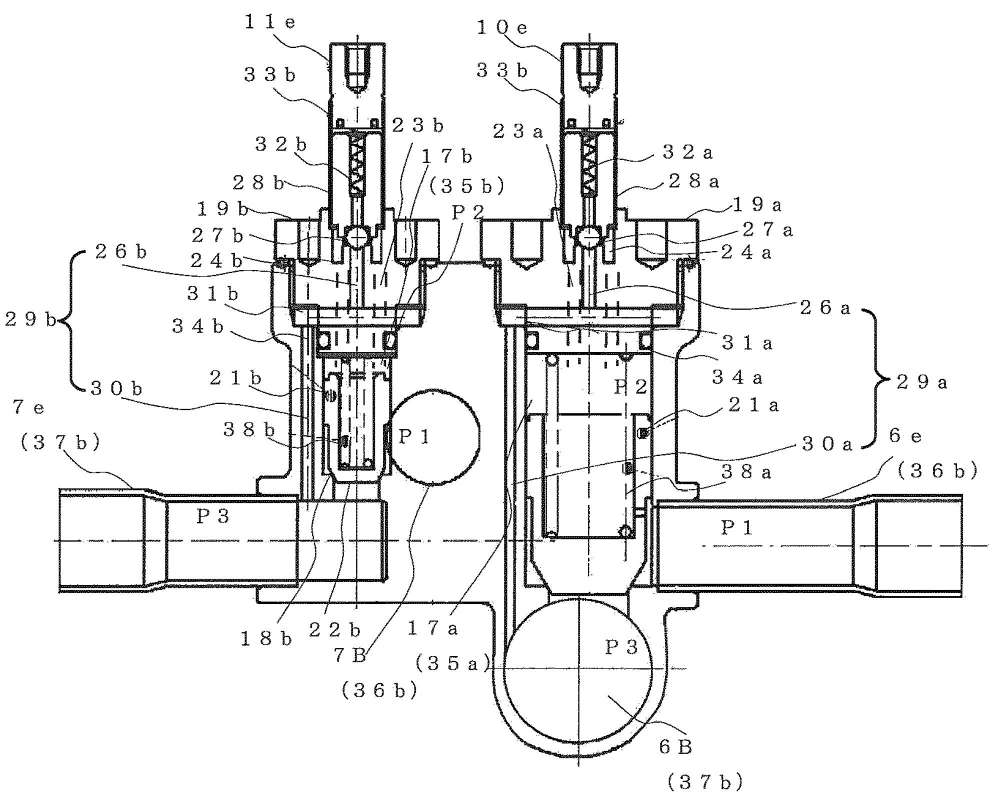




F I G. 2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P 2
1 9 a
2 7 b
2 7 a
2 6 b
2 4 b
2 4 a
3 1 b
2 6 a
2 9 b
3 4 b
3 1 a
3 4 a
2 9 a
2 1 b
P 2
3 0 b
2 1 a
7 e
P 1
3 8 b
6 e
(3 7 b)
3 0 a
3 8 a
(3 6 b)
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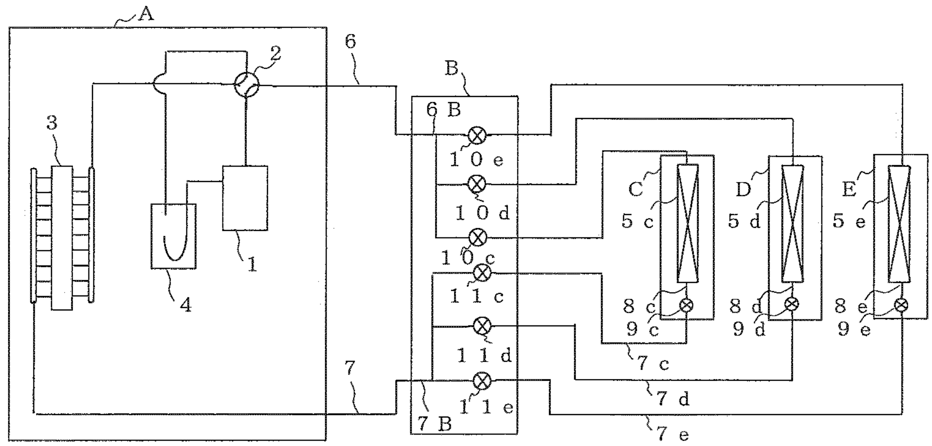
F I G. 3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B
6 B
3
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C
D
E
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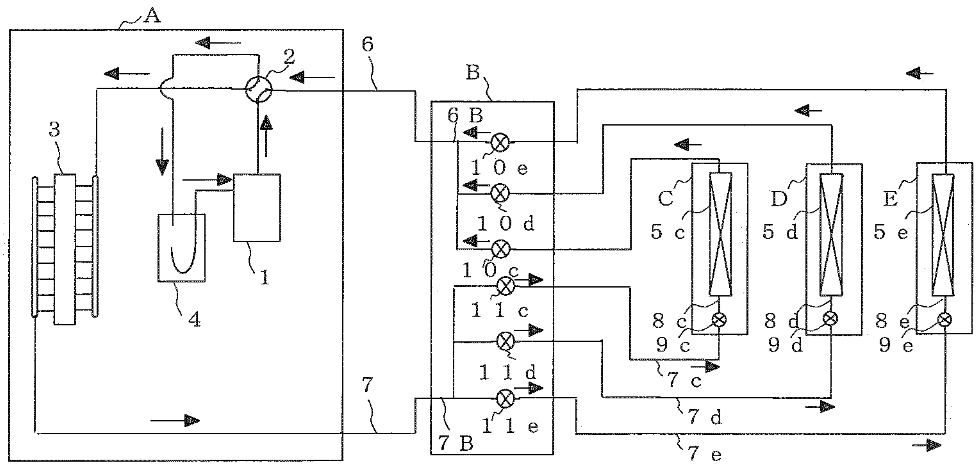
7 B
7 e

FIG. 4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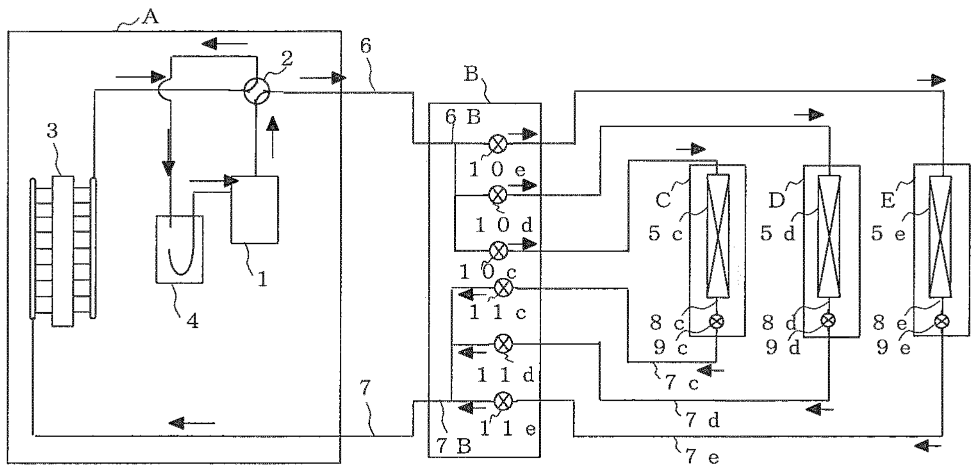
7e

FIG. 5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7B
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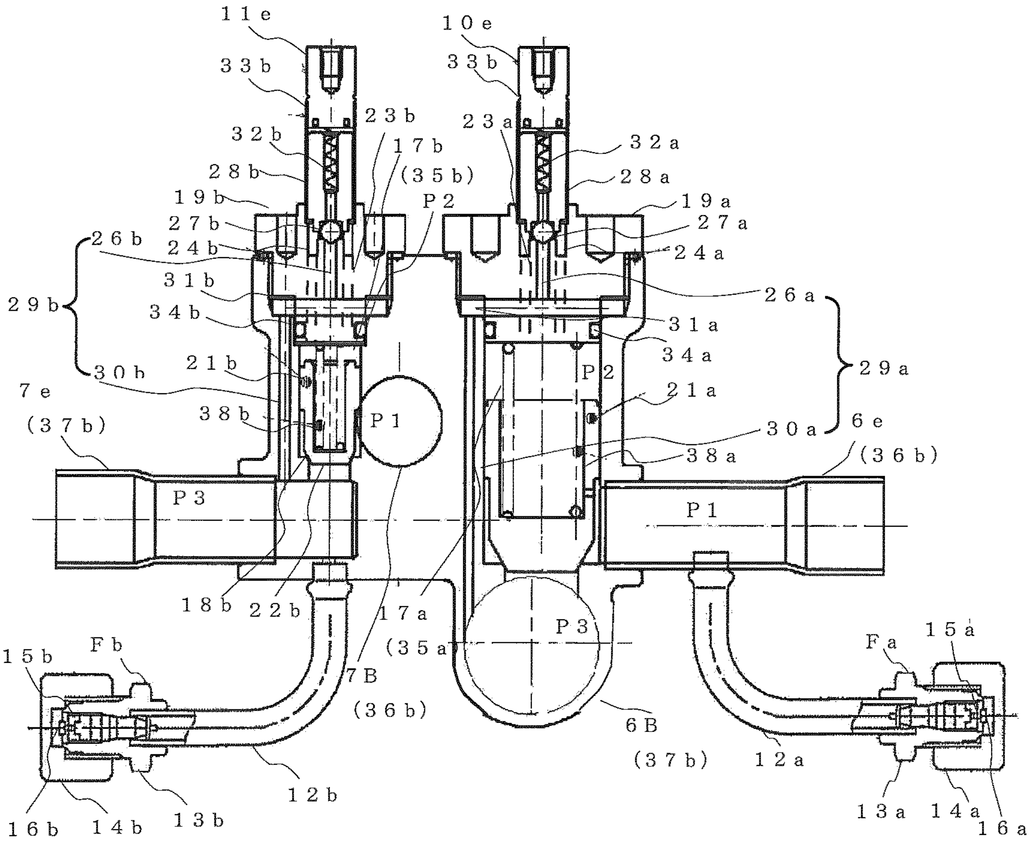
7e

FIG. 6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10e
33b
33b
23b
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28b
28a
P2
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27a
26b
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26a
29b
34b
31a
34a
30b
21b
P2
29a
7e
21a
(37b)
38b
P1
30a
6e
38a
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P3
P1
18b
22b
17a
P3
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Fb
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Fa
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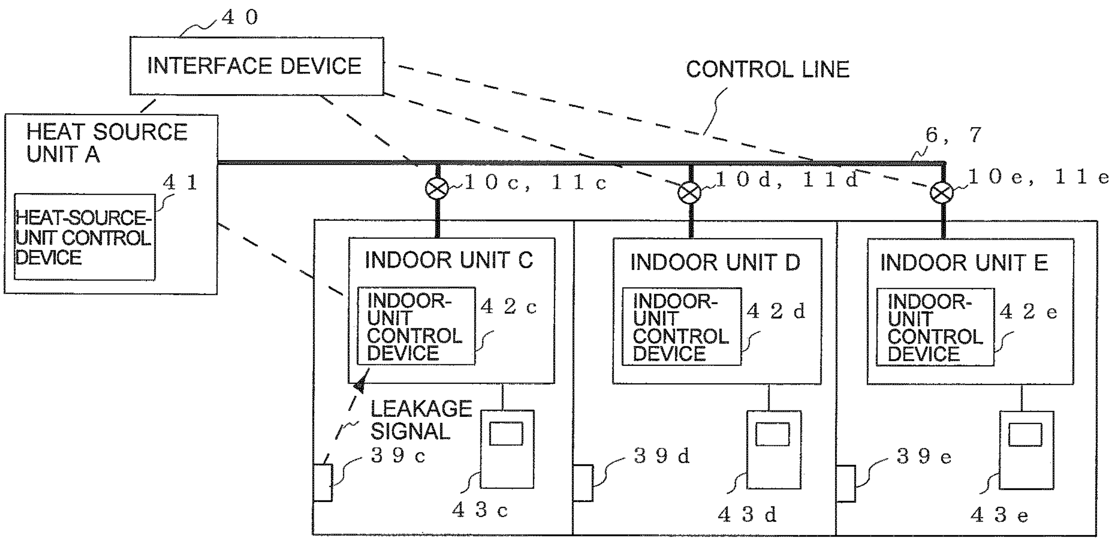
FIG. 7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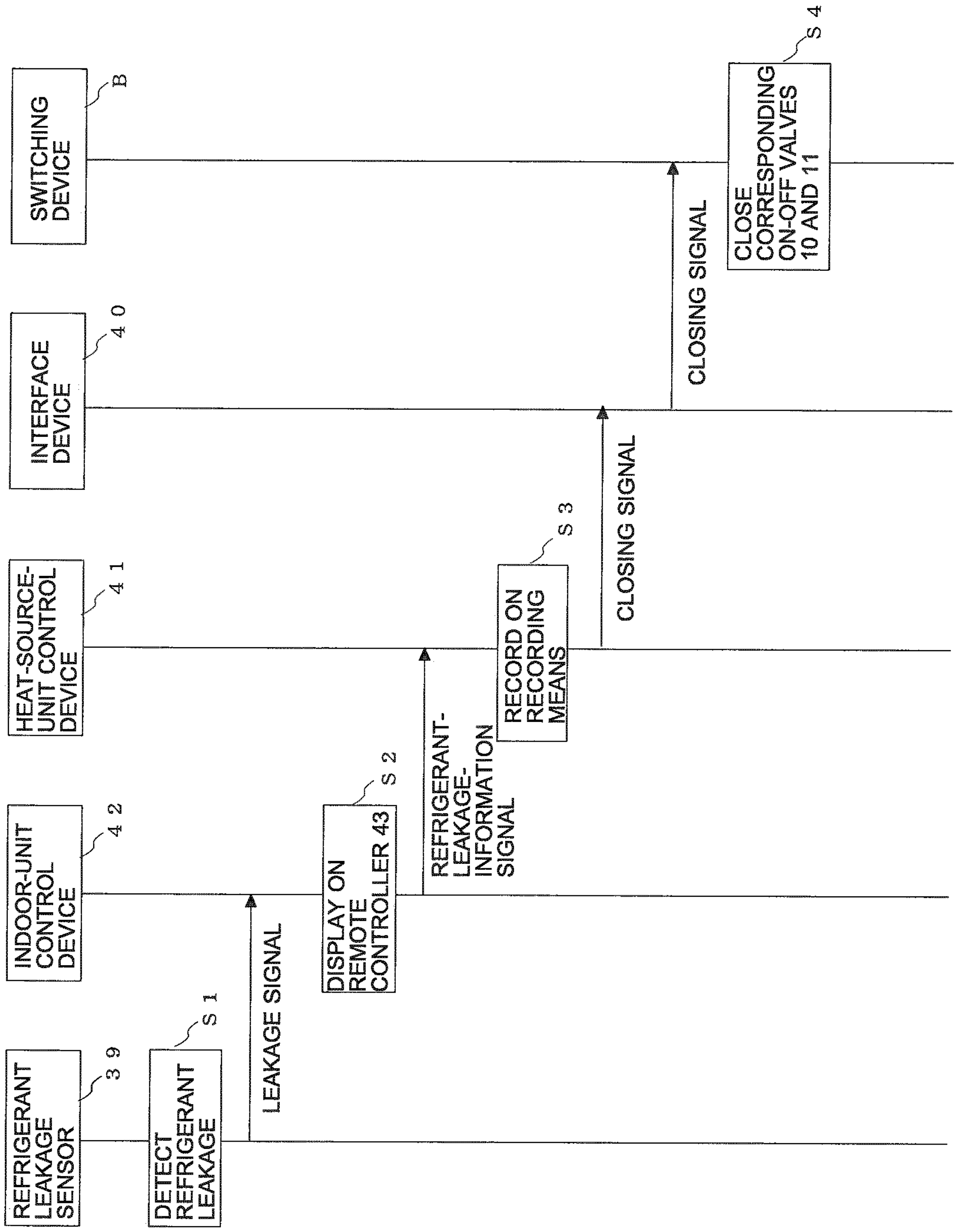
INTERFACE DEVICE
CONTROL LINE
HEAT SOURCE UNIT A
6, 7
41
HEAT-SOURCE-UNIT CONTROL DEVICE
10c, 11c
10d, 11d
10e, 11e
INDOOR UNIT C
INDOOR UNIT D
INDOOR UNIT E
INDOOR-UNIT CONTROL DEVICE
42c
INDOOR-UNIT CONTROL DEVICE
42d
INDOOR-UNIT CONTROL DEVICE
42e
LEAKAGE SIGNAL
39c
39d
39e
43c
43d
43e

FIG. 8


REFRIGERANT LEAKAGE SENSOR
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INDOOR-UNIT CONTROL DEVICE
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HEAT-SOURCE-UNIT CONTROL DEVICE
41
INTERFACE DEVICE
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SWITCHING DEVICE
B
DETECT REFRIGERANT LEAKAGE
S1
LEAKAGE SIGNAL
DISPLAY ON REMOTE CONTROLLER 43
S2
REFRIGERANT-LEAKAGE-INFORMATION SIGNAL
RECORD ON RECORDING MEANS
S3
CLOSING SIGNAL
CLOSING SIGNAL
CLOSE CORRESPONDING ON-OFF VALVES 10 AND 11
S4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/003207

A. CLASSIFICATION OF SUBJECT MATTER
F24F1/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24F1/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2003-130482 A (Mitsubishi Electric Corp.), 08 May 2003 (08.05.2003), paragraphs [0046], [0054]; fig. 1 to 10 (Family: none)	1-4 5-7
Y	WO 2008/035418 A1 (Mitsubishi Electric Corp.), 27 March 2008 (27.03.2008), paragraphs [0012], [0027]; fig. 1 & EP 1970651 A1	5-7

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

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- "&" document member of the same patent family

Date of the actual completion of the international search 09 July, 2010 (09.07.10)	Date of mailing of the international search report 20 July, 2010 (20.07.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/003207

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 4-335967 A (Mitsubishi Electric Corp.), 24 November 1992 (24.11.1992), entire text; all drawings & US 5297392 A & EP 676595 A1 & EP 514086 A2 & DE 69212225 C & DE 69226381 C & AU 5936894 A & AU 649810 B & ES 2092035 T & ES 2120104 T & AU 1603492 A & AU 660124 B	1-7
A	JP 9-42804 A (Mitsubishi Electric Corp.), 14 February 1997 (14.02.1997), entire text; all drawings (Family: none)	1-7
A	JP 2000-346488 A (Mitsubishi Electric Corp.), 15 December 2000 (15.12.2000), entire text; all drawings (Family: none)	1-7

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 6180166 A **[0004]**