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(54) **AIR CONDITIONER**

(57) An air conditioner according to one embodiment includes an outdoor unit, an indoor unit, a pipe, a battery unit, a permission unit, and a valve control unit. The indoor unit cools or heats an interior of a room with a refrigerant supplied from the outdoor unit. The pipe connects the outdoor unit and the indoor unit together and carries the refrigerant. The battery unit supplies power when supply of power from an AC power source is stopped. A shutoff valve opens and closes the pipe by the power from the AC power source or the power from the battery unit. The permission unit permits valve closure operation of the shutoff valve. The valve control unit closes the shutoff valve by the power from the battery unit when the supply of the power from the AC power source to the shutoff valve is stopped after permission from the permission unit, and before the permission from the permission unit, keeps the pipe open through the shutoff valve even if the supply of the power from the AC power source to the shutoff valve is stopped.

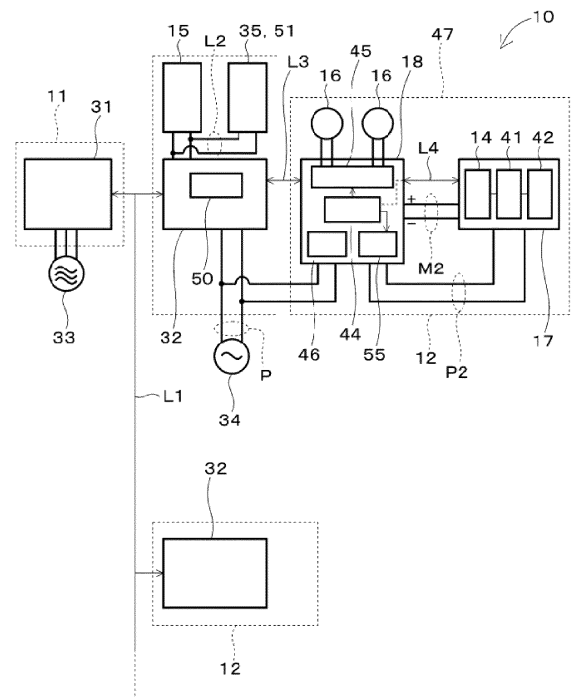


FIG.2

Description

Technical Field

[0001] This embodiment relates to an air conditioner.

Background Art

[0002] Refrigerants used in a refrigeration cycle of an air conditioner may be flammable refrigerants including micro-flammable ones, to improve air conditioning performance and environmental performance. For such air conditioners, as disclosed in WO2016/088167, for example, a refrigerant detection unit that detects a refrigerant is installed in a target room to be air-conditioned, and when a refrigerant leak is detected from the refrigeration cycle, an electric open and close valve, also called a shutoff valve, shuts off a pipe for the refrigerant to flow to an indoor unit that air-conditions the room. However, if power supply is cut off due to a power failure or the like, the shutoff valve cannot be driven even if the refrigerant leaks, and the refrigerant leakage cannot be stopped. Therefore, the refrigerant charged in the entire refrigeration cycle, including an outdoor unit of the air conditioner, is released from a leakage point to the target room.

[0003] To avoid this, the air conditioner includes a battery unit. As a result, the shutoff valve for shutting off the pipe to the indoor unit is supplied with power from this battery unit to a drive circuit. When a power-off happening to the shutoff valve is detected, power is supplied from the battery unit to the shutoff valve and the shutoff valve is closed. This prevents a large amount of refrigerants from leaking into the target room because the shutoff valve is already closed even if a refrigerant leaks during a power failure. This improves the safety of the air conditioner even during a power failure.

[0004] When the shutoff valve is configured to be closed by supplying power from the battery unit to the shutoff valve upon such a power-off, if, during installation work, the power supply is shut off for some reason after power is temporarily supplied from the power supply to the shutoff valve with the battery unit connected, the shutoff valve is closed using the battery unit as the power source in response to the power-off. Consequently, the pipe to the indoor unit is shut off.

[0005] During the installation work of an air conditioner, the indoor unit is positioned and fixed at a predetermined location such as back of a ceiling, and the indoor unit and the outdoor unit, which is installed outdoors, are connected through a refrigerant pipe which is called "crossover pipe". It is necessary to connect the indoor unit and the outdoor unit together and the indoor unit and a remote control unit together by wiring. It is also necessary to connect each device to the power supply to confirm that communication between these devices is normal. For this reason, power-on and power-off at each device is often repeated during the installation work.

[0006] However, during the installation work, after

each device and the refrigerant pipe are connected together, it is necessary to perform vacuuming to depressurize these pipes that serve as refrigerant channels, in order to exhaust air existing inside the connection pipes and piping of heat exchangers and the like accommodated in the indoor unit. However, if the shutoff valve is closed, the air inside the indoor unit that is disconnected by the shutoff valve cannot be exhausted. As a result, air may get in the refrigerant during subsequent operation, which may prevent normal operation or cause the air conditioner to malfunction. Besides, an additional refrigerant may be added to the refrigeration cycle after the vacuuming during the installation work, depending on a pipe length and other factors. However, if the shutoff valve is closed, the indoor unit cannot be filled with the refrigerant, which also causes problems that make normal refrigerant charging difficult. To avoid such a condition, a procedure of connecting the battery unit should be performed after completion of the installation work. However, shutoff valves are often installed at some midpoint in pipes at back of a ceiling or under floor near the indoor unit. The battery unit is installed near the shutoff valves. Therefore, in arrangement of devices, it is very time-consuming to connect the battery unit after completion of all the installation work.

Summary of Invention

Technical Problem

[0007] An object is therefore to provide an air conditioner that can properly vacuum refrigerant pipes and charge refrigerant by prohibiting operation of shutoff valves until installation work is completed, while improving safety by driving the shutoff valves in an event of a refrigerant leakage or a power failure.

Solution to Problem

[0008] An air conditioner according to one embodiment comprises an outdoor unit, an indoor unit, a pipe, a battery unit, a permission unit, and a valve control unit.

[0009] The indoor unit cools or heats an interior of a room with a refrigerant supplied from the outdoor unit. The pipe connects the outdoor unit and the indoor unit together and carries the refrigerant. The battery unit supplies power when the power supply from an AC power source is stopped. A shutoff valve opens and closes the pipe by power from the AC power source or power from the battery unit. The permission unit permits valve closure operation of the shutoff valve. The valve control unit closes the shutoff valve by power from the battery unit when the supply of power from the AC power source to the shutoff valve is stopped after permission from the permission unit, and before the permission from the permission unit, keeps the pipe open through the shutoff valve even if the supply of power from the AC power source to the shutoff valve is stopped.

Brief Description of Drawings

[0010]

[Figure 1] Figure 1 is a diagram of a refrigeration cycle of an air conditioner according to a first embodiment,

[Figure 2] Figure 2 is a schematic control block diagram of the air conditioner according to the first embodiment,

[Figure 3] Figure 3 is a circuit block diagram of an indoor unit and a valve control unit of the air conditioner according to the first embodiment,

[Figure 4] Figure 4 is a schematic diagram of a procedure of installation work of the air conditioner according to the first embodiment,

[Figure 5] Figure 5 is a control flowchart showing a flow of processing in a valve control circuit of the air conditioner according to the first embodiment,

[Figure 6] Figure 6 is a control flowchart following the control flowchart of Figure 5,

[Figure 7] Figure 7 is a control flowchart showing a flow of processing in a battery control unit of the air conditioner according to the first embodiment,

[Figure 8] Figure 8 is a circuit block diagram of an indoor unit and a valve control unit in an air conditioner according to a second embodiment,

[Figure 9] Figure 9 is a control flowchart showing a flow of processing in a valve control circuit of the air conditioner according to the second embodiment,

[Figure 10] Figure 10 is a control flowchart following the control flowchart in Figure 9, and

[Figure 11] Figure 11 is a control flowchart showing a flow of processing in a battery control unit of the air conditioner according to the second embodiment.

Description of Embodiments

[0011] Embodiments of an air conditioner will be described with reference to the accompanying drawings. In the following multiple embodiments and modifications, substantially identical components will be denoted by the same reference numerals and their repeated description will be omitted.

(First Embodiment)

[0012] As shown in Figures 1 to 3, an air conditioner 10 includes an outdoor unit 11, indoor units 12, a pipe 13, an energization detection unit 14, a refrigerant detection unit 15, shutoff valves 16, a battery unit 17, and a valve control unit 18. The outdoor unit 11, the indoor units 12, and the pipe 13 constitute a refrigeration cycle which uses a refrigerant as shown in Figure 1. The pipe 13 is also referred to as a crossover pipe. A first embodiment is a so-called multi-type air conditioner 10 in which a single outdoor unit 11 is connected to multiple indoor units 12 via the pipe 13. However, the air conditioner 10

may also be a so-called single type one in which a single outdoor unit 11 is connected to a single indoor unit 12. The outdoor unit 11 has a compressor 21, a heat exchanger 22, an expansion valve 23, and an outdoor fan, not shown in the drawing, which promotes heat exchange of the heat exchanger 22 with the outdoor air. The outdoor unit 11 is installed outside a target room for air conditioning, usually outdoors. The refrigerant is, for example, a slightly flammable HFC-R32. The refrigerant is charged into refrigeration cycle components and the pipe 13 in the outdoor unit 11 and indoor units 12 that constitute the refrigeration cycle.

[0013] The indoor units 12 are each installed in one or more target rooms. The target room is a space, such as a room, for example, which is subject to air conditioning by the air conditioner 10. Each indoor unit 12 has a heat exchanger 25, an expansion valve, not shown in the drawing, and an indoor fan. The indoor unit 12 performs cooling or heating operation for the target room, using a low-temperature or high-temperature refrigerant supplied from the outdoor unit 11.

[0014] The pipe 13 connects the outdoor unit 11 and the indoor unit 12 together. The refrigerant circulates between the outdoor unit 11 and the indoor unit 12 through the pipe 13 as the refrigeration cycle is operated. The pipe 13 generally has two paths: a liquid path and a gas path. The liquid path is a so-called liquid pipe through which mainly a liquefied refrigerant flows. The gas path is a so-called gas pipe through which mainly a vaporized refrigerant flows. However, in a case of a so-called "simultaneously cooling and heating multi-standard air conditioning system" in which multiple indoor units 12 are connected to the single outdoor unit 11 and cooling or heating operation can be switched for each of the indoor units 12, the pipe 13 may have three paths, including an intermediate pressure pipe. In the examples herein, for simplicity of explanation, the pipe 13 shall be two pipes.

[0015] The outdoor unit 11 has an outdoor control unit 31 as shown in Figure 2. The outdoor control unit 31 is composed of a microcomputer having, for example, a CPU, a ROM, and a RAM, which are not shown in the drawing, and controls the outdoor unit 11 by a computer program stored in the ROM. The indoor unit 12 has an indoor control unit 32. The indoor control unit 32, like the outdoor control unit 31, is composed of a microcomputer having a CPU, a ROM, and a RAM, and controls the indoor unit 12 by a computer program stored in the ROM. Each indoor control unit 32 and the outdoor control unit 31 are communicatively connected by a communication line L1, and exchange information and instructions with each other.

[0016] The outdoor unit 11 is supplied with electric power from a commercial three-phase AC power source 33, for example. Each indoor unit 12 is supplied with electric power from a commercial single-phase AC power source 34, for example. The indoor unit 12 is wired to a remote control unit 35, which is a so-called remote controller. The remote control unit 35 accepts inputs for op-

erating the indoor unit 12. The remote control unit 35 is connected to the indoor control unit 32 through two communication lines L2, for example. The communication lines L2 serve as both a communication line and a power line. As a result, operating power of the remote control unit 35 is supplied from the indoor unit 12. The remote control unit 35 receives inputs, for example, start and stop of operation of the indoor unit 12, air conditioning temperature, humidity, and air volume. The indoor control unit 32 executes operation of the indoor unit 12 based on the input from the remote control unit 35. The indoor unit 12 has a rectifier circuit 36, such as an AC/DC converter, for example, as shown in Figure 3. Electric power supplied from the power source 34 is rectified and increased in voltage in the rectifier circuit 36 and supplied as DC power to the indoor control unit 32, the remote control unit 35, and the refrigerant detection unit 15 described below.

[0017] The refrigerant detection unit 15 consists of, for example, a gas sensor and a detection judgement circuit, and a reporting circuit including communication functions and detects a refrigerant leakage in the target room. In this embodiment, the refrigerant is R32, which is slightly flammable. Therefore, to ensure safety, the refrigerant detection unit 15 detects leakage of this refrigerant into the target room. On the other hand, when the capacity of the target room is large, the refrigerant concentration in the air is low even if the refrigerant leaks, and the effect of leakage is small. For this reason, the refrigerant detection unit 15 need not be installed in all the indoor units 12, but only in the indoor unit 12 of the target room that has a relatively small capacity and thus is more susceptible to a refrigerant leakage. Although the refrigerant detection unit 15 is housed in the indoor unit 12 in this embodiment, it may be installed outside of the indoor unit 12, for example, on a wall of the target room. In other words, the refrigerant detection unit 15 should be installed at a position where it can appropriately detect a refrigerant leakage. The refrigerant detection unit 15 is electrically connected to the indoor control unit 32. Upon detection of a refrigerant leakage, the refrigerant detection unit 15 outputs a specific electrical signal to the indoor control unit 32 via the communication line L2 to report the leakage. Upon reception of the signal of a refrigerant leakage, the indoor control unit 32 notifies the valve control unit 18 via the communication line L3.

[0018] The shutoff valves 16 are installed at some midpoint in the pipe 13 and open and close this pipe 13 as shown in Figure 1. To be specific, the shutoff valves 16 are installed at inlets of the indoor units 12 mounted with refrigerant detection units 15, i.e., on the side of the outdoor unit 11. The shutoff valves 16 are electrically opened and closed by being driven by a valve drive circuit 45 based on commands from the valve control unit 18. The shutoff valves 16 stop the inflow of a refrigerant to the target indoor unit 12 by shutting off the pipe 13. Since the refrigerant is flammable as described above, in an event of detection of leakage to the target room, the shut-

off valves 16 shut off the pipe 13 connecting to the indoor unit 12 of the target room where leakage has been detected, thereby stopping the inflow of the refrigerant to the indoor unit 12. The shutoff valves 16 are installed in respective paths constituting the pipe 13 in order to separate the indoor unit 12 from the refrigeration cycle. In other words, if there are two pipes 13, two shutoff valves 16 are required, and these multiple shutoff valves 16 are opened and closed synchronously by the valve drive circuit 45. The shutoff valves 16 can be electrically controlled to open and close, and pulse motor valves, so-called PMVs, or ball valves are used to fully close the refrigerant paths.

[0019] The battery unit 17 shown in Figures 2 and 3 is a small box-shaped housing. The battery unit 17 houses the energization detection unit 14, which detects whether the power source 34 is energized or not, i.e., detects a power failure, the battery 41, and the battery control unit 42. The battery 41 rectifies and stores AC power supplied from the commercial single-phase AC power source 34, which is the same as that for the indoor unit 12 and the valve control unit 18. Although it is desirable that the battery 41 and the valve control unit 18 be supplied with power from the same AC power source, the indoor unit 12 may be supplied with power from an AC power source different from these devices. The battery 41 is a secondary battery or a capacitor of various types that can be charged and discharged. The battery control unit 42 is composed of a microcomputer having, for example, a CPU, a ROM, and a RAM that operates by power from the power source 34 or a battery, and controls the operation of the battery unit 17, including charging and discharging of the battery 41, by executing a computer program stored in the ROM.

[0020] The refrigerant detection unit 15, which detects a refrigerant leakage as described above, and the battery unit 17, which ensures the operation of the shutoff valves 16 in the event of a power failure, enhance the safety of the air conditioner 10 as a safety device.

[0021] The valve control unit 18 has a valve control circuit 44, the valve drive circuit 45, and a switch unit 55. The valve control circuit 44 is composed of a microcomputer having, for example, a CPU, a ROM, and a RAM, and controls the opening and closing of the shutoff valves 16 by executing a computer program stored in the ROM. The valve drive circuit 45 is electrically connected to the shutoff valves 16. The valve drive circuit 45 controls the energization of the shutoff valves 16 according to commands from the valve control circuit 44 to drive the shutoff valves 16 to open and close the shutoff valves 16. As shown in Figure 3, both the valve control circuit 44 and the valve drive circuit 45 operate by power received through a DC power line M1 from the rectifier circuit 46, such as an AC/DC converter, connected to the power source 34. This DC power line M1 is parallel-connected to a DC power line M2, which is a DC discharge line of the battery 41. Consequently, the valve control circuit 44 and the valve drive circuit 45 can continue to operate

even if the power source 34 is shut off, as long as the battery 41 is discharged from the battery control unit 42 and supply of operation power is maintained. DC output voltage of the rectifier circuit 46 and DC output voltage due to discharge of the battery 41 are set approximately equal or set so that the output voltage on a battery 41 side is slightly lower within a range of operating voltage of the valve control circuit 44 and the valve drive circuit 45. The DC output line M2 has a diode D on a "+ output" side of the battery control unit 42 so that it is in a forward direction toward the rectifier circuit 46. This prevents the output voltage of the rectifier circuit 46 from being applied back to a battery output terminal of the battery control unit 42.

[0022] When a refrigerant leakage is detected by the refrigerant detection unit 15, the valve control unit 18 operates the valve drive circuit 45 upon reception of a notification of the refrigerant leakage from the indoor control unit 32 via the communication line L3. Accordingly, the valve control unit 18 closes the shutoff valves 16 to shut off the pipe 13. Furthermore, after conditions are met, as described below, when not powered from the power source 34, the valve control unit 18 drives the shutoff valves 16 by power from the battery unit 17 to shut off the pipe 13. In the case of using a flammable refrigerant, when a refrigerant leakage is detected, the shutoff valves 16 are required to conduct valve closure operation even when energization from the power source 34 to the valve control unit 18 is shut off. Therefore, in the event of a power failure, the valve control unit 18 drives the shutoff valves 16 and shuts off the pipe 13, being powered from the battery unit 17 in advance. The switch unit 55 is installed at some midpoint in a power line P2 between the power source 34 and the battery unit 17, and interrupts the energization from the power source 34 to the battery unit 17. In the first embodiment, the switch unit 55 is a normally open relay located on one side of the power line P2. The switch unit 55 may be a relay located on both sides of the power line P2, or the relay may be replaced by a semiconductor switch.

[0023] The valve control unit 18, the shutoff valves 16, and the battery unit 17 are incorporated in a shutoff valve unit 47, a box-shaped housing, to be installed at back of a ceiling or under floor or in a pipe installation space. Alternatively, the shutoff valve unit 47 may incorporate only the shutoff valves 16 and the valve control unit 18, the battery unit 17 may be installed separately, and an external wiring connection may be established between the single-phase AC power source 34 and the valve control unit 18.

[0024] In addition to the aforementioned ones, the air conditioner 10 includes a permission unit 50 and an input unit 51 as shown in Figures 2 and 3.

[0025] In this embodiment, the permission unit 50 is provided in the indoor control unit 32. The permission unit 50 is implemented as software, for example, by executing a computer program in the microcomputer of the indoor control unit 32. The permission unit 50 may be

implemented as hardware or a cooperative combination of software and hardware. The permission unit 50 is used to permit the valve closure operation of the shutoff valves 16 that opens and closes the pipe 13.

[0026] When the battery unit 17 is electrically connected, the valve control unit 18 is capable of closing the shutoff valves 16 by power supplied from the battery unit 17, even when not energized from the power source 34. On the other hand, the valve control unit 18 may close the shutoff valves 16 by power from the battery unit 17 if an energized state is interrupted for some reason during the installation work of the air conditioner 10. In this case, the pipe 13 is shut off by the shutoff valves 16. Shutting off the pipe 13 with the shutoff valves 16 prevents vacuuming and refrigerant charging during installation work of the air conditioner 10. Therefore, the valve control unit 18 maintains the switch unit 55 opened until reception of permission from the permission unit 50 and shuts off the power from the power source 34 to the battery unit 17. Therefore, the valve control unit 18 does not close the shutoff valves 16 until it receives permission from the permission unit 50. Then, upon reception of permission from the permission unit 50, the valve control unit 18 turns on the switch unit 55 to shut off the energization of the power source 34, i.e., to close the shutoff valves 16 in the event of a power failure, which means that the shutoff valves 16 can shut off the pipe 13. Note that the permission unit 50 is not necessarily provided to the indoor control unit 32, but may be configured to be provided to other control units such as the remote control unit 35 and the outdoor control unit 31 that can be indirectly connected to the valve control unit 18 or the valve control circuit 44 by communication. Furthermore, the permission unit 50 may be provided in more than one of these locations.

[0027] The input unit 51 receives permission command inputs from the installer and installation operator of the air conditioner 10. The input unit 51 is, for example, a mechanical or a software switch. The input unit 51 is preferably operable only by the installation operator of the air conditioner 10. In other words, in order not to be operated by a normal user of the air conditioner 10, the input unit 51 should preferably require special operation or be located in a position where it cannot be operated by the user. The installation operator of the air conditioner 10 inputs a permission command to the valve control unit 18 through this input unit 51. In other words, when the permission command is input by the operator through the input unit 51, the permission unit 50 transmits this permission command to the valve control circuit 44 of the valve control unit 18 through the communication line L3 in order to permit the shutoff valve 16 to shut off the pipe 13.

[0028] The valve control unit 18 has the pipe 13 opened with the shutoff valve 16 in an initial state when the air conditioner 10 is shipped. For instance, during installation work of the air conditioner 10, the air conditioner 10 is electrically disconnected from the power sources 33 and 34. Accordingly, the indoor units 12 of the air condi-

tioner 10 are not powered from the power source 34, i.e., is not energized from the power source 34. As a result, the shutoff valves 16 maintain their initial state and keeps the pipe 13 open. When, at some point after progress of the installation work or repair of the air conditioner 10, the battery unit 17 is connected to the valve control unit 18 or the indoor unit 12 is connected to the power source 34, the shutoff valves 16 become operable by the supplied power. Therefore, the shutoff valves 16 may shut off the pipe 13 under some conditions. On the other hand, the air conditioner 10 requires depressurization, or so-called vacuuming, of the pipe 13 to charge a refrigerant. In other words, when refrigerant is charged, a vacuum pump 52 is connected at a predetermined position as shown in Figure 1 and the pipe 13 is depressurized. In this case, the pipe 13 must be sufficiently depressurized to remove air remaining in the pipe 13. If the pipe 13 is shut off by the shutoff valves 16 during this vacuuming process, air remains in the pipe 13 and the indoor unit 12. To avoid this, in this embodiment, the valve control unit 18 does not drive the shutoff valves 16 and keeps the pipe 13 open until it receives a permission command from the permission unit 50. As a result, the pipe 13 remains open until the installation operator of the air conditioner 10 operates the input unit 51 to permit the shutoff valves 16 to operate. This facilitates vacuuming and additional refrigerant charging. The following will explain a specific control mechanism for implementing this operation.

[0029] In the first embodiment, as shown in Figure 3, the battery unit 17 includes the energization detection unit 14 and the valve control unit 18 includes the switch unit 55. The energization detection unit 14 detects whether or not the battery unit 17 is energized from the power source 34, i.e., whether or not the valve control unit 18 is powered from the power source 34. The energization detection unit 14 is composed of, for example, a photocoupler connected at an output side of a full-wave rectifier, and a so-called zero-crossing detection circuit is used to detect a "zero crossing" of the voltage of the power source 34. The output of this energization detection unit 14 is input to the battery control unit 42. When the energization detection unit 14 detects a "zero crossing" during a half cycle period of AC power source frequency, the battery control unit 42 determines that the battery is energized. On the contrary, if the battery control unit 42 does not detect a "zero crossing" of the power source 34 after the aforementioned half cycle period of the AC power source frequency in the state where it determines that there is energization, it determines that the power source 34 has been shut off, or that a power failure has occurred. As mentioned above, the battery control unit 42 can operate as long as power is supplied from either the power source 34 or the battery 41. For this reason, even if the power source 34 is shut off, the battery control unit 42 can operate as long as the battery 41 has power. The battery control unit 42 may be powered only from the battery 41. The energization detection unit 14 may be

configured to involve the aforementioned power-off determination in the battery control unit 42. In this case, the energization detection unit 14 independently inputs results of determination of the energization and shut-off of the power source 34 to the battery control unit 42. This section has given an example in which the energization and shut-off of the power source 34 are determined using the periodic occurrence of "zero crossings" of the voltage of the power source 34. However, the determination of the energization and shut-off of the power source 34 may be detected by other methods, for example, by detecting the voltage of the power source 34.

[0030] In the first embodiment, the permission unit 50 permits the battery 41 of the battery unit 17 to be energized from the power source 34, thereby permitting the shutoff valve 16 to be powered from the battery unit 17. The valve control circuit 44 does not turn on the switch unit 55 until it receives a permission command from the permission unit 50. Thus, the battery unit 17 is not powered from the power source 34, and the battery unit 17 is not charged. Besides, the battery unit 17 does not detect power-off even if the battery 41 is fully charged at the time of shipment. This is because the energization detection unit 14 and the battery control unit 42 are configured to determine that power is being shut off, when detecting the fact that power is no longer being supplied from the power source 34 after energization is once started; and thus does not determine that power is being shut off, when detecting no energization from the power source 34 even once.

[0031] As a result, until reception of a permission command from the permission unit 50, the battery unit 17 does not supply power to the valve control circuit 44 and the valve drive circuit 45 of the valve control unit 18 even if the power source 34 is shut off, and the shutoff valve 16 does not operate. On the contrary, upon reception of a permission command from the permission unit 50, the switch unit 55 turns on, the power source 34 is connected to the battery unit 17, the battery 41 starts charging, and power supply to the shutoff valves 16 from the battery 41 becomes possible. Upon detection of the halt of power supply from the power source 34 at the energization detection unit 14 after the permission command, the battery control unit 42 supplies power from the battery 41 to the valve control unit 18, i.e., the valve control circuit 44 and the valve drive circuit 45. Consequently, the shutoff valves 16 are made operable by the valve drive circuit 45 by power from the battery 41 even without power supplied from the power source 34. Accordingly, when the power source 34 is shut off after reception of the permit command from the permission unit 50, the valve control unit 18 drives the shutoff valves 16 through the valve control circuit 44 and the valve drive circuit 45 so as to shut off the pipe 13 by power supplied from the battery 41. After the shutoff valves 16 are closed in response to the detection of power-off of the power source 34, if the energization detection unit 14 detects re-energization after the shut-off of the power source 34, the battery control

unit 42 notifies the valve control circuit 44 of the valve control unit 18 of that fact via a communication line L4. This brings the valve control unit 18 ready to open the shutoff valves 16. There are two types of energization status signals related to energization sent from the battery control unit 42 to the valve control circuit 44: a "discharging stopped" signal indicating that energization is going on; and a "discharging" signal indicating that energization is stopped. The battery control unit 42 determines that the power source 34 has started to re-energize once the energization status signal changes from "discharging" to "discharging stopped".

[0032] When the shutoff valves 16 are closed, operation of the air conditioner 10 is stopped. Accordingly, receiving again a command for restarting operation from the indoor unit 12 of the air conditioner 10 via the communication line L3 after making the re-energization determination, the valve control circuit 44 operates the valve drive circuit 45 to open the shutoff valves 16. Meanwhile, the closure of the shutoff valves 16 based on the refrigerant leakage detection is not released unless special operation is performed by an inspector and a repairer after inspection confirmation and repair of the refrigerant leakage.

[0033] An installation flow, or procedure, of the air conditioner 10 will now be explained with reference to Figure 4.

[0034] The air conditioner 10 is installed as a facility of a building, for example. In this case, the outdoor unit 11 and the indoor units 12 of the air conditioner 10 are installed at predetermined positions in the facility (F101). The air conditioner 10 is then connected to piping and wiring by the installer (F102). The pipe 13 connects the outdoor unit 11 and the indoor units 12 together. The wiring includes power lines connecting the power source 33 and the outdoor unit 11 together and the power source 34 and the indoor units 12 together, as well as various types of wiring such as the communication line L1 between the outdoor unit 11 and the indoor units 12 and the communication line L2 between the remote control unit 35 and the indoor units 12. The shutoff valves 16 are opening the pipes 13 in the initial state at the time of shipment. In other words, the air conditioner 10 is installed as a facility with the shutoff valves 16 keeping the pipes 13 open.

[0035] The air conditioner 10 is equipped with a safety device to ensure safety (F103). In this embodiment, the safety device is the shutoff valve unit 47 which includes the refrigerant detection unit 15, the valve control unit 18, and the battery unit 17 as described above. A power line is then connected between the power source 34 and the shutoff valve unit 47. In addition, the wiring of each of the communication line L2 between the refrigerant detection unit 15 and the indoor unit 12, the communication line L3 between the indoor unit 12 and the shutoff valve unit 47, and the communication line L4 between the valve control unit 18 in the shutoff valve unit 47 and the battery unit 17 is connected to complete the installation of the safety

device. Note that there is no restriction on a sequence of F102 and F103, and they may be performed concurrently. If the power sources 33 and 34 are turned on in F103, the air conditioner 10 will be able to communicate with each part. In this case, even if the power source 34 is shut off thereafter, the permission unit 50 does not output a permission command to the valve control unit 18. Hence, the switch unit 55 remains off, i.e., open. Accordingly, the energization detection unit 14 does not detect the shut-off of the power source 34, and power is not supplied from the battery unit 17 to the valve control unit 18. As a result, the valve control unit 18 does not operate and the shutoff valves 16 do not close, keeping the pipe 13 open.

[0036] The installation operator of the air conditioner 10 then determines whether the connection of the pipe 13 has been completed and the vacuuming is ready to be performed. When the vacuuming is ready (F104: Yes), the installation operator of the air conditioner 10 performs vacuuming of the indoor units 12 and the pipe 13 (F105). As shown in Figure 1, the vacuum pump 52 is connected to a part of the pipe 13 with a valve of the pipe 13 on the outdoor unit 11 side closed, and the vacuuming of the refrigeration cycle components in the pipe 13 and the indoor units 12 is performed over several hours, for example. Upon completion of the vacuuming in F105, the installation operator removes the vacuum pump from the outdoor unit 11, and then opens the valve on the outdoor unit 11 side toward the pipe 13 side to make the refrigeration cycle communicating. Depending on the installation conditions, such as a large pipe length, an additional refrigerant is charged into the refrigeration cycle through the valve at the outdoor unit 11 in F106. If a length of the pipe 13 is short and an amount of refrigerants charged to the outdoor unit 11 is adequate from the beginning, the additional refrigerant charging in F106 is omitted. Even during this vacuuming and this additional refrigerant charging, the shutoff valves 16 are not allowed to operate and the pipe 13 is open. Hence, the outdoor unit 11, the indoor units 12, and the pipe 13 can be vacuumed without any hindrance, and the refrigerant can be charged easily.

[0037] The installation operator of the air conditioner 10 then confirms that each power line and communication line are connected, and turns on the power sources 33 and 34 by operating a breaker or the like (F107). The installation operator then operates the input unit 51 to give a permission command from the permission unit 50 (F108). Receiving this command, the valve control unit 18 determines that the shutoff valves 16 are ready for operation, i.e., ready to shut off the pipe 13. This initiates the operation of the safety device, and the refrigerant detection unit 15, the shutoff valves 16, and the battery unit 17 start normal operation (F109). If the power source 34 is shut off after this permission command is issued, the valve control unit 18 closes the shutoff valves 16 and shuts off the pipe 13, using the battery 41 as the power source. At this time, the vacuuming and the refrigerant

charging have been completed, and no problem therefore arises even if the shutoff valves 16 are closed. According to the aforementioned procedure, the permission command is issued after the vacuuming and the refrigerant charging have been completed as described above. Therefore, there is no hindrance to the vacuuming and the refrigerant charging. If the power source 34 is shut off after the permission command is issued, the valve control unit 18 and the valve drive circuit 45 operate with the battery 41 as the power source to drive the shutoff valves 16, thereby shutting off the pipe 13. When the power source 34 is shut off, the indoor units 12 and the refrigerant detection unit 15 are not powered. Thus, the refrigerant detection unit 15 may not be able to detect a refrigerant even if a refrigerant leakage occurs. In this case, however, the shutoff valves 16 are driven in advance at the time of the power source 34 shutoff to shut off the pipe 13. Therefore, even if a refrigerant leakage occurs during a power failure, distribution of a refrigerant to the indoor units 12 is blocked, thereby improving the safety of the air conditioner 10.

[0038] The installation operator then performs a trial run of the air conditioner 10 (F110). In other words, the trial run of the air conditioner 10 is performed with the refrigerant detection units 15, the shutoff valves 16, and the battery units 17 enabled.

[0039] Through the aforementioned procedure, a series of the installation, the vacuuming, the refrigerant charging, and the trial run of the air conditioner 10 is performed, leading to a ready-to-operate condition.

[0040] The following will explain control operation by the valve control circuit 44 of the valve control unit 18 according to the first embodiment with reference to Figures 5 and 6, and control operation by the battery control unit 42 with reference to Figure 7. The control by the valve control circuit 44 and the control by the battery control unit 42 are executed in parallel.

(Control by Valve Control Circuit 44)

[0041] When the valve control circuit 44 in the valve control unit 18 starts operating, it determines whether or not a refrigerant leakage has been detected by the refrigerant detection unit 15 (S201). To be specific, it determines whether or not a notification of the occurrence of a refrigerant leakage has been input to the valve control circuit 44 from the indoor control unit 32 of the indoor unit 12 via the communication line L2. If the valve control circuit 44 detects the occurrence of a refrigerant leakage (S201: Yes), the valve control circuit 44 operates the valve drive circuit 45 to close the shutoff valves 16 and shut off the pipe 13 (S202). In this case, the valve control circuit 44 closes the shutoff valves 16 of the indoor unit 12 provided in the target room where the refrigerant leakage has been detected. When shutoff valves 16 are provided in multiple indoor units 12, the valve control circuit 44 may close the shutoff valves 16 of all the indoor units 12.

[0042] The valve control circuit 44 then determines whether or not a restoration command has been received (S203). The restoration command is issued when it is determined that the operation of the air conditioner 10 can be restored by preset safety measures, for example, when a refrigerant leakage is repaired. The restoration command is issued by operation of a repair/inspector of the air conditioner 10 by any means, such as mechanical switches not shown in the drawing, software switches, or input from the remote control unit 35. When determining that there is a restoration command (S203: Yes), the valve control circuit 44 drives the shutoff valves 16 to open the pipe 13 (S204). In other words, when there is a restoration command, it is considered that operational safety has been secured so the pipe 13 is opened and normal air conditioning operation is restored. At this time, the valve control circuit 44 closes the shutoff valves 16 via the valve drive circuit 45 to open the pipe 13. On the contrary, when determining that there is no restoration command (S203: No), the valve control circuit 44 waits until there is a restoration command. In other words, when there is no restoration command, it is considered that safe operation is not sufficiently secured so the valve control circuit 44 keeps the pipe 13 shut off with the shutoff valves 16.

[0043] When no refrigerant leakage is detected in S201 (S201: No), the valve control circuit 44 determines whether a permission command has been issued from the permission unit 50 to allow the shutoff valves 16 to close during a power failure, i.e., whether there has been operation in F103 in the procedure shown in Figure 4 (S205). To be specific, the valve control circuit 44 determines whether a permission command has reached the valve control circuit 44 from the indoor control unit 32 via the communication line L3.

[0044] When receiving a permission command (S205: Yes), the valve control circuit 44 turns on the switch unit 55 of the battery unit 17 (S206). As a result, an electrical connection is established between the power source 34 and the battery 41 of the battery unit 17. Thus, the battery 41 is supplied with power from the power source 34. On the contrary, if there is no command to start operation (S205: No), the process returns to S201 and repeats these processing steps. At the time of installation of the air conditioner 10, usually S201 becomes NO, S205 becomes YES, and the process moves through S206 to Step S207 in Figure 6. On the contrary, if a leakage is detected at the time of installation (S201: YES), the processing of Steps S202 and S203 is performed.

[0045] After turning on the switch unit 55, the valve control circuit 44 determines whether or not the shutoff valves 16 are closed (S207). If the valve control circuit 44 determines that the shutoff valves 16 are closed at that point of time to shut off the pipe 13 (S207: Yes), it determines whether or not the battery 41 is being discharged (S208). Whether or not the battery 41 is discharging is determined by the energization status signal sent from the battery control unit 42 via the communica-

tion line L4. In other words, if the energization status signal is "discharging stopped," the battery 41 is not discharging. On the contrary, if the energization status signal is "discharging," the battery 41 is discharging. When the valve control circuit 44 determines that the battery 41 is discharging (S208: Yes), it determines whether the battery 41 has stopped discharging, i.e., whether or not the energization status signal has changed from "discharging" to "discharging stopped" (S209). If the valve control circuit 44 determines that the discharge of the battery 41 has not stopped (S209: No), it waits until the discharge stops, and the shutoff valves 16 remain closed.

[0046] When the valve control circuit 44 determines that the battery 41 has stopped discharging, i.e., that restoration from a power failure has been made (S209: Yes), it determines whether or not a refrigerant leakage has been detected (S210). When the valve control circuit 44 determines that no refrigerant leakage has been detected (S210: No), it determines whether or not a valve opening command has been received (S211). In other words, when the valve control circuit 44 does not detect any refrigerant leakage upon restoration from a power failure, it determines whether or not a valve opening command for opening the pipe 13 with the shutoff valves 16 has been received. The valve opening command is a command for starting operation of the air conditioner 10, and is input from the indoor control unit 32 to the valve control circuit 44 via the communication line L3 when the user of the air conditioner 10 operates, for example, the remote control unit 35 for starting operation. When the valve control circuit 44 determines that the valve opening command has been received (S211: Yes), it operates the valve drive circuit 45, drives the shutoff valves 16 to open them, and opens the pipe 13 (S212), and the process returns to S207.

[0047] After this, the air conditioner 10 will start operation. On the contrary, if the valve control circuit 44 determines that no valve opening command has been received, i.e., the air conditioning operation remains stopped in S211 (S211: No), it returns to S210 to wait for the valve opening command which is transmitted at the start of air conditioning operation. On the contrary, if a refrigerant leakage is detected in S210 (S210: Yes), the process returns to S207 and the shutoff valves 16 continues to close the pipe 13.

[0048] If the valve control circuit 44 determines in S208 that the battery 41 is not discharging (S208: No), it determines whether a restoration command has been received (S213). The restoration command is the same as in S203. Here, if the battery 41 is not discharging in S208, it means that the shutoff valves 16 are closed due to the detection of a refrigerant leakage, and in this case, the inspection and repair are completed and the shutoff valves 16 are not opened without a restoration command. Upon reception of a restoration command (S213: Yes), the valve control circuit 44 proceeds to S212 and opens the pipe 13 through the shutoff valves 16. On the contrary, with no restoration command received (S213: No), the

valve control circuit 44 waits until it receives a restoration command. This ensures the safety of the air conditioner 10 because the shutoff valves 16 remain closed and air conditioning operation cannot be started until a restoration command is received.

[0049] If the valve control circuit 44 determines that the shutoff valves 16 are not shutting off the pipe 13 in S207 (S207: No), it determines whether or not a refrigerant leakage has been detected (S214). In other words, if the valve control circuit 44 determines that the shutoff valves 16 are opening the pipe 13 in S207, it continues to detect a refrigerant leakage. If the valve control circuit 44 detects a refrigerant leakage in S214 (S214: Yes), it shuts off the pipe 13 with the shutoff valves 16 (S215) and the process returns to S207. On the contrary, if the valve control circuit 44 determines that no refrigerant leakage has been detected (S214: No), it determines whether or not the battery 41 is discharging (S216). When the valve control circuit 44 determines that the battery 41 is discharging (S216: Yes), it proceeds to S215 to shut off the pipe 13 with the shutoff valves 16. In this case, the valve drive circuit 45 used to drive the shutoff valves 16 is powered from the battery 41. Note that the valve control circuit 44 itself, which is performing the procedure of this flowchart, is also operating on the power from the battery 41 at this point. Note that there is a period of several tens of milliseconds from the occurrence of a power failure or other loss of power until the energization detection unit 14 and the battery control unit 42 detect this, the battery 41 starts discharging, and the valve control circuit 44 is notified of this. During this period, the valve control circuit 44 continues to operate by power stored in the capacitors and the like in the rectifier circuit 46 and other components. Thus, the valve control circuit 44 does not have any interruption in processing.

[0050] If the valve control circuit 44 determines that the battery 41 is not discharging (S216: No), the process returns to S207. Under normal conditions, NO in S207, NO in S214, and NO in S216 are repeated. During this time, the shutoff valves 16 are open, so the air conditioner 10 can freely stop operation.

(Control by Battery Control Unit 42)

[0051] The following will explain the operation of the battery control unit 42, which operates in cooperation with the valve control circuit 44, with reference to Figure 7. Upon initiation of the processing, the battery control unit 42 determines whether or not an energization interruption, or a power failure, of the power source 34 has been detected (S301). When detecting an energization interruption through the energization detection unit 14 (S301: Yes), the battery control unit 42 starts discharging the battery 41 (S302). The battery control unit 42 then sends a "discharging" signal indicating the fact that the battery 41 is discharging to the valve control circuit 44 (S303), and sets "under power failure" as an internal judgment flag (S304).

[0052] When the battery control unit 42 does not detect an energization interruption in S301 (S301: No), it determines whether or not the judgment flag is set to "under power failure" (S305). In other words, the battery control unit 42 determines whether or not "under power failure" has been set in S304 in the series of processing. When the battery control unit 42 determines that "under power failure" has been set (S305: Yes), it determines whether or not the energization of the power source 34 has been restored (S306). In other words, the battery control unit 42 determines whether the energization from the power source 34 has been restored through the energization detection unit 14.

[0053] When determining that the energization has been restored in S306 (S306: Yes), the battery control unit 42 stops discharging the battery 41 (S307). In other words, the battery control unit 42 stops supplying power from the battery 41 to the valve control unit 18. Along with this, the battery control unit 42 sends the "discharging stopped" signal indicating that the battery 41 has stopped discharging as the energization status signal to the valve control circuit 44, and releases the internal flag "under power failure" (S308). In S209, the aforementioned valve control circuit 44 receives the "discharging stopped" energization status signal in S308 from the battery control unit 42. If the battery control unit 42 determines that energization has not been restored in S306 (S306: No), the process returns to S301.

[0054] After sending the "discharging stopped" in S308, the battery control unit 42 determines whether or not the remaining amount of the battery 41 is adequate (S309). The battery control unit 42 determines, for example, whether or not remaining capacity P of the battery 41 is greater than preset set charging amount Ps. The set charging amount Ps can be set arbitrarily, for example, to 95% of maximum capacity of the battery 41. If the battery control unit 42 determines that the remaining capacity of the battery 41 is adequate, i.e., $P > P_s$ (S309: Yes), it stops charging the battery 41 (S310) and the process returns to S301. On the contrary, if the battery control unit 42 determines that the remaining capacity of the battery 41 is not adequate, i.e., $P \leq P_s$ (S309: No), it charges the battery 41 by power from the power source 34 (S311) and the process returns to S301. When the battery control unit 42 determines that the battery is not "under power failure" in S305 (S305: No), the process proceeds to S309 and the subsequent processing is continued. In normal conditions, that is, when regular power is supplied from the power source 34, the battery control unit 42 repeats NO in S301, NO in S305, S309, and S310 or S311, and controls a charge amount of the battery 41 so that it becomes the set charging amount Ps.

[0055] To summarize the keys of the operation of the first embodiment, (1) the shutoff valves 16 are not closed using the battery 41 as the power source until the permission command is input to the valve control unit 18, (2) if the power source of the valve control unit 18 is shut off or when a refrigerant leakage is detected after the

permission command has been issued, the shutoff valves 16 are closed, and (3) when the power source of the valve control unit 18 is shut off and the shutoff valves are closed, the shutoff valves 16 are driven using the battery 41 as the power source.

[0056] In the first embodiment described above, while the energization of the valve control unit 18 from the power source 34 is stopped, the shutoff valves 16 can be shut off by power from the battery 41, which improves safety. Furthermore, the valve control unit 18 limits the drive of the shutoff valves 16 and keeps the pipe 13 open until a permission command is given. For this reason, even if connection and disconnection of the power source 34 to/from the battery unit 17 is repeated during installation of the air conditioner 10, the shutoff valves 16 are not blocked and the pipe 13 remains open. This facilitates the vacuuming and the refrigerant charging before the permission command is issued.

(Second Embodiment)

[0057] A second embodiment will be now described with reference to Figure 8. In the second embodiment, a connection point of the energization detection unit 14 is not on the battery unit 17 as shown in the first embodiment but on the valve control unit 18 side. As a result, the energization detection unit 14 and the valve control circuit 44 cooperate to detect whether or not power is supplied from the power source 34 to the valve control unit 18. When detecting no power supply from the power source 34, i.e., a shut-off or a power failure, the valve control circuit 44 instructs the battery control unit 42 via the communication line L4 to discharge the battery 41. Receiving this signal, the battery control unit discharges the battery 41 to supply operating power to the valve control circuit 44 and the valve drive circuit 45. In other words, in the first embodiment, the valve control unit 18 and the battery unit 17 cooperate to determine when it is necessary and close the shutoff valves 16, whereas in the second embodiment, the valve control unit 18 does not cooperate and manages the valve closure operation of the shutoff valves 16 and the discharge from the battery unit 17 while the power source 34 is shut off. The rest of the configuration is the same as in the first embodiment.

[0058] In the second embodiment, the permission unit 50 permits the valve control unit 18 to close the shutoff valves 16. The valve control unit 18 does not close the shutoff valves 16 until it receives the permission command from the permission unit 50. On the contrary, after receiving the permission command from the permission unit 50, the valve control unit 18 closes the shutoff valves 16 when a refrigerant leakage is detected and when the power source 34 is shut off.

[0059] The following will explain a specific flow of control by the valve control circuit 44 during normal operation of the air conditioner 10 according to the second embodiment with reference to Figures 9 and 10, and a flow of control by the battery control unit 42 with reference to

Figure 11. The detailed explanation of the processing that is the same as in the first embodiment will be omitted.

(Control by Valve Control Circuit 44)

[0060] First, the operation of the valve control circuit 44 shown in Figure 9 is the same as each step in Figure 5 except that the last step S206 in Figure 5 is deleted, so its explanation will be omitted.

[0061] If a permission command is found in a last step S205 in Figure 9 (S205: Yes), the process proceeds to a first step S406 in Figure 10 to determine whether the shutoff valves 16 are shutting off the pipe 13. When determining that the shutoff valves 16 are shutting off the pipe 13 (S406: Yes), the valve control circuit 44 determines whether it retains "under power failure" indicating the fact that the energization from the power source 34 is stopped (S407). Here, the retention of "under power failure" is a flag which is set in S420 described below. When the valve control circuit 44 determines that "under power failure" is being set (S407: Yes), it determines whether or not energization from the power source 34 to the valve control unit 18 has been restored through the energization detection unit 14 (S408). When determining that energization has not been restored (S408: No), the valve control circuit 44 waits until power from the power source 34 is restored.

[0062] When determining that energization has been restored (S408: Yes), the valve control circuit 44 outputs a "discharge stopping command" to the battery control unit 42 via the communication line L4 (S409). Once energization is restored, power supply from the battery 41 is no longer required. Hence, the valve control unit 18 outputs a "discharge stopping command" to the battery control unit 42, which controls the battery 41, to stop discharging the battery 41. In the first embodiment, the battery control unit 42 determines whether or not the battery 41 needs to be discharged; whereas in this second embodiment, the valve control circuit 44 determines whether or not the battery 41 needs to be discharged and instructs the battery control unit 42.

[0063] After outputting the "discharge stopping command," the valve control circuit 44 determines whether or not a refrigerant leakage has been detected (S410). When the valve control circuit 44 determines that it has not detected any refrigerant leakage (S410: No), it again determines whether or not it has detected a power failure (S411). When determining that it has not detected a power failure (S411: No), the valve control unit 18 determines whether or not a valve opening command for starting operation of the air conditioner 10 has been received (S412). In other words, when the valve control circuit 44 does not detect any refrigerant leakage and does not detect a power failure, it determines whether or not a valve opening command has been received. When determining that there is a valve opening command (S412: Yes), the valve control unit 18 opens the pipe 13 through the shutoff valves 16 (S413) and the process returns to

S406. On the other hand, when determining that there is no valve opening command in S412 (S412: No), the valve control unit 18 returns to S410 and continues the subsequent processing. When determining that a refrigerant leakage has been detected in S410 (S410: Yes) and that a power failure has been detected in S411 (S411: Yes), the valve control unit 18 retains "under power failure" in S420 and returns to S406 to continue closing the pipe 13 through the shutoff valves 16.

[0064] When the valve control circuit 44 determines that the system is not "under power failure" in S407 (S407: No), it determines whether or not a restoration command has been received (S414). If it is determined that a restoration command has been received (S414: Yes), the process proceeds to S413, the shutoff valves 16 are driven open, and the pipe 13 is opened. On the contrary, if no restoration command has been found (S414: No), it waits until it receives a restoration command. When it is not "under power failure" in S407 (S407: No), the shutoff valves 16 are closed because a refrigerant leakage has been detected. Therefore, after measures against a refrigerant leakage have been taken, the shutoff valves are not opened unless the restoration command is input by the inspector, thereby enhancing safety.

[0065] When determining that the shutoff valves 16 are not shutting off the pipe 13 in S406 (S406: No), the valve control circuit 44 determines whether or not a power failure has been detected (S415). In other words, when determining that the shutoff valves 16 are opening the pipe 13 in S406, the valve control circuit 44 determines whether or not a power failure has occurred. When determining that a power failure has been detected in S415 (S415: Yes), the valve control circuit 44 outputs a "discharge command" for instructing the battery 41 to discharge, to the battery control unit 42 (S416) and, using this battery 41 as the power source, operates the valve drive circuit 45 to close the shutoff valves 16 to shut off the pipe 13 (S417). After closing the shutoff valves 16 in S417, the valve control circuit 44 retains "under power failure" as a flag indicating the status (S420) and the process returns to S406.

[0066] If a power failure has not been detected in S415 (S415: No), the valve control circuit 44 determines whether or not a refrigerant leakage has been detected (S418). When detecting a refrigerant leakage in the refrigerant detection unit 15, i.e., when receiving a notification of "refrigerant leakage" from the indoor control unit 32 through the communication line L3 (S418: Yes), the valve control unit 18 proceeds to S417 to close the shutoff valves 16 to shut off the pipe 13. On the contrary, if no refrigerant leakage has been detected (S418: No), the process returns to S406 and repeats NO in S406, NO in S415, and NO in S418. In this flow, the shutoff valves 16 are in the open state, which is a normal state in which the pipe 13 is made communicating. Thus, during this time, the start and stop of the air conditioner 10 are executed by the user.

(Control by Battery Control Unit 42)

[0067] The following will explain the operation of the battery control unit 42 according to the second embodiment with reference to Figure 11. The battery control unit 42 determines whether a "discharge command" has been received (S501). Although the battery control unit 42 uses the battery 41 or the power source 34 as its power source, it can operate by the power stored in an internal capacitor even if the power source 34 loses power during a period from the power failure to the discharge of the battery 41.

[0068] The battery control unit 42 determines whether or not a "discharge command" output in S416 of the valve control unit 18 has been received as described above, and if it determines that a "discharge command" has been received (S501: Yes), it retains the fact that the "discharge command" has been received as an internal flag as "discharge command in progress" (S502). In other words, the battery control unit 42 retains the fact that a "discharge command" has been received, in a storage unit such as a RAM or a nonvolatile memory, which is not shown in the drawings, and discharges the battery 41 (S504). In other words, once the "discharge command" has been issued, the battery control unit 42 keeps discharging the power stored in the battery 41 until it receives a "discharge stopping command" and cancels the retention of "discharge command in progress" in S506, which will be described later, and the process returns to S501.

[0069] When determining that no "discharge command" has been received from the valve control circuit 44 in S501 (S501: No), the battery control unit 42 determines whether or not a "discharge stopping command" which is output in S409 of the flowchart of control by the valve control circuit 44 shown in Figure 10 has been received (S505). Upon reception of the "discharge stopping command" (S505: Yes), the battery control unit 42 cancels the retention of the "discharge command in progress" (S506). In other words, the battery control unit 42 deletes the "discharge command in progress" retained in the storage unit, not shown in the drawings, in S502. The battery control unit 42 then stops discharging from the battery 41 (S507). The reason why the "discharge command in progress" data is retained as an internal flag is because the "discharge command" sent from the valve control circuit 44 to the battery control unit 42 is sent only once, when the shut-off of the power source 34 is detected.

[0070] When the battery control unit 42 stops discharging from the battery 41 in S506, it determines whether the battery 41 has enough remaining capacity (S508). When determining that the battery 41 has enough remaining capacity, that is, $P > P_s$ (S508: Yes), the battery control unit 42 stops charging the battery 41 (S509) and the process returns to S501. When the battery control unit 42 determines that the battery 41 does not have enough remaining capacity (S508: No), the battery 41 is charged (S510) and the process returns to S501. When

the power source 34 is in the normal state, the battery control unit 42 repeats the processing of NO in S501, NO in S505, NO in S503, S507, S508, and S509, or S510 without discharging the battery 41.

[0071] In the second embodiment, the valve control circuit 44 prohibits discharge from the battery unit 17 until the permission command is issued, thus prohibiting the valve closure operation of the shutoff valve 16 which is executed upon detection of a power failure of the power source 34, and keeping the pipe 13 open. Consequently, during installation of the air conditioner 10, the pipe 13 remains open even if power supply and interruption are repeated due to connection to the power source 34 or the battery unit 17. Hence, the pipe 13 is not shut off until a permission command is issued, allowing the vacuuming and the refrigerant charging to be carried out smoothly. Afterward, when the energization of the power source 34 is stopped after the vacuuming and the refrigerant charging are completed and a permission command is issued, the shutoff valves 16 can be closed by the power from the battery unit 17, which enhances safety.

[0072] The present invention that has been described above is not limited to the aforementioned embodiments, but can be applied to various embodiments without departing from the gist thereof.

[0073] Although several embodiments of the present invention have been described, these embodiments are merely illustrative and are not intended to limit the scope of the invention. These novel embodiments can be implemented in various other modes, and various omissions, substitutions, and modifications can be made without departing from the gist of the present invention. These embodiments and variations thereof are included in the scope and gist of the invention, as well as in the invention and its equivalents described in the claims.

Reference Signs List

[0074] In the drawings, 10 represents air conditioner, 11 outdoor unit, 12 indoor unit, 13 pipe, 14 energization detection unit, 15 refrigerant detection unit, 16 shutoff valve, 17 battery unit, 18 valve control unit, 34 commercial single-phase AC power source, 41 battery, 42 battery control unit, 44 valve control circuit, 45 valve drive circuit, 50 permission unit, and 51 input unit.

Claims

1. An air conditioner comprising:

an outdoor unit;
an indoor unit that cools or heats an interior of a room with a refrigerant supplied from the outdoor unit;
a pipe that connects the outdoor unit and the indoor unit together and carries the refrigerant;
a battery unit that supplies power when supply

- of power from an AC power source stops;
 a shutoff valve that opens and closes the pipe
 by the power from the AC power source or the
 power from the battery unit;
 a permission unit that permits valve closure op-
 eration of the shutoff valve; and
 a valve control unit that closes the shutoff valve
 by the power from the battery unit when the sup-
 ply of the power from the AC power source to
 the shutoff valve is stopped after permission
 from the permission unit, and before the permis-
 sion from the permission unit, keeps the pipe
 open through the shutoff valve even if the supply
 of the power from the AC power source to the
 shutoff valve is stopped.
2. The air conditioner according to claim 1, further com-
 prising a refrigerant detection unit that detects a leak-
 age of the refrigerant in the interior of the room to be
 cooled or heated by the indoor unit,
 wherein the valve control unit is configured to close
 the shutoff valve to shut off the pipe when the leakage
 of the refrigerant is detected by the refrigerant de-
 tection unit, regardless of the permission by the per-
 mission unit.
3. The air conditioner according to claim 1, further com-
 prising an input unit that is provided in at least one
 of the outdoor unit or the indoor unit, and accepts
 input of a permission command for permitting the
 valve closure operation of the shutoff valve,
 wherein the permission unit is configured to permit
 the valve closure operation based on the input at the
 input unit.
4. The air conditioner according to claim 1 or 2, wherein
 the valve control unit is configured to permit ener-
 gization from the power source to the battery unit
 and the supply of the power from the battery unit to
 the shutoff valve according to the permission from
 the permission unit.
5. The air conditioner according to claim 3, further com-
 prising an energization detection unit provided be-
 tween the power source and the battery unit,
 wherein the battery unit is configured to supply the
 power to the shutoff valve when the energization de-
 tection unit detects a halt of the supply of the power
 from the power source.
6. The air conditioner according to claim 1 or 2, further
 comprising an energization detection unit provided
 between the power source and the valve control unit,
 wherein the valve control unit is configured to drive
 the shutoff valve by the power supplied from the bat-
 tery unit when the energization detection unit detects
 a halt of the supply of the power from the power
 source.
7. The air conditioner according to any one of claims 1
 to 6, wherein the valve control unit is configured to
 operate by the power supplied from the battery unit
 as a power source when the supply of the power
 from the power source is stopped.
8. The air conditioner according to any one of claims 1
 to 7, wherein the valve control unit is configured to
 open the shutoff valve and makes the pipe commu-
 nicating, when receiving a command for starting op-
 eration of the indoor unit after the supply of the power
 from the power source is stopped to close the shutoff
 valve and the supply of the power from the power
 source is started again.
9. The air conditioner according to any one of claims 1
 to 8, wherein the valve control unit includes a valve
 drive circuit to drive the shutoff valve.

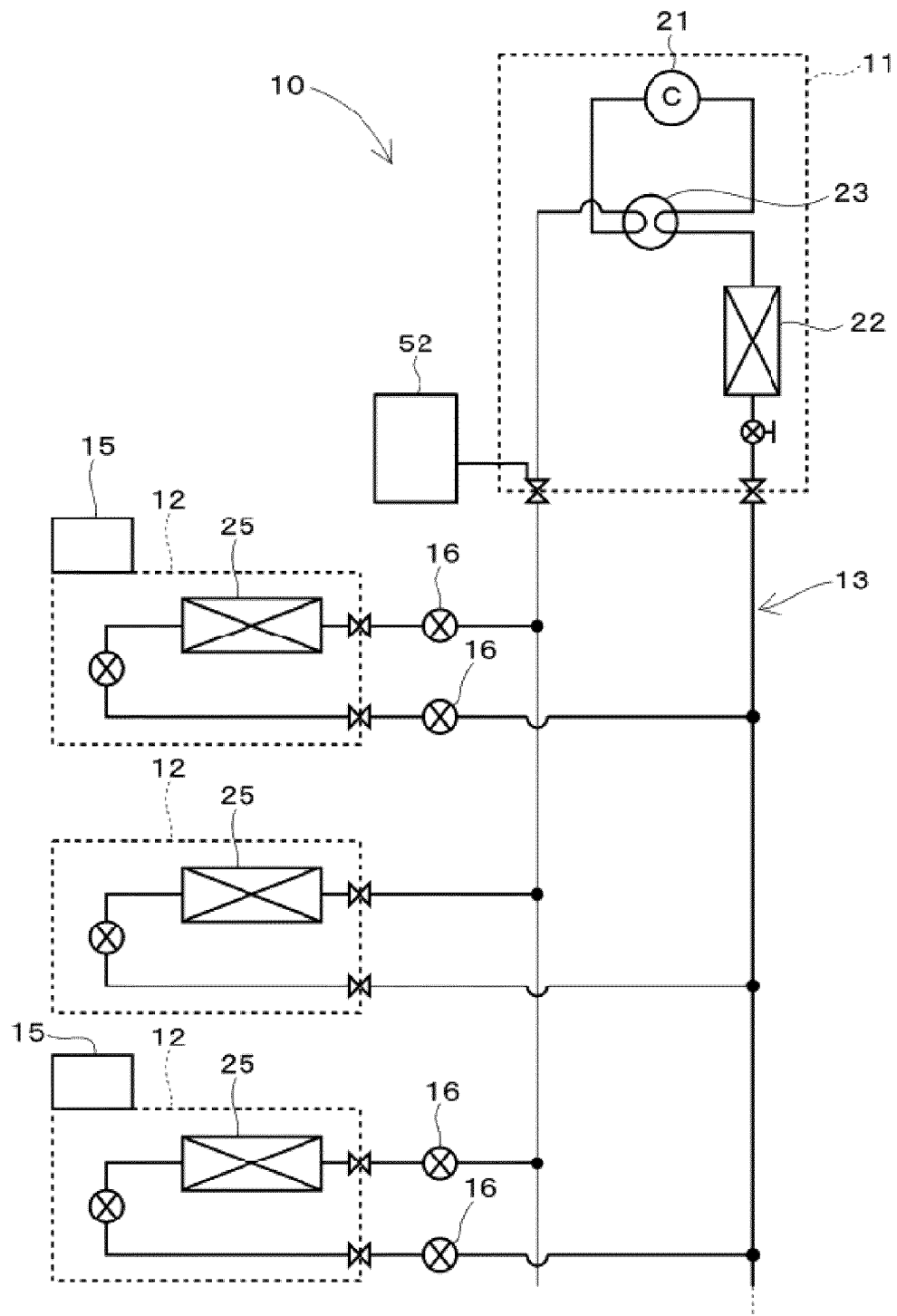


FIG.1

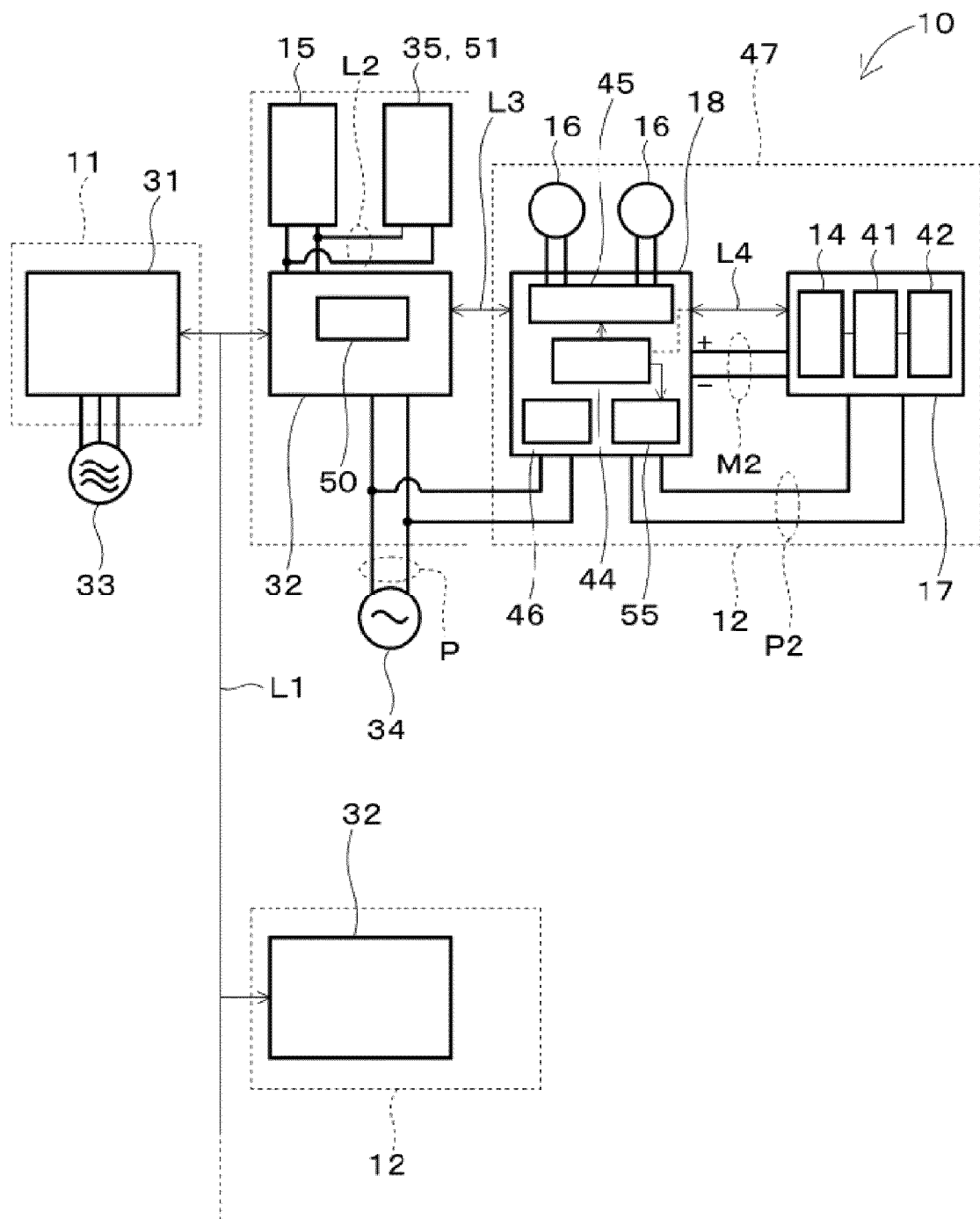


FIG.2

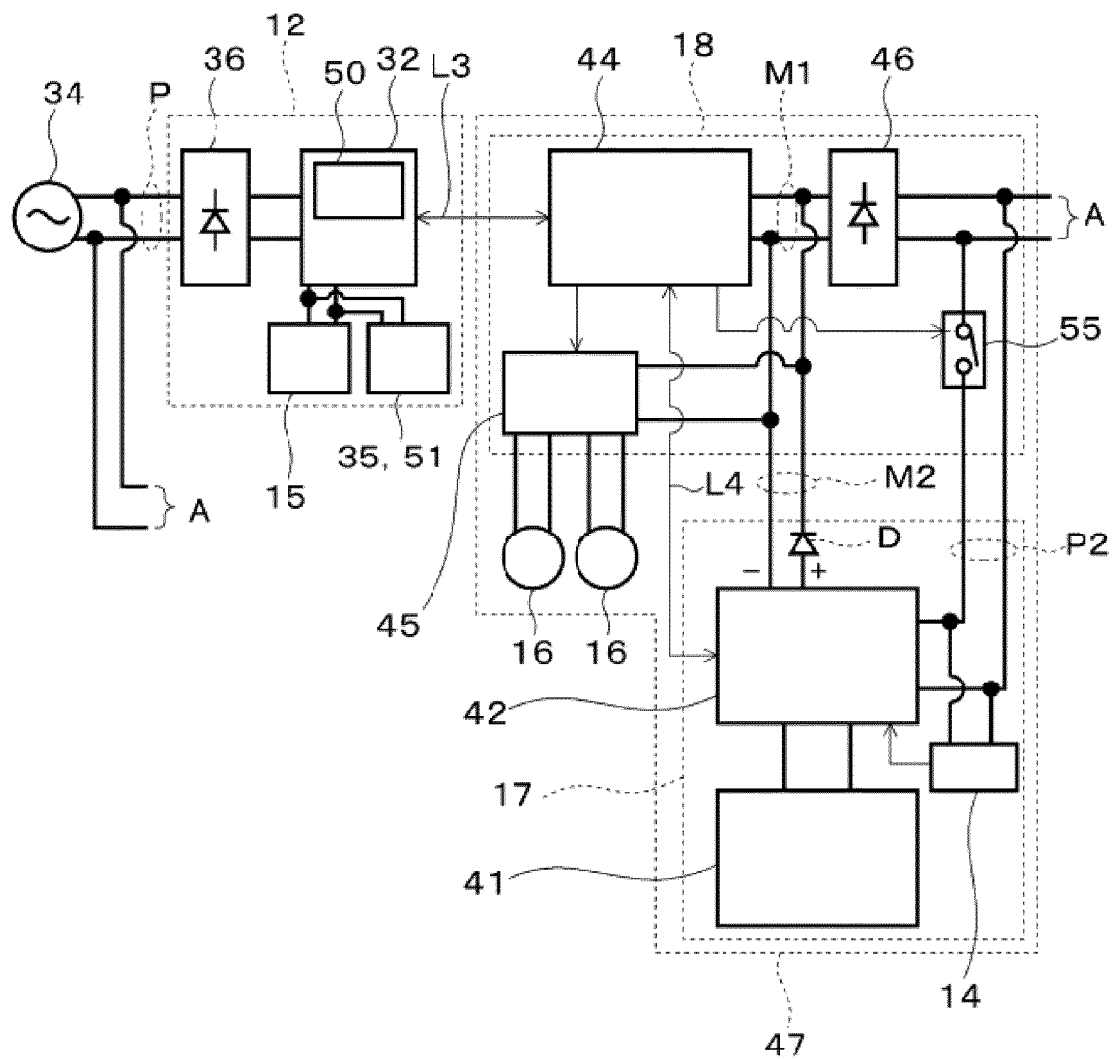


FIG.3

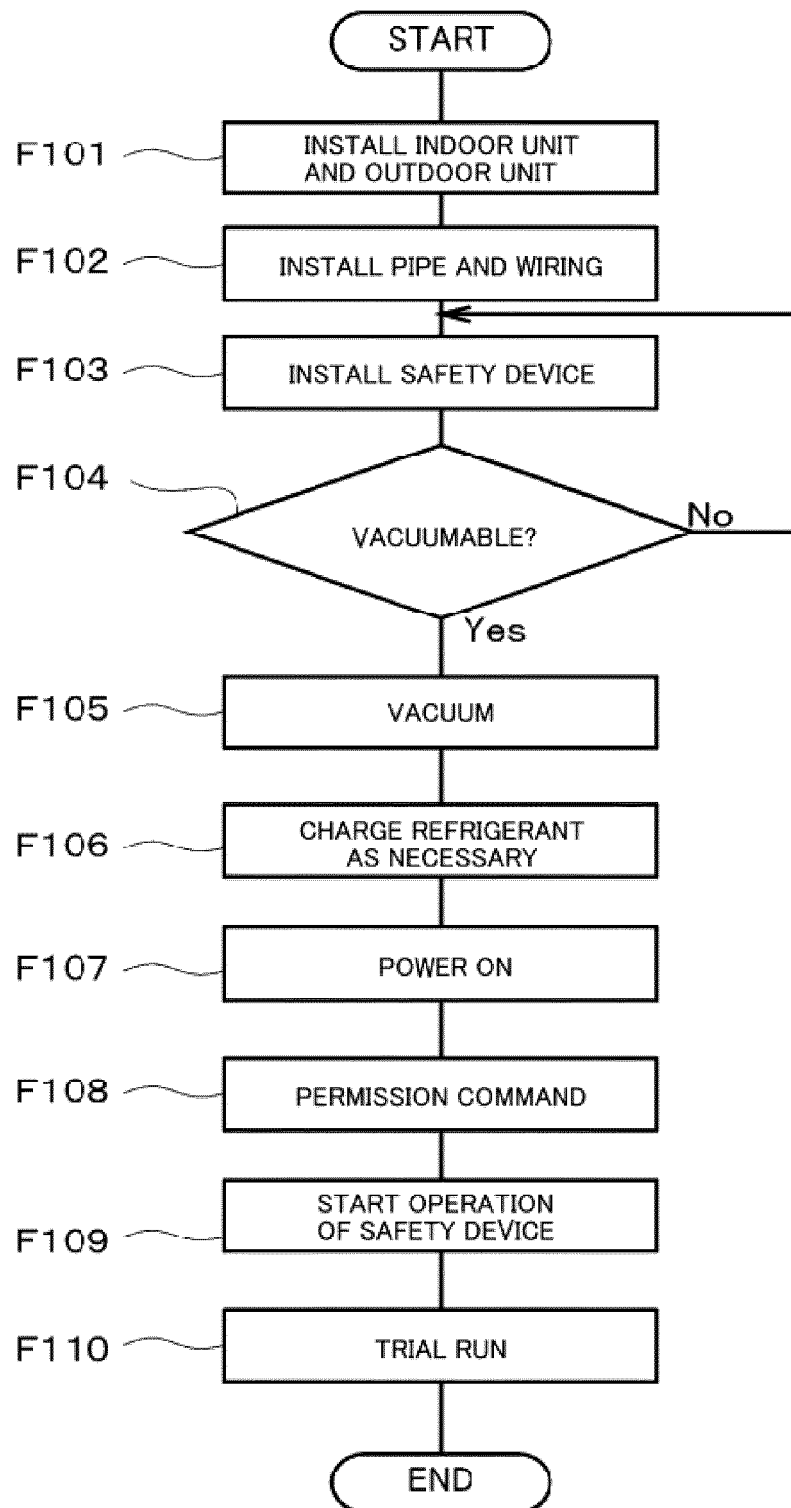


FIG.4

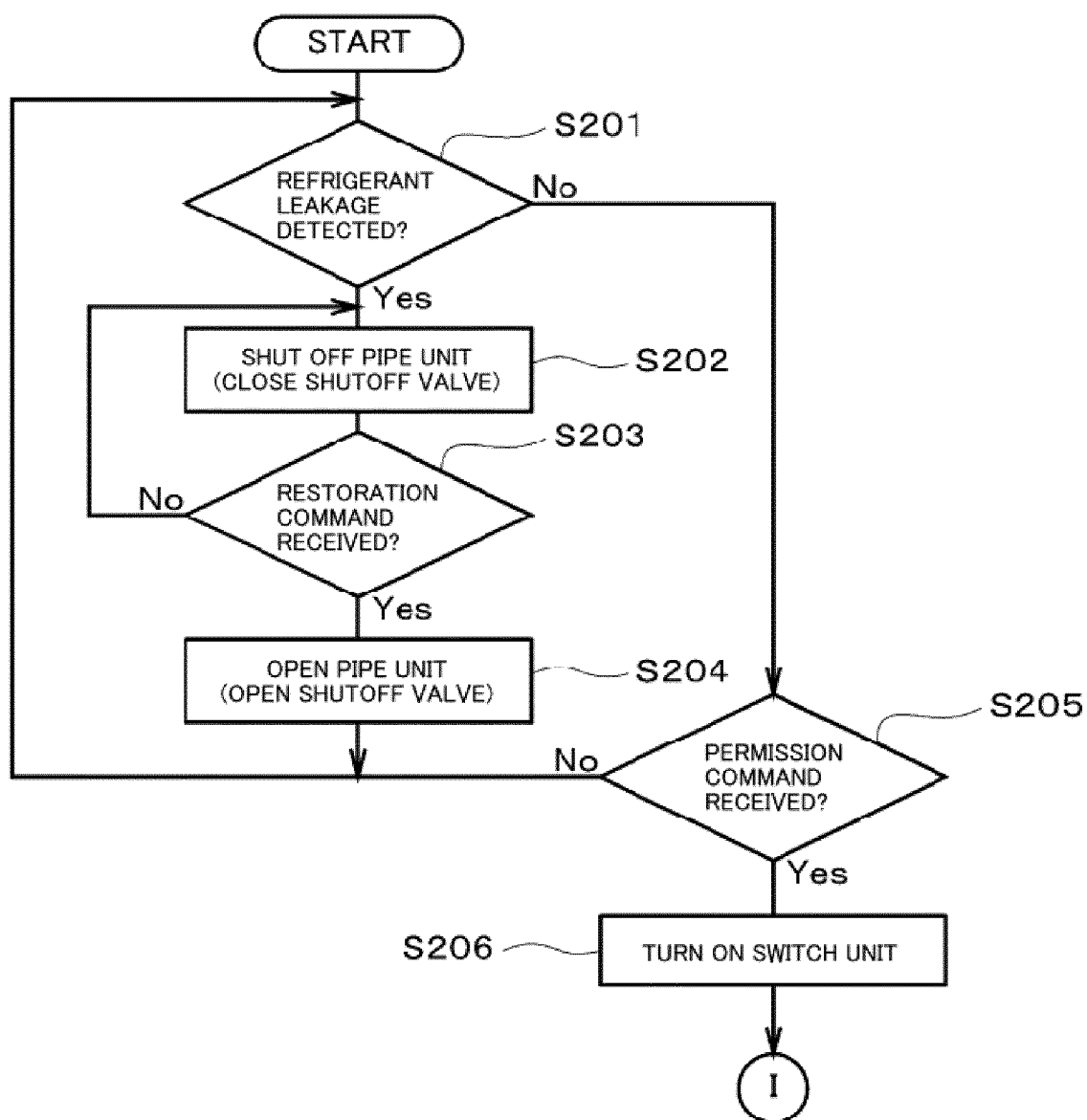


FIG.5

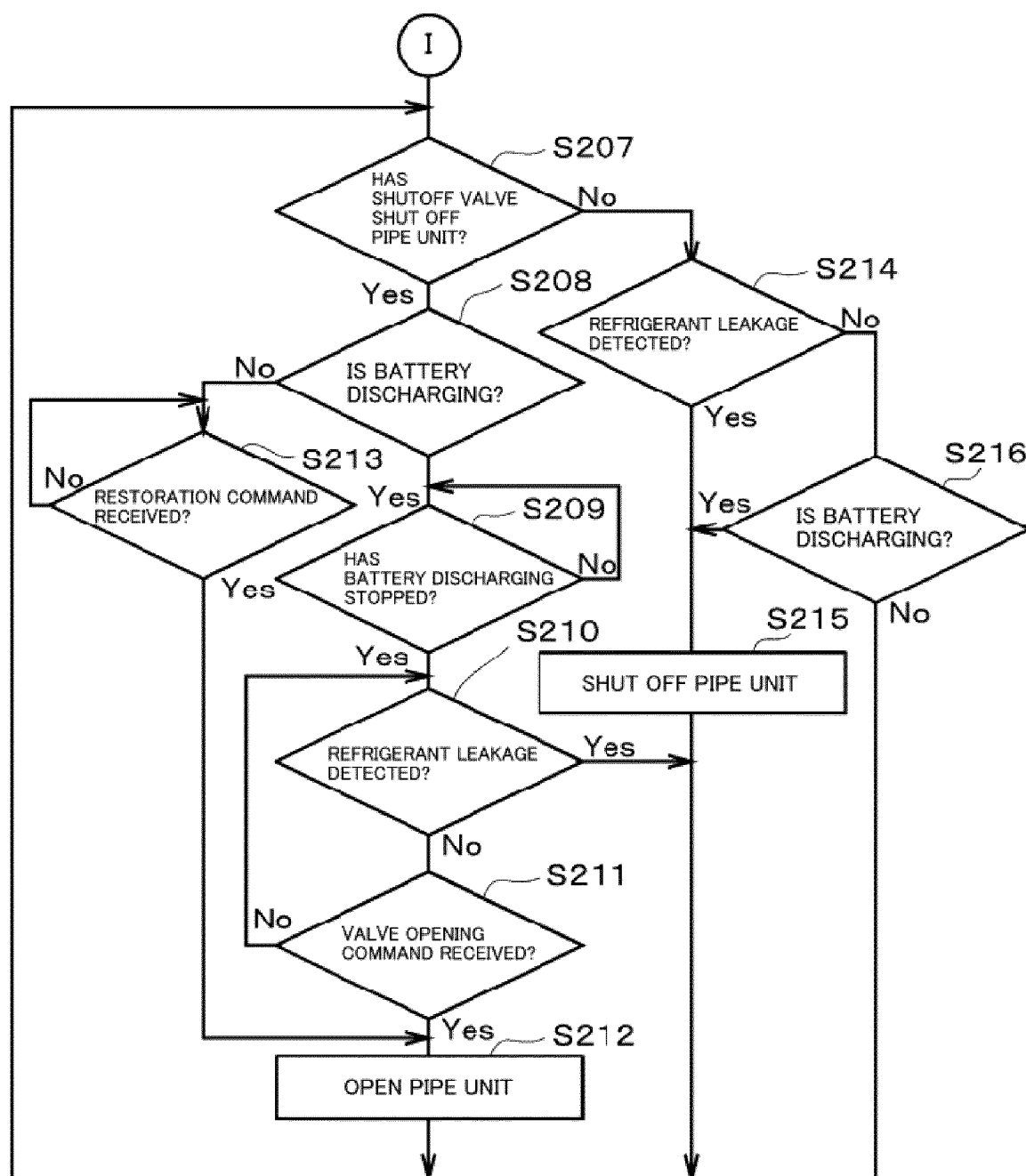


FIG.6

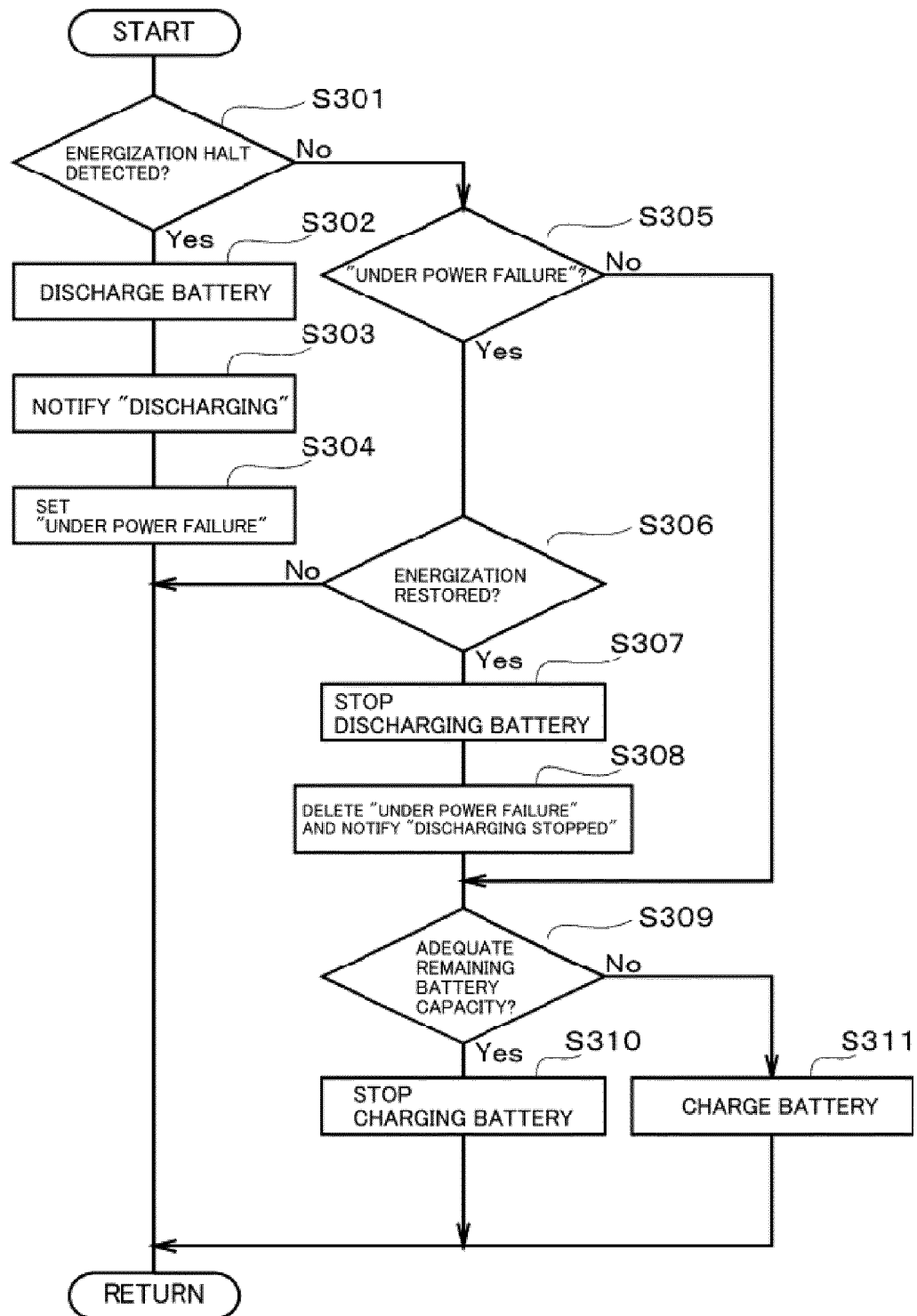


FIG.7

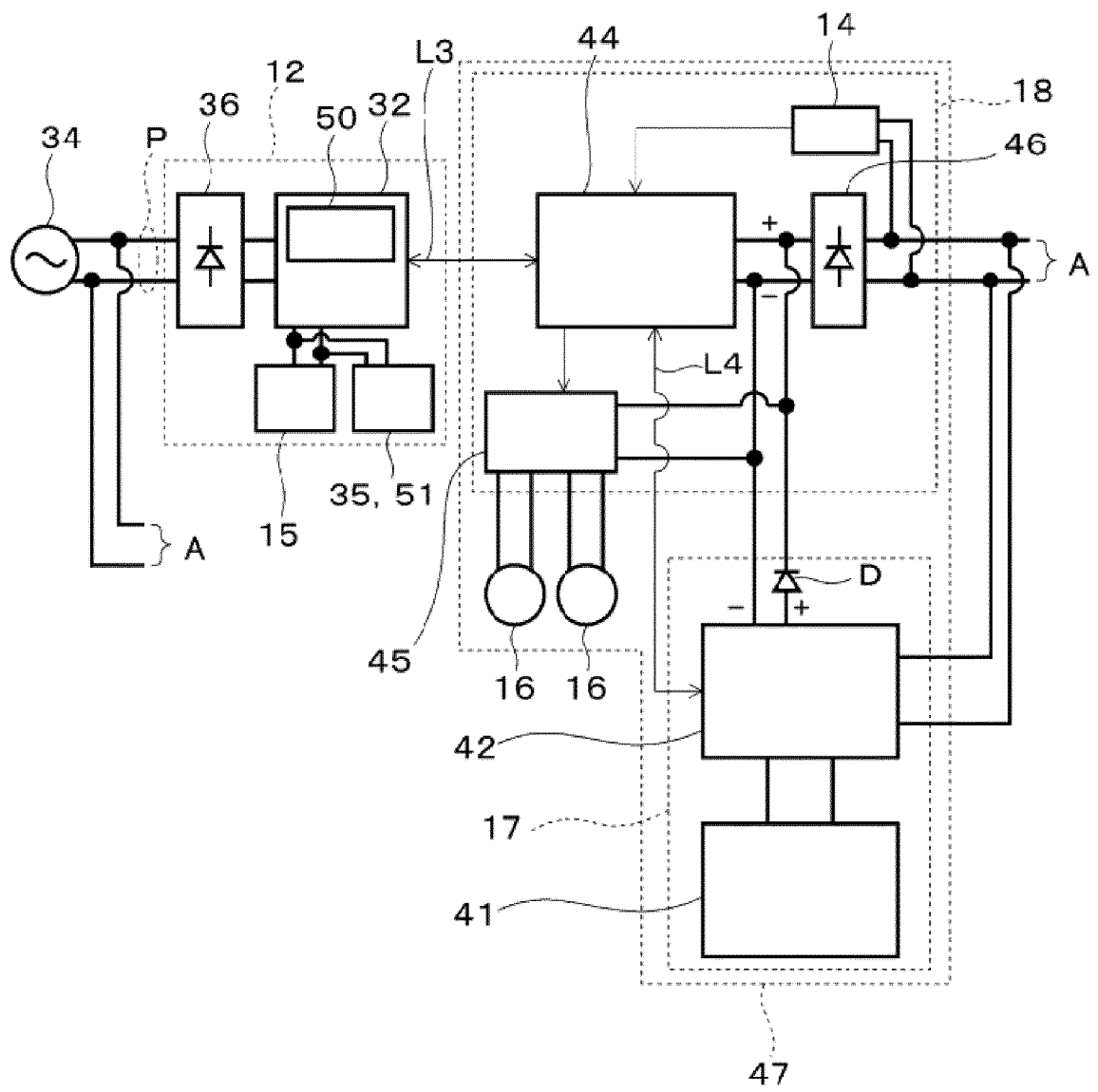


FIG.8

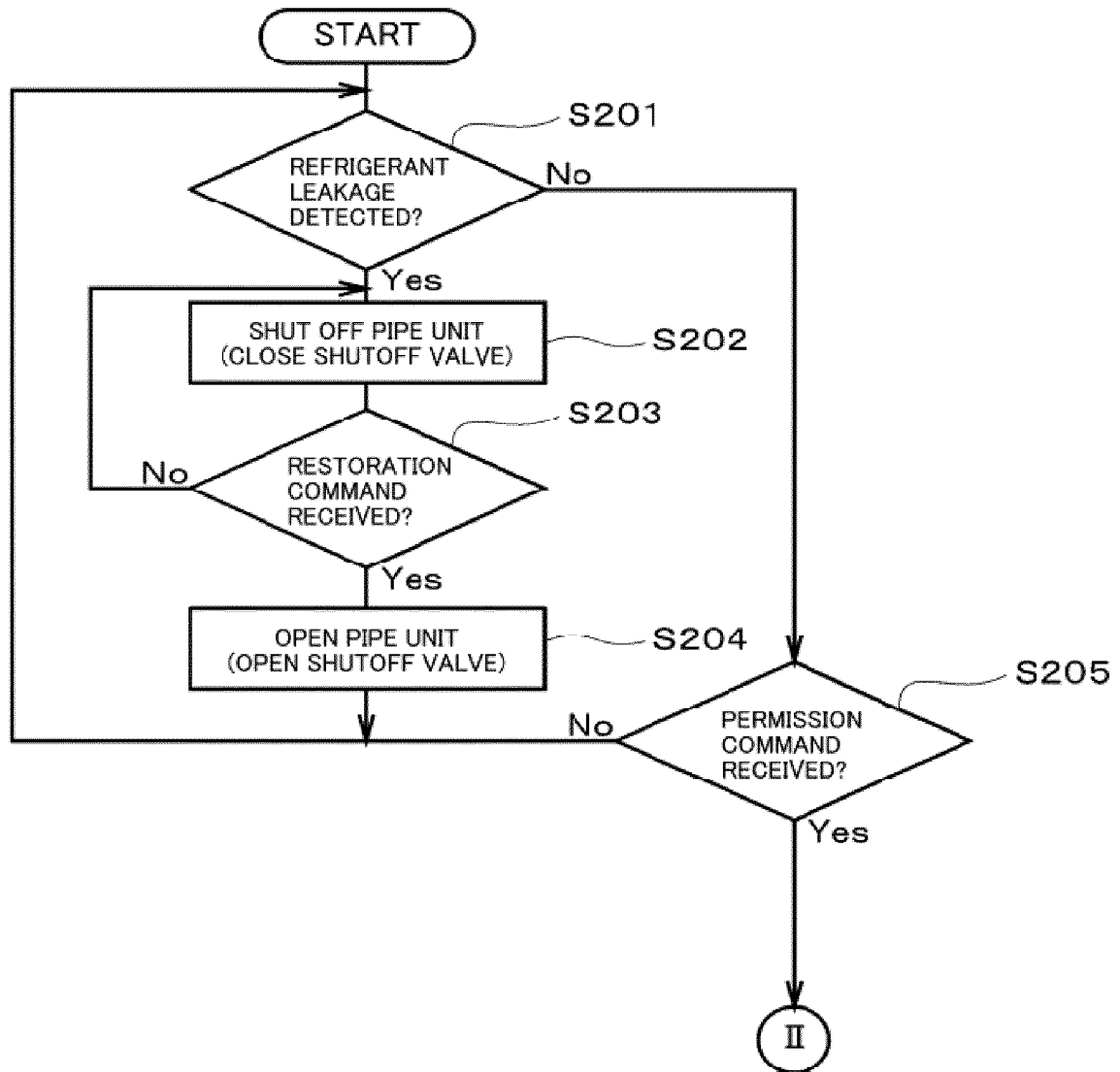


FIG.9

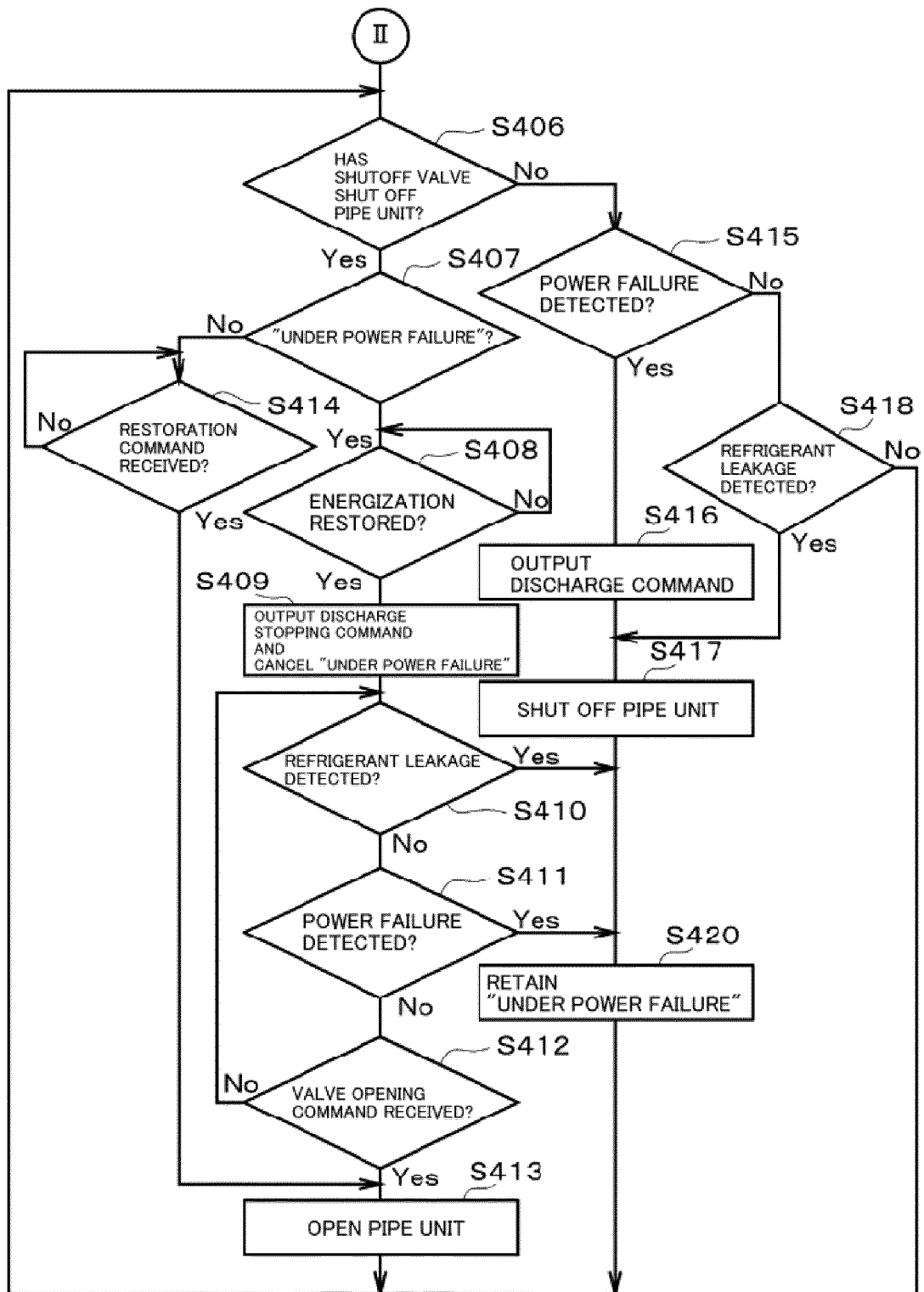


FIG.10

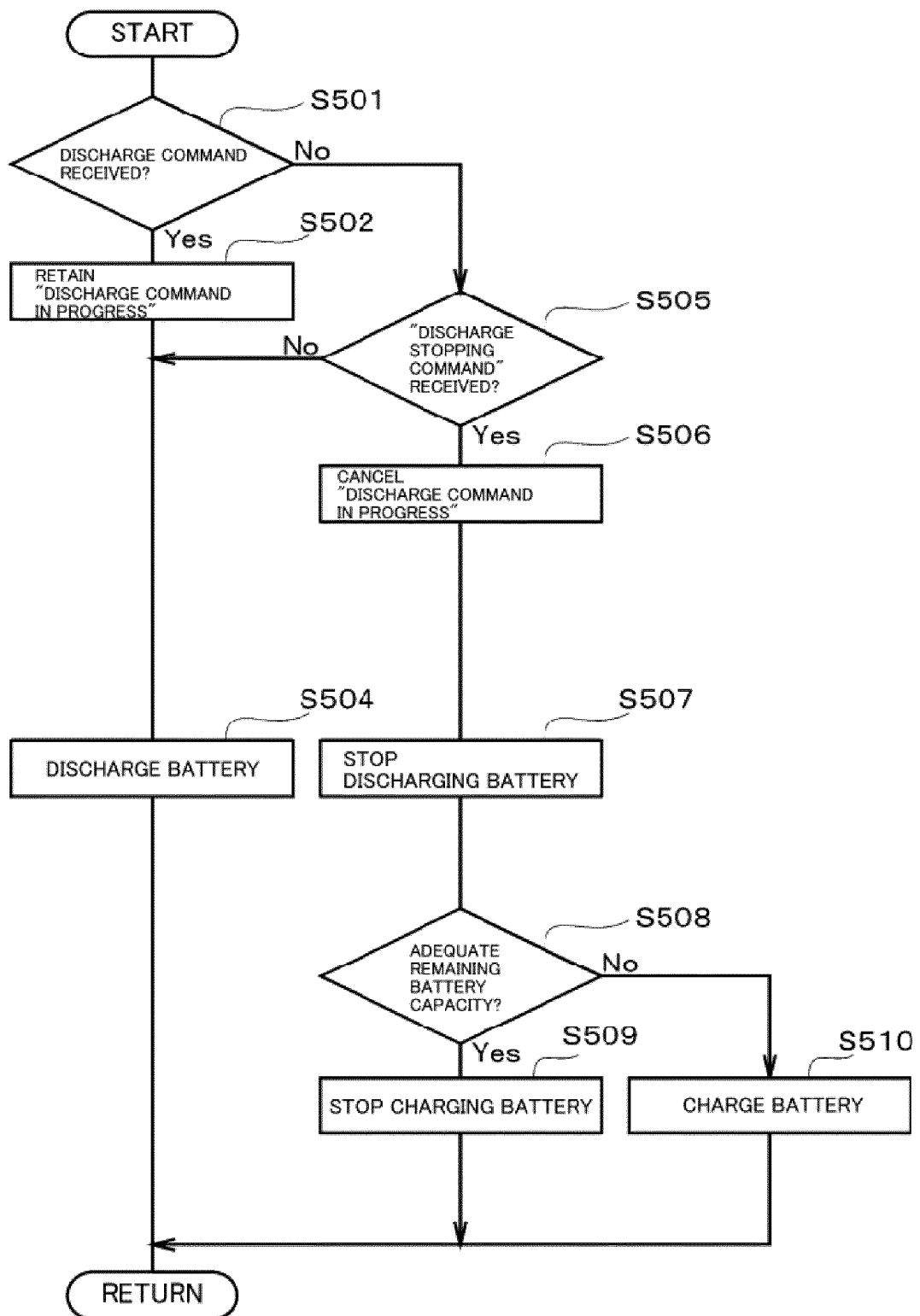


FIG.11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/042972

A. CLASSIFICATION OF SUBJECT MATTER F24F 11/36 (2018.01)i FI: F24F11/36 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) F24F11/36 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2022 Registered utility model specifications of Japan 1996-2022 Published registered utility model applications of Japan 1994-2022 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)												
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>Y</td> <td>WO 2020/110425 A1 (HITACHI JOHNSON CONTROLS AIR CONDITIONING INC) 04 June 2020 (2020-06-04) paragraphs [0015]-[0026], [0034]</td> <td>1-9</td> </tr> <tr> <td>Y</td> <td>JP 6-189470 A (KANSAI ELECTRIC POWER CO INC) 08 July 1994 (1994-07-08) paragraphs [0025]-[0026], [0029]</td> <td>1-9</td> </tr> <tr> <td>Y</td> <td>JP 2021-131200 A (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 09 September 2021 (2021-09-09) paragraphs [0008]-[0009], [0029]</td> <td>8-9</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	Y	WO 2020/110425 A1 (HITACHI JOHNSON CONTROLS AIR CONDITIONING INC) 04 June 2020 (2020-06-04) paragraphs [0015]-[0026], [0034]	1-9	Y	JP 6-189470 A (KANSAI ELECTRIC POWER CO INC) 08 July 1994 (1994-07-08) paragraphs [0025]-[0026], [0029]	1-9	Y	JP 2021-131200 A (PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.) 09 September 2021 (2021-09-09) paragraphs [0008]-[0009], [0029]	8-9
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Date of the actual completion of the international search 21 January 2022	Date of mailing of the international search report 01 February 2022											
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.											

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/042972

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO	2020/110425	A1	04 June 2020	(Family: none)	
JP	6-189470	A	08 July 1994	(Family: none)	
JP	2021-131200	A	09 September 2021	(Family: none)	

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Patent documents cited in the description

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