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(71) Applicant: **Panasonic Intellectual Property
 Management Co., Ltd.**
Kadoma-shi, Osaka 571-0057 (JP)

(72) Inventors:

- **HIWATA, Akira**
Kadoma-shi, Osaka 571-0057 (JP)
- **DOYAMA, Yoshiaki**
Kadoma-shi, Osaka 571-0057 (JP)

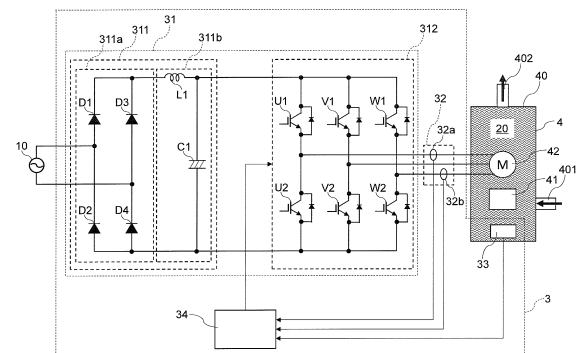
(74) Representative: **Eisenführ Speiser
 Patentanwälte Rechtsanwälte PartGmbB**
Postfach 31 02 60
80102 München (DE)

(54) REFRIGERATION CYCLE DEVICE

(57) There is provided a refrigeration cycle device which enables suppression of a disproportionation reaction of the working medium. The refrigeration cycle device (1) includes a control device (3) configured to control a compressor (4) of a refrigeration cycle circuit allowing circulation of a working medium. The working medium contains ethylene-based fluoroolefin as a refrigerant component. The compressor (4) includes: a sealed container (40) constituting a fluidic pathway for the working medium (20); and a compression mechanism (41) and an electric motor (42) positioned inside the sealed container (40). The control device (3) includes: a drive circuit (31) configured to drive the electric motor (42); a state detection circuit (32) configured to detect a state of at least one of the compressor (4) or the drive circuit (31); a temperature measurement circuit (33) configured to measure an internal temperature of the sealed container (40); and a control circuit (34) configured to control the drive circuit (31). The control circuit (34) is configured to stop operation of the drive circuit (31) during a state where an abnormality of at least one of the compressor (4) or the drive circuit (31) has been detected based on the state detected by the state detection circuit (32) and the internal temperature measured by the temperature measure-

ment circuit (33) has exceeded a predetermined temperature.

Fig. 2



Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigeration cycle device.

BACKGROUND ART

[0002] Conventionally, R410A has been widely used as a working medium (heat medium, refrigerant) for refrigeration cycle devices. However, the global warming potential (GWP) of R410A is as high as 2090. Therefore, from the viewpoint of preventing global warming, research and development of working media with smaller GWPs has been conducted. Patent Document 1 discloses 1,1,2-trifluoroethylene (HFO1123) as a working medium with a smaller GWP than R410A. Patent Document 2 discloses 1,2-difluoroethylene (HFO1132) as a working medium with a smaller GWP than R410A.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0003]

Patent Document 1: WO 2012/157764 A1

Patent Document 2: WO 2012/157765 A1

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] In particular, HFO1123 and HFO1132 have a smaller GWP than R410A, but are therefore less stable than R410A. For example, the generation of radicals may cause a disproportionation reaction of HFO1123 or HFO1132, resulting in the conversion of HFO1123 and HFO1132 to other compounds.

[0005] The present disclosure provides a refrigeration cycle device enabling suppression of a disproportionation reaction of a working medium.

SOLUTIONS TO THE PROBLEMS

[0006] A refrigeration cycle device according to one aspect of the present disclosure includes: a refrigeration cycle circuit including a compressor, a condenser, an expansion valve and an evaporator, and allowing circulation of a working medium; and a control device configured to control the compressor of the refrigeration cycle circuit. The working medium contains ethylene-based fluoroolefin as a refrigerant component. The compressor includes: a sealed container constituting a fluidic pathway for the working medium; a compression mechanism positioned inside the sealed container to compress the working medium; and an electric motor positioned inside

the sealed container to operate the compression mechanism. The control device includes: a drive circuit configured to drive the electric motor; a state detection circuit configured to detect a state of at least one of the compressor or the drive circuit; a temperature measurement circuit configured to measure an internal temperature of the sealed container of the compressor; and a control circuit configured to control the drive circuit. The control circuit is configured to stop operation of the drive circuit during a state where an abnormality of at least one of the compressor or the drive circuit has been detected based on the state detected by the state detection circuit and the internal temperature measured by the temperature measurement circuit has exceeded a predetermined temperature.

EFFECTS OF THE INVENTION

[0007] The present aspect enables suppression of a disproportionation reaction of a working medium.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

[Fig. 1] Fig. 1 is a block diagram of a configuration example of a refrigeration cycle device in accordance with one embodiment.

[Fig. 2] Fig. 2 is a schematic diagram of configuration examples of a compressor and a control device of the refrigeration cycle device of Fig. 1.

[Fig. 3] Fig. 3 is a flow chart of one example of operation of a control circuit of the control device of Fig. 2.

[Fig. 4] Fig. 4 is a schematic diagram of configuration examples of a compressor and a control device of a refrigeration cycle device of variation 1.

[Fig. 5] Fig. 5 is a schematic diagram of configuration examples of a compressor and a control device of a refrigeration cycle device of variation 2.

[Fig. 6] Fig. 6 is a schematic diagram of configuration examples of a compressor and a control device of a refrigeration cycle device of variation 3.

DETAILED DESCRIPTION

[1. EMBODIMENTS]

[0009] Hereinafter, embodiments of the present disclosure will be described with reference to the drawings where appropriate. However, the following embodiments are merely examples for explaining the present disclosure, and are not intended to limit the present disclosure to the following content. Positional relationships such as up, down, left, and right are based on the positional relationships shown in the drawings, unless otherwise specified. Each figure described in the following embodiments is a schematic diagram, and the ratios of size and

thickness of each component in each figure do not necessarily reflect the actual dimensional ratios. Furthermore, the dimensional ratios of each element are not limited to the ratios shown in the drawings.

[0010] Note that, in the following description, if it is necessary to distinguish a plurality of components from each other, prefixes, such as, "first", "second", or the like are attached to names of such components. However, if these components can be distinguished from each other by reference signs attached to those components, such prefixes, such as, "first", "second", or the like, may be omitted in consideration of readability of texts.

[1.1 CONFIGURATIONS]

[0011] Fig. 1 is a block diagram of a configuration example of a refrigeration cycle device 1 in accordance with the present embodiment. The refrigeration cycle device 1 of Fig. 1 constitutes an air conditioner enabling a cooling operation and a heating operation, for example.

[0012] The refrigeration cycle device 1 of Fig. 1 includes a refrigeration cycle circuit 2 and a control device 3.

[0013] The refrigeration cycle circuit 2 constitutes a fluidic pathway where the working medium circulates. In the present embodiment, the working medium contains ethylene-based fluoroolefin as a refrigerant component. The ethylene-based fluoroolefin may be ethylene-based fluoroolefin likely to undergo a disproportionation reaction. Examples of the ethylene-based fluoroolefin likely to undergo a disproportionation reaction may include 1,1,2-trifluoroethylene (HFO1124), trans-1,2-difluoroethylene (HFO1132(E)), cis-1,2-difluoroethylene (HFO-1132(Z)), 1,1-difluoroethylene (HFO-1132a), tetrafluoroethylene ($\text{CF}_2=\text{CF}_2$, FO1114), or monofluoroethylene (HFO-1141).

[0014] The working medium may include a plurality of types of refrigerant components. The working medium may contain ethylene-based fluoroolefin as a main refrigerant component, and additionally contain one or more chemical compounds other than ethylene-based fluoroolefin as one or more auxiliary refrigerant components. Examples of the auxiliary refrigerant components may include hydrofluorocarbons (HFC), hydrofluoroolefins (HFO), saturated hydrocarbons, and carbon dioxide. Examples of hydrofluorocarbons (HFC) may include difluoromethane, difluoroethane, trifluoroethane, tetrafluoroethane, pentafluoroethane, pentafluoropropane, hexafluoropropane, heptafluoropropane, pentafluorobutane, and heptafluorocyclopentane. Examples of hydrofluoroolefins (HFO) may include monofluoropropene, trifluoropropene, tetrafluoropropene, pentafluoropropene, and hexafluorobutene. Examples of saturated hydrocarbons may include ethane, n-propane, cyclopropane, n-butane, cyclobutane, isobutane (2-methylpropane), methylcyclopropane, n-pentane, isopentane (2-methylbutane), neopentane (2,2-dimethylpropane), and methylcyclobutane.

[0015] The working medium may further contain a disproportionation inhibitor for suppressing a disproportionation reaction of the ethylene-based fluoroolefin. Examples of the disproportionation inhibitor may include a saturated hydrocarbon or a haloalkane. Examples of saturated hydrocarbons may include ethane, n-propane, cyclopropane, n-butane, cyclobutane, isobutane (2-methylpropane), methylcyclopropane, n-pentane, isopentane (2-methylbutane), neopentane (2,2-dimethylpropane), and methylcyclobutane. In the above examples, n-propane is preferred. Examples of haloalkanes may include haloalkanes having one or two carbon atoms. Examples of haloalkanes having one carbon atom (i.e., halomethanes) may include (mono)iodomethane (CH_3I), diiodomethane (CH_2I_2), dibromomethane (CH_2Br_2), bromomethane (CH_3Br), dichloromethane (CH_2Cl_2), chloriodomethane (CH_2ClI), dibromochloromethane (CHBr_2Cl), tetraiodomethane (CI_4), carbon tetrabromide (CBr_4), bromotrichloromethane (CBrCl_3), dibromodichloromethane (CBr_2Cl_2), tribromofluoromethane (CBr_3F), fluorodiiodomethane (CHF_2I), difluorodiiodomethane (CF_2I_2), and dibromodifluoromethane (CBr_2F_2), trifluoriodomethane (CF_3I), and difluoriodomethane (CHF_2I). Examples of haloalkanes with two carbon atoms (i.e. haloethanes) may include 1,1,1-trifluoro-2-iodoethane ($\text{CF}_3\text{CH}_2\text{I}$), monoiodoethane ($\text{CH}_3\text{CH}_2\text{I}$), monobromoethane ($\text{CH}_3\text{CH}_2\text{Br}$), and 1,1,1-triiodoethane (CH_3CI_3). The working medium may contain one or more types of haloalkanes having 1 or 2 carbon atoms. In other words, the haloalkanes having 1 or 2 carbon atoms may be used alone or in combination of two or more types.

[0016] The refrigeration cycle circuit 2 of Fig. 1 includes a compressor 4, a first heat exchanger 5, an expansion valve 6, a second heat exchanger 7, and a four-way valve 8.

[0017] The refrigeration cycle device 1 of Fig. 1 includes an outdoor unit 1a and an indoor unit 1b. The outdoor unit 1a includes the control device 3, the compressor 4, the first heat exchanger 5, the expansion valve 6, and the four-way valve 8. The outdoor unit 1a further includes a first air blower 5a for facilitating heat exchange at the first heat exchanger 5. The indoor unit 1b includes the second heat exchanger 7. The indoor unit 1b further includes a second air blower 7a for facilitating heat exchange at the second heat exchanger 7.

[0018] In the refrigeration cycle circuit 2 of Fig. 1, the compressor 4 compresses the working medium to increase a pressure of the working medium. The compressor 4 would be described in detail later. The first heat exchanger 5 and the second heat exchanger 7 enable heat exchange between the working medium circulating in the refrigeration cycle circuit 2 and external air (e.g., the outdoor air or the indoor air). The expansion valve 6 regulates the pressure (evaporation pressure) of the working medium and regulates a flow volume of the working medium. The four-way valve 8 switches a direction of the working medium circulating in the refrigeration

cycle circuit 2 between a first direction corresponding to the cooling operation and a second direction corresponding to the heating operation.

[0019] In the present embodiment, as shown by a solid arrow A1 in Fig. 1, the first direction is a direction in which the working medium circulates in the refrigeration cycle circuit 2 in the order of the compressor 4, the first heat exchanger 5, the expansion valve 6, and the second heat exchanger 7.

[0020] In the cooling operation, the compressor 4 compresses and discharges the gaseous working medium, and thus the gaseous working medium is sent to the first heat exchanger 5 through the four-way valve 8. The first heat exchanger 5 conducts heat exchange between the outdoor air and the gaseous working medium and then the gaseous working medium is condensed to be liquefied. The liquid working medium is decompressed by the expansion valve 6 and is sent to the second heat exchanger 7. The second heat exchanger 7 conducts heat exchange between the liquid working medium and the indoor air, and then the gaseous working medium evaporates to become the gaseous working medium. The gaseous working medium returns to the compressor 4 through the four-way valve 8. In the cooling operation, the first heat exchanger 5 functions as a condenser, and the second heat exchanger 7 functions as an evaporator. Thus, the indoor unit 1b sends air cooled via heat exchange at the second heat exchanger 7 to an interior during cooling.

[0021] In the present embodiment, as shown by a broken arrow A2 in Fig. 1, the second direction is a direction in which the working medium circulates in the refrigeration cycle circuit 2 in the order of the compressor 4, the second heat exchanger 7, the expansion valve 6, and the first heat exchanger 5.

[0022] In the heating operation, the compressor 4 compresses and discharges the gaseous working medium, and thus the gaseous working medium is sent to the second heat exchanger 7 through the four-way valve 8. The second heat exchanger 7 conducts heat exchange between the indoor air and the gaseous working medium and then the gaseous working medium is condensed to be liquefied. The liquid working medium is decompressed by the expansion valve 6 and is sent to the first heat exchanger 5. The first heat exchanger 5 conducts heat exchange between the liquid working medium and the outdoor air, and then the gaseous working medium evaporates to become the gaseous working medium. The gaseous working medium returns to the compressor 4 through the four-way valve 8. In the heating operation, the second heat exchanger 7 functions as a condenser, and the first heat exchanger 5 functions as an evaporator. Thus, the indoor unit 1b sends air warmed via heat exchange at the second heat exchanger 7 to an interior during the heating.

[0023] The control device 3 of Fig. 1 controls the refrigeration cycle circuit 2. Fig. 2 is a schematic diagram of configuration examples of the compressor 4 and the

control device 3.

[0024] The compressor 4 is, for example, a hermetically sealed compressor. The compressor 4 may be of a rotary type, a scroll type, or other well-known type. The compressor 4 of Fig. 2 includes a sealed container 40, a compression mechanism 41, and an electric motor 42.

[0025] The sealed container 40 constitutes a fluidic pathway for the working medium 20. The sealed container 40 includes a suction pipe 401 and a discharge pipe 402. The working medium 20 is suctioned into the sealed container 40 via the suction pipe 401 and then is compressed by the compression mechanism 41 and thereafter is discharged to an exterior of the sealed container 40 via the discharge pipe 402. The inside of the sealed container 40 is filled with the working medium 20 with a high temperature and a high pressure together with a lubricating oil. The sealed container 40 has a bottom part which constitutes an oil reservoir for storing a mixed liquid of the working medium 20 and the lubricating oil.

[0026] The compression mechanism 41 is positioned inside the sealed container 40 to compress the working medium. The compression mechanism 41 may have a conventional configuration. For example, the compression mechanism 41 may include a cylinder forming a compression chamber, a rolling piston disposed in the compression chamber inside the cylinder, and a crank shaft coupled to the rolling piston.

[0027] The electric motor 42 is positioned inside the sealed container 40 to operate the compression mechanism 41. The electric motor 42 is a three-phase brushless motor. Fig. 3 is a schematic diagram of configuration examples of the electric motor 42 and the control device 3. The electric motor 42 includes a rotator fixed to the crank shaft of the compression mechanism 41 and a stator provided in a vicinity of the rotator, for example. The stator is configured by concentrated or distributed winding of stator windings (magnet wires) around a stator core (electrical or magnetic steel sheet or the like) with an insulation paper in-between. The stator windings are covered with insulating material. Examples of the insulating material may include polyethylene terephthalate (PET), polyethylene naphthalate (PEN), aramid polymer, and polyphenylene sulfide (PPS).

[0028] The compressor 4 may include an accumulator for preventing liquid compression in the compression chamber of the compression mechanism 41. The accumulator separates the working medium 20 into the gaseous working medium and the liquid working medium and directs only the gaseous working medium to the sealed container 40 via the suction pipe 401.

[0029] The control device 3 of Fig. 2 includes a drive circuit 31, a state detection circuit 32, a temperature measurement circuit 33, and a control circuit 34.

[0030] The drive circuit 31 is configured to drive the electric motor 42. The drive circuit 31 of Fig. 2 is configured to supply drive power to the electric motor 42 based on power from a power supply 10. In the present embodiment, the power supply 10 is an alternating current power

supply. The drive circuit 31 is configured to supply drive power to the electric motor 42 based on alternating current power from the power supply 10. Especially, the drive circuit 31 supplies three-phase alternating current power to the electric motor 42, as the drive power. The drive circuit 31 includes a converter circuit 311 and an inverter circuit 312.

[0031] The converter circuit 311 is configured to convert alternating current power from the power supply 10 into direct current power. The converter circuit 311 includes a rectification circuit 311a and a smoothing circuit 311b. The rectification circuit 311a is a diode bridge constituted by a plurality of diodes D1 to D4. The power supply 10 is connected between input terminals (a connecting point between the diodes D1, D2 and a connecting point between the diodes D3, D4) of the rectification circuit 311a and the smoothing circuit 311b is connected between output terminals (a connecting point between the diodes D1, D3 and a connecting point between the diodes D2, D4) of the rectification circuit 311a. The smoothing circuit 311b includes a series circuit of an inductor L1 and a capacitor C1, and is configured to smooth a voltage between the output terminals of the rectification circuit 311a to output it as a voltage across the capacitor C1. Configurations of the rectification circuit 311a and the smoothing circuit 311b of Fig. 2 are known and detailed description thereof is omitted.

[0032] The inverter circuit 312 is configured to supply three-phase alternating current power to the electric motor 42 based on the direct current power from the converter circuit 311. The inverter circuit 312 includes a plurality of arms U1, U2, V1, V2, W1, and W2. Each of the plurality of arms U1, U2, V1, V2, W1, and W2 is constituted by a semiconductor switching element such as a transistor. A series circuit of the arms U1, U2 is connected in parallel to the capacitor C1 of the converter circuit 311 and constitutes a U-phase leg. A series circuit of the arms V1, V2 is connected in parallel to the capacitor C1 of the converter circuit 311 and constitutes a V-phase leg. A series circuit of the arms W1, W2 is connected in parallel to the capacitor C1 of the converter circuit 311 and constitutes a W-phase leg. Configuration of the inverter circuit 312 of Fig. 2 is known and detailed description thereof is omitted.

[0033] The state detection circuit 32 is configured to detect a state of the drive circuit 31. The state of the drive circuit 31 includes a current value of a current flowing through the drive circuit 31. In the present embodiment, the current value of the current flowing through the drive circuit 31 includes current values of output alternating currents of the U-phase and W-phase legs of the drive circuit 31. The state detection circuit 32 of Fig. 2 includes a first alternating current sensor 32a and a second alternating current sensor 32b. The first alternating current sensor 32a detects the current value of the output alternating current of the U-phase leg of the drive circuit 31 and outputs a first detection signal indicative of the current value of the detected output alternating current to the

control circuit 34. The second alternating current sensor 32b detects the current value of the output alternating current of the W-phase leg of the drive circuit 31 and outputs a second detection signal indicative of the current value of the detected output alternating current to the control circuit 34.

[0034] The temperature measurement circuit 33 is configured to measure an internal temperature of the sealed container 40 of the compressor 4. The temperature measurement circuit 33 is configured to output a measurement signal indicative of the measured internal temperature, to the control circuit 34. The temperature measurement circuit 33 may be, for example, a temperature sensor positioned inside the sealed container 40. The temperature measurement circuit 33 may not be limited to a temperature sensor positioned inside the sealed container 40. It is sufficient that the temperature measurement circuit 33 can directly or indirectly measure the internal temperature of the sealed container 40 of the compressor 4.

[0035] The control circuit 34 may be realized by a computer system including, at least, one or more processors (microprocessors) and one or more memories, for example. The control circuit 34 is configured to control the drive circuit 31. In detail, the control circuit 34 is configured to control switching of the plurality of arms U1, U2, V1, V2, W1, and W2 of the inverter circuit 312 of the drive circuit 31 to allow the inverter circuit 312 to supply three-phase alternating current power to the electric motor 42 based on the direct current power from the smoothing circuit 311b.

[0036] The control circuit 34 is further configured to perform processing for suppressing a disproportionation reaction of the working medium circulating through the refrigeration cycle circuit 2 based on the first and second detection signals from the state detection circuit 32 and the measurement signal from the temperature measurement circuit 33.

[0037] Factors of a disproportionation reaction of the working medium are considered to include heat and radicals. For example, it is considered that a disproportionation reaction of the working medium may progress when radicals are generated under a high temperature and high pressure environment. Radicals may be generated by a discharge phenomenon which may be triggered when something abnormal occurs at the compressor 4 or the drive circuit 31. In consideration of this point of view, the control circuit 34 is configured to stop operation of the drive circuit 31 during a state where an abnormality of the drive circuit 31 has been detected based on the state detected by the state detection circuit 32 and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature.

[0038] The control circuit 34 is configured to determine whether or not an abnormality of the drive circuit 31 occurs, based on the state of the drive circuit 31 detected by the state detection circuit 32. In the present embodi-

ment, the state of the drive circuit 31 includes a current value of a current flowing through the drive circuit 31. The current value of the current flowing through the drive circuit 31 includes current values of output alternating currents of the U-phase and V-phase legs of the drive circuit 31. In the present embodiment, the abnormality of the drive circuit 31 is an electric abnormality. The electric abnormality of the drive circuit 31 may include an abnormal increase in a direct current component of a current flowing through the drive circuit 31, for example. Such an abnormal increase may be triggered or caused by a malfunction (failure) of the refrigeration cycle device 1 such as a malfunction of the compressor 4 or a malfunction of the inverter circuit 312 (e.g., a malfunction of any of the plurality of arms U1, U2, V1, V2, W1, and W2), for example. Thus, when the electric abnormality of the drive circuit 31 is detected, there may be a possibility of occurrence of a malfunction of the refrigeration cycle device 1 such as a malfunction of the compressor 4 or a malfunction of the inverter circuit 312. However, in some cases, the electric abnormality of the drive circuit 31 may be detected due to some noises or the like.

[0039] In the present embodiment, the control circuit 34 is configured to compare the current values of the output alternating current values indicated by the first and second detection signals from the state detection circuit 32 with a predetermined current value. The predetermined current value may be appropriately set by analyzing a current waveforms or the like, of the drive circuit 31 when the abnormality of the drive circuit 31 occurs actually. Obviously, the predetermined current value is set to be greater than a current value of a current flowing through the drive circuit 31 when no abnormality of the drive circuit 31 occurs.

[0040] The control circuit 34 is configured to determine that the electric abnormality of the drive circuit 31 has occurred when at least one of the current values of the output alternating current values indicated by the first and second detection signals exceeds the predetermined current value. In summary, the control circuit 34 is configured to detect the electric abnormality in response to a situation where the current value of the current flowing through the drive circuit 31 detected by the state detection circuit 32 exceeds the predetermined current value. The control circuit 34 is configured to determine that no electric abnormality of the drive circuit 31 has occurred when each of the current values of the output alternating current values indicated by the first and second detection signals is equal to or smaller than the predetermined current value.

[0041] The control circuit 34 is configured to, when determining that the electric abnormality of the drive circuit 31 has occurred (i.e., when detecting the electric abnormality of the drive circuit 31), stop operation of the drive circuit 31. At the time when the control circuit 34 has detected the electric abnormality of the drive circuit 31, there still be a possibility that the electric abnormality has been caused by some noises or the like. Therefore, in

some cases, detection of the abnormality of the drive circuit 31 may be false detection caused by noises. However, in view of a safety aspect, the control circuit 34 stops the operation of the drive circuit 31.

[0042] The control circuit 34 is configured to, after stopping the operation of the drive circuit 31, compare the internal temperature indicated by the measurement signal from the temperature measurement circuit 33 with a predetermined temperature. The predetermined temperature is, for example, lower than a safety temperature of the working medium and is lower than a heatproof (heat-resistant) temperature of an insulating member of the electric motor 42 of the compressor 4.

[0043] The safety temperature of the working medium may be set based on a temperature at which a disproportionation reaction of the working medium occurs under a pressure condition in a case of normal operation of the refrigeration cycle device 1. In one example, the safety temperature of the working medium is set to 150 °C.

[0044] The heatproof temperature of the electric motor 42 of the compressor 4 may be set based on a heatproof temperature of an insulating member of the electric motor 42 of the compressor 4, for example. For instance, the heatproof temperature of the insulating member of the electric motor 42 may be a heatproof temperature of an insulating component with a heatproof temperature which is the lowest of heatproof temperatures of insulating components of the electric motor 42. When the operation of the refrigeration cycle device 1 continues under a situation where the internal temperature exceeds the heatproof temperature, insulating paper may be destroyed and this may result in an increase in a probability of occurrence of a discharge phenomenon. In one example, an insulating component the heatproof temperature of which is the lowest in the electric motor 42 may be insulating paper between a stator core (electrical or magnetic steel sheet or the like) and a stator winding (magnet wire or the like). The insulating paper has a heatproof temperature of 120 °C when its thermal class is E defined in JIS C 4003, for example.

[0045] When the safety temperature of the working medium is 150 °C and the heatproof temperature of the electric motor 42 of the compressor 4 is 120 °C, the predetermined temperature is set to a temperature lower than 120 °C. In this case, a safety margin may be set to about 5 °C in consideration of a temperature detection time difference between a temperature of the working medium and a stator, or heat dissipation. Thus, the predetermined temperature may be set to 115 °C. The safety margin may depend on a distance between the temperature measurement circuit 33 and the stator or a motor efficiency, and therefore it may not be 5 °C but may be a value within a range of 0 to 20 °C.

[0046] The thermal class of the insulating paper may not be limited to E, but may be B, F, or the like. When the thermal class is B, the heatproof temperature is 130 °C. When the safety temperature of the working medium is

150 °C, the predetermined temperature is set to a temperature lower than 130 °C, e.g., 125 °C. When the thermal class is F, the heatproof temperature is 155 °C. When the safety temperature of the working medium is 150 °C, the predetermined temperature is set to a temperature lower than 150 °C, e.g., 145 °C.

[0047] The control circuit 34 is configured to, when the internal temperature indicated by the measurement signal from the temperature measurement circuit 33 exceeds the predetermined temperature, continues the stop of the operation of the drive circuit 31. When the drive circuit 31 has its abnormality and the internal temperature exceeds the predetermined temperature, a disproportionation reaction of the working medium may be considered to be more likely to progress. Accordingly, to suppress a disproportionation reaction of the working medium, the operation of the drive circuit 31 is kept stopped. As described above, when the abnormality of the drive circuit 31 has been detected based on the state detected by the state detection circuit 32 and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature, the control circuit 34 stops the operation of the drive circuit 31. In this case, the control circuit 34 may output error notification indicating that there may be a possibility of occurrence of a disproportionation reaction of the working medium.

[0048] The control circuit 34 is configured to, when the internal temperature indicated by the measurement signal from the temperature measurement circuit 33 is equal to or lower than the predetermined temperature, restart (resume) the operation of the drive circuit 31. Even when the abnormality of the drive circuit 31 has been detected, it is considered that there is a low possibility that a disproportionation reaction of the working medium progresses if the internal temperature is equal to or lower than the predetermined temperature. Therefore, the control circuit 34 restarts the operation of the drive circuit 31.

[0049] As described above, in some cases detection of the abnormality of the drive circuit 31 may be false detection caused by noises. However, in a case where the abnormality of the drive circuit 31 has been detected at multiple number of times, there may be a high probability that an abnormality such as a malfunction of the refrigeration cycle device 1 has actually occurred. In the present embodiment, the control circuit 34 is configured to count a number of times of detection of the abnormality. the control circuit 34 is configured to compare the number of times of detection of the drive circuit 31 with a predetermined number of times corresponding to the abnormality of the drive circuit 31. The control circuit 34 is configured to, when the number of times of detection exceeds the predetermined number of times, stop the operation of the drive circuit 31. In this case, the control circuit 34 may output error notification indicating that there may be a possibility of occurrence of the abnormality such as a malfunction of the refrigeration cycle device 1.

[0050] As described above, in the present embodiment, the control circuit 34 stops the operation of the drive circuit 31 at the time of detection of the current abnormality of the drive circuit 31. Therefore, the control circuit 34 continues the stop of the operation of the drive circuit 31 when the number of times of detection has exceeded the predetermined number of times. The control circuit 34 may restart the operation of the drive circuit 31 while the number of times of detection is kept equal to or smaller than the predetermined number of times. However, when the internal temperature indicated by the measurement signal from the temperature measurement circuit 33 has exceed the predetermined temperature, the control circuit 34 continues the stop of the operation of the drive circuit 31 even in a case where the number of times of detection is kept equal to or smaller than the predetermined number of times.

[1.2 OPERATION]

[0051] Hereinafter, one example of operation of the control circuit 34 of the control device 3 of the refrigeration cycle device 1 will be described simply with reference to Fig. 3. Fig. 3 is a flow chart of one example of operation of the control circuit 34 of the control device 3.

[0052] The control circuit 34 detects the state of the drive circuit 31, by the state detection circuit 32 (S11). In the present embodiment, the state of the drive circuit 31 is the current value of the current flowing through the drive circuit 31. The current value of the current flowing through the drive circuit 31 includes the current values of the output alternating current values of the U-phase and W-phase legs of the drive circuit 31.

[0053] The control circuit 34 determines whether or not the abnormality of the drive circuit 31 has occurred, based on the state detected by the state detection circuit 32 (S12). In the present embodiment, the control circuit 34 compares the current values of the output alternating current values indicated by the first and second detection signals from the state detection circuit 32, with the predetermined current value.

[0054] When each of the current values of the output alternating current values indicated by the first and second detection signals is equal to or smaller than the predetermined current value, the control circuit 34 determines that the electric abnormality of the drive circuit 31 has not yet occurred (S12; NO).

[0055] When at least one of the current values of the output alternating current values indicated by the first and second detection signals exceeds the predetermined current value, the control circuit 34 determines that the electric abnormality of the drive circuit 31 has occurred (S12; YES). The control circuit 34 stops the operation of the drive circuit 31 (S13).

[0056] After the stop of the operation of the drive circuit 31, the control circuit 34 compares the internal temperature indicated by the measurement signal from the temperature measurement circuit 33, with the predetermined

temperature (S14).

[0057] When the internal temperature indicated by the measurement signal from the temperature measurement circuit 33 exceeds the predetermined temperature (S14; YES), the control circuit 34 continues the stop of the operation of the drive circuit 31 (S15). Then, the control circuit 34 outputs error notification indicating that there may be a possibility of occurrence of a disproportionation reaction (S16).

[0058] In step S14, when the internal temperature indicated by the measurement signal from the temperature measurement circuit 33 is equal to or smaller than the predetermined temperature, the control circuit 34 increments the number of times of detection of the abnormality of the drive circuit 31, by one (S17).

[0059] The control circuit 34 compares the number of times of detection of the abnormality of the drive circuit 31 with the predetermined number of times corresponding to the abnormality of the drive circuit 31 (S18).

[0060] When the number of times of detection exceeds the predetermined number of times (S18; YES), the control circuit 34 continues the stop of the operation of the drive circuit 31 (S19). Then, the control circuit 34 outputs the error notification indicating that there may be a possibility of occurrence of the abnormality such as a malfunction of the refrigeration cycle device 1 (S20).

[0061] In step S18, when the number of times of detection is equal to or smaller than the predetermined number of times (S18; NO), the control circuit 34 restarts the operation of the drive circuit 31 (S21).

[0062] As described above, the control circuit 34 stops the operation of the drive circuit 31 during a state where the abnormality of the drive circuit 31 has been detected based on the state detected by the state detection circuit 32 and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. In particular, the control circuit 34 stops the operation of the drive circuit 31 when the abnormality is detected, and continues the stop of the operation of the drive circuit 31 while the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature. Thus, the control circuit 34 can suppress a discharge phenomenon which may cause radicals which may triggers a disproportionation reaction of the working medium.

[1.3 ADVANTAGEOUS EFFECTS]

[0063] The aforementioned refrigeration cycle device 1 and includes: the refrigeration cycle circuit 2 including the compressor 4, the condenser (the first heat exchanger 5, the second heat exchanger 7), the expansion valve 6 and the evaporator (the first heat exchanger 5, the second heat exchanger 7) and allowing circulation of the working medium 20; and the control device 3 configured to control the compressor 4 of the refrigeration cycle circuit 2. The working medium 20 contains ethylene-based fluoroolefin as a refrigerant component. The com-

pressor 4 includes: the sealed container 40 constituting a fluidic pathway for the working medium 20; the compression mechanism 41 positioned inside the sealed container 40 to compress the working medium 20; and the electric motor 42 positioned inside the sealed container 40 to operate the compression mechanism 41. The control device 3 includes: the drive circuit 31 configured to drive the electric motor 42; the state detection circuit 32 configured to detect the state of the drive circuit 31; the temperature measurement circuit 33 configured to measure the internal temperature of the sealed container 40 of the compressor 4; and the control circuit 34 configured to control the drive circuit 31. The control circuit 34 is configured to stop operation of the drive circuit 31 during a state where an abnormality of the drive circuit 31 has been detected based on the state detected by the state detection circuit 32 and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. This configuration enables suppression of a disproportionation reaction of the working medium.

[0064] In the refrigeration cycle device 1, the control circuit 34 is configured to: in response to detection of the abnormality, stop the operation of the drive circuit 31; subsequent to stop of the operation of the drive circuit 31, determine whether or not the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature; and when the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature, continues the stop of the operation of the drive circuit 31, and when the internal temperature measured by the temperature measurement circuit 33 is equal to or lower than the predetermined temperature, restart the operation of the drive circuit 31. This configuration enables improvement of effect of suppression of a disproportionation reaction of the working medium.

[0065] In the refrigeration cycle device 1, the control circuit 34 is configured to: count a number of times of detection of the abnormality; and when the number of times of detection exceeds a predetermined number of times corresponding to the abnormality, stop the operation of the drive circuit 31. This configuration enables improvement of safety of operation of the refrigeration cycle device 1.

[0066] In the refrigeration cycle device 1, the state includes the current value of the current flowing through the drive circuit 31 (current values of output alternating currents of the U-phase and W-phase legs of the drive circuit 31). The abnormality includes the electric abnormality of the drive circuit 31. The control circuit 34 is configured to detect the electric abnormality in response to a situation where the current value of the current flowing through the drive circuit 31 detected by the state detection circuit 32 exceeds the predetermined current value. This configuration enables suppression of a disproportionation reaction of the working medium caused by the abnormality of the drive circuit 31.

[0067] In the refrigeration cycle device 1, the predetermined temperature is lower than the safety temperature of the working medium 20 and is lower than the heatproof temperature of the electric motor 42 of the compressor 4. This configuration enables suppression of a disproportionation reaction of the working medium.

[0068] In the refrigeration cycle device 1, the ethylene-based fluoroolefin contains ethylene-based fluoroolefin likely to undergo a disproportionation reaction. This configuration enables suppression of a disproportionation reaction of the working medium.

[0069] In the refrigeration cycle device 1, the ethylene-based fluoroolefin is 1,1,2-trifluoroethylene, trans-1,2-difluoroethylene, cis-1,2-difluoroethylene, 1,1-difluoroethylene, tetrafluoroethylene, or monofluoroethylene. This configuration enables suppression of a disproportionation reaction of the working medium.

[0070] In the refrigeration cycle device 1, the working medium 20 contains difluoromethane as the refrigerant component. This configuration enables suppression of a disproportionation reaction of the working medium.

[0071] In the refrigeration cycle device 1, the working medium 20 further contains a saturated hydrocarbon. This configuration enables suppression of a disproportionation reaction of the working medium.

[0072] In the refrigeration cycle device 1, the working medium 20 contains a haloalkane with 1 or 2 carbon atoms as a disproportionation inhibitor for suppressing a disproportionation reaction of the ethylene-based fluoroolefin. This configuration enables suppression of a disproportionation reaction of the working medium.

[0073] In the refrigeration cycle device 1, the saturated hydrocarbon contains n-propane. This configuration enables suppression of a disproportionation reaction of the working medium.

[2. VARIATIONS]

[0074] Embodiments of the present disclosure are not limited to the above embodiment. The above embodiment may be modified in various ways in accordance with designs or the like to an extent that they can achieve the problem of the present disclosure. Hereinafter, some variations or modifications of the above embodiment will be listed. One or more of the variations or modifications described below may apply in combination with one or more of the others.

[2.1 VARIATION 1]

[0075] Fig. 4 is a schematic diagram of configuration examples of the compressor 4 and a control device 3A of a refrigeration cycle device of variation 1.

[0076] The control device 3A of Fig. 4 includes the drive circuit 31, a state detection circuit 32A, the temperature measurement circuit 33, and a control circuit 34A.

[0077] The state detection circuit 32A is configured to detect a state of the drive circuit 31. The state of the drive

circuit 31 is a current value of a current flowing through the drive circuit 31. In variation 1, the current value of the current of the drive circuit 31 includes a current value of a direct current flowing between the converter circuit 311 and the inverter circuit 312, of the drive circuit 31. The state detection circuit 32A of Fig. 4 is a shunt resistor connected between a connecting point between the diode D4 and the capacitor C1, of the converter circuit 311 and a connecting point among the legs U2, V2, and W2 of the inverter circuit 312, for example. A voltage across the state detection circuit 32A indicates the current value of the direct current flowing between the converter circuit 311 and the inverter circuit 312, of the drive circuit 31.

[0078] The control circuit 34A is configured to determine whether or not an abnormality of the drive circuit 31 occurs, based on the state of the drive circuit 31 detected by the state detection circuit 32A. In variation 1, the state of the drive circuit 31 includes a current value of a current flowing through the drive circuit 31. The current value of the current flowing through the drive circuit 31 includes the current value of the direct current flowing between the converter circuit 311 and the inverter circuit 312, of the drive circuit 31. Also in variation 1, the abnormality of the drive circuit 31 is an electric abnormality of the drive circuit 31. The electric abnormality of the drive circuit 31 may include an abnormal increase in a direct current component of a current flowing through the drive circuit 31, for example. Such an abnormal increase may be triggered or caused by a malfunction of the refrigeration cycle device 1 such as a malfunction of the compressor 4 or a malfunction of the inverter circuit 312 (e.g., a malfunction of any of the plurality of arms U1, U2, V1, V2, W1, and W2), for example. Thus, when the electric abnormality of the drive circuit 31 is detected, there may be a possibility of occurrence of a malfunction of the refrigeration cycle device 1 such as a malfunction of the compressor 4 or a malfunction of the inverter circuit 312. However, in some cases, the electric abnormality of the drive circuit 31 may be detected due to some noises or the like.

[0079] The control circuit 34A is configured to compare the current value of the direct current flowing between the converter circuit 311 and the inverter circuit 312, of the drive circuit 31 obtained from the voltage across the state detection circuit 32A, with a predetermined current value. The predetermined current value may be appropriately set by analyzing a current waveforms or the like, of the drive circuit 31 when the abnormality of the drive circuit 31 occurs actually. Obviously, the predetermined current value is set to be greater than a current value of a current flowing through the drive circuit 31 when no abnormality of the drive circuit 31 occurs.

[0080] The control circuit 34A is configured to determine that the electric abnormality of the drive circuit 31 has occurred when the current value of the direct current flowing between the converter circuit 311 and the inverter circuit 312, of the drive circuit 31 exceeds the predetermined current value. In summary, the control circuit 34A

is configured to detect the electric abnormality in response to a situation where the current value of the direct current flowing between the converter circuit 311 and the inverter circuit 312, of the drive circuit 31 exceeds the predetermined current value. The control circuit 34A is configured to determine that no electric abnormality of the drive circuit 31 has occurred when the current value of the direct current flowing between the converter circuit 311 and the inverter circuit 312, of the drive circuit 31 is equal to or smaller than the predetermined current value.

[0081] The control circuit 34A stops the operation of the drive circuit 31 during a state where the abnormality of the drive circuit 31 (the electric abnormality of the drive circuit 31) has been detected based on the state detected by the state detection circuit 32A and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. In particular, the control circuit 34A stops the operation of the drive circuit 31 when the abnormality is detected, and continues the stop of the operation of the drive circuit 31 while the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature. Thus, the control circuit 34A can suppress a discharge phenomenon which may cause radicals which may triggers a disproportionation reaction of the working medium.

[0082] As described above, in variation 1, the control device 3A includes: the drive circuit 31 configured to drive the electric motor 42; the state detection circuit 32A configured to detect the state of the drive circuit 31; the temperature measurement circuit 33 configured to measure the internal temperature of the sealed container 40 of the compressor 4; and the control circuit 34A configured to control the drive circuit 31. The control circuit 34A is configured to stop operation of the drive circuit 31 during a state where the abnormality of the drive circuit 31 has been detected based on the state detected by the state detection circuit 32A and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. This configuration enables suppression of a disproportionation reaction of the working medium.

[0083] In variation 1, the state includes the current value of the current flowing through the drive circuit 31. The abnormality includes the electric abnormality of the drive circuit 31. The control circuit 34A is configured to detect the electric abnormality in response to a situation where the current value of the current flowing through the drive circuit 31 detected by the state detection circuit 32A exceeds the predetermined current value. This configuration enables suppression of a disproportionation reaction of the working medium caused by the abnormality of the drive circuit 31.

[2.2 VARIATION 2]

[0084] Fig. 5 is a schematic diagram of configuration examples of the compressor 4 and a control device 3B of

a refrigeration cycle device of variation 2.

[0085] The control device 3B of Fig. 5 includes the drive circuit 31, a state detection circuit 32B, the temperature measurement circuit 33, and a control circuit 34B.

[0086] The state detection circuit 32B is configured to detect a state of the compressor 4. The state of the compressor 4 is a current value of a phase current of the compressor 4. The current value of the phase current of the compressor 4 includes current values of individual U-phase, V-phase, and W-phase currents. The state detection circuit 32B of Fig. 5 includes a U-phase shunt resistor R_u , a V-phase shunt resistor R_v , and a W-phase shunt resistor R_w . The U-phase shunt resistor R_u is inserted between the U-phase arm of the inverter circuit 312 and the U-phase stator winding of the electric motor 42 of the compressor 4. The V-phase shunt resistor R_v is inserted between the V-phase arm of the inverter circuit 312 and the V-phase stator winding of the electric motor 42 of the compressor 4. The W-phase shunt resistor R_w is inserted between the W-phase arm of the inverter circuit 312 and the W-phase stator winding of the electric motor 42 of the compressor 4. Voltages across the U-phase, V-shape, and W-shape shunt resistors R_u , R_v , and R_w of the state detection circuit 32B respectively indicate the current values of the U-phase, V-phase and W-phase currents.

[0087] The control circuit 34B is configured to determine whether or not an abnormality of the compressor 4 occurs, based on the state of the compressor 4 detected by the state detection circuit 32B. The abnormality of the compressor 4 includes an abnormality relating to layer short of the compressor 4. The abnormality relating to the layer short of the compressor 4 may include the layer short of the compressor 4 as such, an abnormality likely to cause the layer short of the compressor 4, and an abnormality possibly caused or triggered by the layer short of the compressor 4. Concrete examples of the abnormality relating to the layer short of the compressor 4 may include the layer short of the compressor 4, an electric fault of the compressor 4, and an open-phase operation of the compressor 4. In a state where imbalance of the phase current of the compressor 4 occurs, the abnormality relating to the layer short of the compressor 4 may have occurred.

[0088] The control circuit 34B is configured to determine whether or not the imbalance of the phase current of the compressor 4 has occurred, based on the current value of the phase current of the compressor 4 obtained from the state detection circuit 32B. The imbalance of the phase current of the compressor 4 is considered to have occurred, if it is not satisfied that the U-phase, V-phase and W-phase currents of the compressor 4 have the same amplitude but phases 120 degrees shifted.

[0089] The control circuit 34B is configured to determine that the abnormality relating to the layer short of the compressor 4 occurs when the imbalance of the phase current of the compressor 4 has occurred. In summary, the control circuit 34B is configured to detect the abnorm-

ality relating to the layer short of the compressor 4 in response to the imbalance of the phase current of the compressor 4. The control circuit 34B is configured to determine that the abnormality relating to the layer short of the compressor 4 does not occur when the imbalance of the phase current of the compressor 4 has not occurred.

[0090] The control circuit 34B stops the operation of the drive circuit 31 during a state where the abnormality of the compressor 4 (the abnormality relating to the layer short of the compressor 4) has been detected based on the state detected by the state detection circuit 32B and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. In particular, the control circuit 34B stops the operation of the drive circuit 31 when the abnormality is detected, and continues the stop of the operation of the drive circuit 31 while the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature. Thus, the control circuit 34B can suppress a discharge phenomenon which may cause radicals which may triggers a disproportionation reaction of the working medium, and as a result can suppress a disproportionation reaction of the working medium.

[0091] As described above, In variation 2, the control device 3B includes: the drive circuit 31 configured to drive the electric motor 42; the state detection circuit 32B configured to detect the state of the compressor 4; the temperature measurement circuit 33 configured to measure the internal temperature of the sealed container 40 of the compressor 4; and the control circuit 34B configured to control the drive circuit 31. The control circuit 34B is configured to stop operation of the drive circuit 31 during a state where the abnormality of the compressor 4 has been detected based on the state detected by the state detection circuit 32B and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. This configuration enables suppression of a disproportionation reaction of the working medium.

[0092] In variation 2, the state includes the phase current of the compressor 4. The abnormality includes the abnormality relating to the layer short of the compressor 4. The control circuit 34B is configured to detect the abnormality relating to the layer short of the compressor 4 in response to the imbalance of the phase current of the compressor 4. This configuration enables suppression of a disproportionation reaction of the working medium caused by the abnormality of the compressor 4.

[2.3 VARIATION 3]

[0093] Fig. 6 is a schematic diagram of configuration examples of the compressor 4 and a control device 3C of a refrigeration cycle device of variation 3.

[0094] The control device 3C of Fig. 6 includes the

drive circuit 31, a state detection circuit 32C, the temperature measurement circuit 33, and a control circuit 34C.

[0095] The state detection circuit 32C is configured to detect a state of the compressor 4. The state of the compressor 4 is a rotational frequency of the electric motor 42 of the compressor 4. The state detection circuit 32C of Fig. 6 includes a rotational frequency sensor configured to measure the rotational frequency of the electric motor 42 of the compressor 4. The rotational frequency sensor may be a conventional configuration such as, an electromagnetic pick-up sensor, a proximity sensor, a photoelectric sensor, a laser sensor, or the like.

[0096] The control circuit 34C is configured to determine whether or not an abnormality of the compressor 4 occurs, based on the state of the compressor 4 detected by the state detection circuit 32C. The abnormality of the compressor 4 includes an abnormality relating to the layer short of the compressor 4. The abnormality relating to the layer short of the compressor 4 may include the layer short of the compressor 4 as such, an abnormality likely to cause the layer short of the compressor 4, and an abnormality possibly caused or triggered by the layer short of the compressor 4. Concrete examples of the abnormality relating to the layer short of the compressor 4 may include the layer short of the compressor 4, an electric fault of the compressor 4, and an open-phase operation of the compressor 4. In a state where a deviation of the rotational frequency of the electric motor 42 of the compressor 4 occurs, the abnormality relating to the layer short of the compressor 4 may have occurred.

[0097] The control circuit 34C is configured to determine whether or not the deviation of the rotational frequency of the electric motor 42 of the compressor 4 has occurred, based on the rotational frequency of the electric motor 42 of the compressor 4 obtained from the state detection circuit 32C. The control circuit 34C is configured to set operation frequencies (switching frequencies) of the plurality of legs U1, U2, V1, V2, W1, and W2 of the inverter circuit 312 of the drive circuit 31 to allow the rotational frequency of the electric motor 42 of the compressor 4 to be equal to a desired rotational frequency. While there is no abnormality of the compressor 4, the rotational frequency of the electric motor 42 of the compressor 4 detected by the state detection circuit 32C falls within a predetermined range based on the desired rotational frequency. The control circuit 34C is configured to determine that the deviation of the rotational frequency of the electric motor 42 of the compressor 4 has occurred, when the rotational frequency of the electric motor 42 of the compressor 4 detected by the state detection circuit 32C does not fall within the predetermined range.

[0098] The control circuit 34C is configured to determine that the abnormality relating to the layer short of the compressor 4 occurs when the deviation of the rotational frequency of the electric motor 42 of the compressor 4 has occurred. In summary, the control circuit 34C is configured to detect the abnormality relating to the layer

short of the compressor 4 in response to the deviation of the rotational frequency of the electric motor 42 of the compressor 4. The control circuit 34C is configured to determine that the abnormality relating to the layer short of the compressor 4 does not occur when the deviation of the rotational frequency of the electric motor 42 of the compressor 4 has not occurred.

[0099] The control circuit 34C stops the operation of the drive circuit 31 during a state where the abnormality of the compressor 4 (the abnormality relating to the layer short of the compressor 4) has been detected based on the state detected by the state detection circuit 32C and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. In particular, the control circuit 34C stops the operation of the drive circuit 31 when the abnormality is detected, and continues the stop of the operation of the drive circuit 31 while the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature. Thus, the control circuit 34C can suppress a discharge phenomenon which may cause radicals which may triggers a disproportionation reaction of the working medium, and as a result can suppress a disproportionation reaction of the working medium.

[0100] The aforementioned control device 3C includes: the drive circuit 31 configured to drive the electric motor 42; the state detection circuit 32C configured to detect the state of the compressor 4; the temperature measurement circuit 33 configured to measure the internal temperature of the sealed container 40 of the compressor 4; and the control circuit 34C configured to control the drive circuit 31. The control circuit 34C is configured to stop operation of the drive circuit 31 during a state where the abnormality of the compressor 4 has been detected based on the state detected by the state detection circuit 32C and the internal temperature measured by the temperature measurement circuit 33 has exceeded the predetermined temperature. This configuration enables suppression of a disproportionation reaction of the working medium.

[0101] In the control device 3C, the state includes the rotational frequency of the electric motor 42 of the compressor 4. The abnormality includes the abnormality relating to the layer short of the compressor 4. The control circuit 34C is configured to detect the abnormality relating to the layer short of the compressor 4 in response to the deviation of the rotational frequency of the electric motor 42 of the compressor 4. This configuration enables suppression of a disproportionation reaction of the working medium caused by the abnormality of the compressor 4.

[2.4 OTHER VARIATIONS]

[0102] In one variation, the state detection circuit 32, 32A, 32B, 32C may be modified appropriately. For example, the current value of the current flowing through the drive circuit 31 detected by the state detection circuit 32

may not be limited to the current values of the output alternating current values of the U-phase and W-phase legs of the drive circuit 31. The current value of the current flowing through the drive circuit 31 detected by the state detection circuit 32 may include at least one of the current values of the output alternating current values of the U-phase, V-phase and W-phase legs of the drive circuit 31. For example, the state detection circuit 32A may be a shunt resistor connected between a connecting point between the inductor L1 and the capacitor C1, of the converter circuit 311 and a connecting point among the legs U1, V1, and W1 of the inverter circuit 312. The state detection circuit 32A may not be limited to shunt resistors. The state detection circuit 32A may be a conventional direct current sensor. For example, the state detection circuit 32B may not be limited to shunt resistors. The state detection circuit 32B may be a conventional alternating current sensor.

[0103] In one variation, the refrigeration cycle device may include at least one of the state detection circuits 32 and 32A, and at least one of the state detection circuits 32B and 32C. In summary, the refrigeration cycle device may detect both the abnormality of the compressor 4 and the abnormality of the drive circuit 31. The number of times of detection of the abnormality may be counted for each state detection circuit.

[0104] In one variation, the control circuit 34, 34A, 34B, or 34C may not always stop the operation of the drive circuit 31 when the abnormality is detected. The control circuit 34, 34A, 34B, or 34C may stop the operation of the drive circuit 31 when the abnormality is detected and the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature.

[0105] In one variation, the control circuit 34, 34A, 34B, or 34C may not always count the number of times of detection of the abnormality.

[0106] In one variation, when the abnormality has been detected, the control circuit 34, 34A, 34B, or 34C may stop the operation of the drive circuit 31 only in a duration when the internal temperature measured by the temperature measurement circuit 33 exceeds the predetermined temperature.

[0107] In one variation, the refrigeration cycle device is not limited to an air conditioner with a configuration where one indoor unit is connected to one outdoor unit (so called, a room air conditioner (RAC)). The refrigeration cycle device may be an air conditioner with a configuration where a plurality of indoor units are connected to one or more outdoor units (so-called, a package air conditioner (PAC) or a variable refrigerant flow (VRF)). Or, the refrigeration cycle device is not limited to an air conditioner, but may be a freezing or refrigerating device such as a refrigerator or a freezer.

[3. ASPECTS]

[0108] As apparent from the above embodiment and

variations, the present disclosure includes the following aspects. Hereinafter, reference signs in parenthesis are attached for the purpose of clearly showing correspondence with the embodiments only. Note that, in consideration of readability of texts, the reference signs in parentheses may be omitted from the second and subsequent times.

[0109] A first aspect is a refrigeration cycle device (1) and includes: a refrigeration cycle circuit (2) including a compressor (4), a condenser (the first heat exchanger 5, the second heat exchanger 7), an expansion valve (6) and an evaporator (the first heat exchanger 5, the second heat exchanger 7), and allowing circulation of a working medium (20); and a control device (3; 3A; 3B; 3C) configured to control the compressor (4) of the refrigeration cycle circuit (2). The working medium (20) contains ethylene-based fluoroolefin as a refrigerant component. The compressor (4) includes: a sealed container (40) constituting a fluidic pathway for the working medium (20); a compression mechanism (41) positioned inside the sealed container (40) to compress the working medium (20); and an electric motor (42) positioned inside the sealed container (40) to operate the compression mechanism (41). The control device (3; 3A; 3B; 3C) includes: a drive circuit (31) configured to drive the electric motor (42); a state detection circuit (32; 32A; 32B; 32C) configured to detect a state of at least one of the compressor (4) or the drive circuit (31); a temperature measurement circuit (33) configured to measure an internal temperature of the sealed container (40) of the compressor (4); and a control circuit (34; 34A; 34B; 34C) configured to control the drive circuit (31). The control circuit (34; 34A; 34B; 34C) is configured to stop operation of the drive circuit (31) during a state where an abnormality of at least one of the compressor (4) or the drive circuit (31) has been detected based on the state detected by the state detection circuit (32; 32A; 32B; 32C) and the internal temperature measured by the temperature measurement circuit (33) has exceeded a predetermined temperature. This aspect enables suppression of a disproportionation reaction of the working medium.

[0110] A second aspect is a refrigeration cycle device (1) based on the first aspect. In the second aspect, the control circuit (34; 34A; 34B; 34C) is configured to: in response to detection of the abnormality, stop the operation of the drive circuit (31); subsequent to stop of the operation of the drive circuit (31), determine whether or not the internal temperature measured by the temperature measurement circuit (33) exceeds the predetermined temperature; and when the internal temperature measured by the temperature measurement circuit (33) exceeds the predetermined temperature, continues the stop of the operation of the drive circuit (31), and when the internal temperature measured by the temperature measurement circuit (33) is equal to or lower than the predetermined temperature, restart the operation of the drive circuit (31). This aspect enables improvement of effect of suppression of a disproportionation reaction of

the working medium.

[0111] A third aspect is a refrigeration cycle device (1) based on the second aspect. In the third aspect, the control circuit (34; 34A; 34B; 34C) is configured to: count a number of times of detection of the abnormality; and when the number of times of detection exceeds a predetermined number of times corresponding to the abnormality, stop the operation of the drive circuit (31). This aspect enables improvement of safety of operation of the refrigeration cycle device (1).

[0112] A fourth aspect is a refrigeration cycle device (1) based on any one of the first to third aspects. In the fourth aspect, the state includes a current value of a current flowing through the drive circuit (31). The abnormality includes an electric abnormality of the drive circuit (31). The control circuit (34; 34A) is configured to detect the electric abnormality in response to a situation where the current value of the current flowing through the drive circuit (31) detected by the state detection circuit (32; 32A) exceeds a predetermined current value. This aspect enables suppression of a disproportionation reaction of the working medium caused by the abnormality of the drive circuit (31).

[0113] A fifth aspect is a refrigeration cycle device (1) based on any one of the first to fourth aspects. In the fifth aspect, the state includes at least one of a phase current of the compressor (4) or a rotational frequency of the electric motor (42) of the compressor (4). The abnormality includes an abnormality relating to layer short of the compressor (4). The control circuit (34B; 34C) is configured to detect the abnormality relating to the layer short of the compressor (4) in response to at least one of imbalance of the phase current of the compressor (4) or a deviation of the rotational frequency of the electric motor (42) of the compressor (4). This aspect enables suppression of a disproportionation reaction of the working medium caused by the abnormality of the compressor (4).

[0114] A sixth aspect is a refrigeration cycle device (1) based on any one of the first to fifth aspects. In the sixth aspect, the predetermined temperature is lower than a safety temperature of the working medium (20) and is lower than a heatproof temperature of the electric motor (42) of the compressor (4). This aspect enables suppression of a disproportionation reaction of the working medium.

[0115] A seventh aspect is a refrigeration cycle device (1) based on any one of the first to sixth aspects. In the seventh aspect, the ethylene-based fluoroolefin contains ethylene-based fluoroolefin likely to undergo a disproportionation reaction. This aspect enables suppression of a disproportionation reaction of the working medium.

[0116] An eighth aspect is a refrigeration cycle device (1) based on any one of the first to seventh aspects. In the eighth aspect, the ethylene-based fluoroolefin is 1,1,2-trifluoroethylene, trans-1,2-difluoroethylene, cis-1,2-difluoroethylene, 1,1-difluoroethylene, tetrafluoroethylene, or monofluoroethylene. This aspect enables suppression of a disproportionation reaction of the working

medium.

[0117] A ninth aspect is a refrigeration cycle device (1) based on any one of the first to eighth aspects. In the ninth aspect, the working medium (20) contains difluoromethane as the refrigerant component. This aspect enables suppression of a disproportionation reaction of the working medium.

[0118] A tenth aspect is a refrigeration cycle device (1) based on any one of the first to ninth aspects. In the tenth aspect, the working medium (20) further contains a saturated hydrocarbon. This aspect enables suppression of a disproportionation reaction of the working medium.

[0119] An eleventh aspect is a refrigeration cycle device (1) based on any one of the first to tenth aspects. In the eleventh aspect, the working medium contains a haloalkane with 1 or 2 carbon atoms as a disproportionation inhibitor for suppressing a disproportionation reaction of the ethylene-based fluoroolefin. This aspect enables suppression of a disproportionation reaction of the working medium.

[0120] A twelfth aspect is a refrigeration cycle device (1) based on the tenth aspect. In the twelfth aspect, the saturated hydrocarbon contains n-propane. This aspect enables suppression of a disproportionation reaction of the working medium.

[0121] The second to twelfth aspects are optional and not essential.

INDUSTRIAL APPLICABILITY

[0122] The present disclosure is applicable to refrigeration cycle devices. In particular, the present disclosure is applicable to a refrigeration cycle device using a working medium containing ethylene-based fluoroolefin as a refrigerant component.

REFERENCE SIGNS LIST

[0123]

- 1 Refrigeration Cycle Device
- 2 Refrigeration Cycle Circuit
- 20 Working Medium
- 3, 3A, 3B, 3C Control Device
- 31 Drive Circuit
- 32, 32A, 32B, 32C State Detection Circuit
- 33 Temperature Measurement Circuit
- 34, 34A, 34B, 34C Control Circuit
- 4 Compressor
- 40 Sealed Container
- 41 Compression Mechanism
- 42 Electric Motor
- 5 First Heat Exchanger (Condenser, Evaporator)
- 6 Expansion Valve
- 7 Second Heat Exchanger (Condenser, Evaporator)

Claims

1. A refrigeration cycle device comprising:

a refrigeration cycle circuit including a compressor, a condenser, an expansion valve and an evaporator, and allowing circulation of a working medium; and

a control device configured to control the compressor of the refrigeration cycle circuit, the working medium containing ethylene-based fluoroolefin as a refrigerant component, the compressor including

a sealed container constituting a fluidic pathway for the working medium, a compression mechanism positioned inside the sealed container to compress the working medium, and

an electric motor positioned inside the sealed container to operate the compression mechanism,

the control device including

a drive circuit configured to drive the electric motor,

a state detection circuit configured to detect a state of at least one of the compressor or the drive circuit,

a temperature measurement circuit configured to measure an internal temperature of the sealed container of the compressor, and a control circuit configured to control the drive circuit, and

the control circuit being configured to stop operation of the drive circuit during a state where an abnormality of at least one of the compressor or the drive circuit has been detected based on the state detected by the state detection circuit and the internal temperature measured by the temperature measurement circuit has exceeded a predetermined temperature.

2. The refrigeration cycle device according to claim 1, wherein the control circuit is configured to:

in response to detection of the abnormality, stop the operation of the drive circuit; subsequent to stop of the operation of the drive circuit, determine whether or not the internal temperature measured by the temperature measurement circuit exceeds the predetermined temperature; and when the internal temperature measured by the temperature measurement circuit exceeds the predetermined temperature, continues the stop

- of the operation of the drive circuit, and when the internal temperature measured by the temperature measurement circuit is equal to or lower than the predetermined temperature, restart the operation of the drive circuit. 5
3. The refrigeration cycle device according to claim 2, wherein the control circuit is configured to:
- count a number of times of detection of the abnormality; and 10
- when the number of times of detection exceeds a predetermined number of times corresponding to the abnormality, stop the operation of the drive circuit. 15
4. The refrigeration cycle device according to any one of claims 1 to 3, wherein:
- the state includes a current value of a current flowing through the drive circuit; 20
- the abnormality includes an electric abnormality of the drive circuit; and
- the control circuit is configured to detect the electric abnormality in response to a situation where the current value of the current flowing through the drive circuit detected by the state detection circuit exceeds a predetermined current value. 25
5. The refrigeration cycle device according to any one of claims 1 to 4, wherein:
- the state includes at least one of a phase current of the compressor or a rotational frequency of the electric motor of the compressor; 30
- the abnormality includes an abnormality relating to layer short of the compressor; and
- the control circuit is configured to detect the abnormality relating to the layer short of the compressor in response to at least one of imbalance of the phase current of the compressor or a deviation of the rotational frequency of the electric motor of the compressor. 35
6. The refrigeration cycle device according to any one of claims 1 to 5, wherein the predetermined temperature is lower than a safety temperature of the working medium and is lower than a heatproof temperature of the electric motor of the compressor. 40
7. The refrigeration cycle device according to any one of claims 1 to 6, wherein 45
- the ethylene-based fluoroolefin contains ethylene-based fluoroolefin likely to undergo a disproportionation reaction. 50
8. The refrigeration cycle device according to any one of claims 1 to 7, wherein 55
- the ethylene-based fluoroolefin is 1,1,2-trifluoroethylene, trans-1,2-difluoroethylene, cis-1,2-difluoroethylene, 1,1-difluoroethylene, tetrafluoroethylene, or monofluoroethylene.
9. The refrigeration cycle device according to any one of claims 1 to 8, wherein the working medium contains difluoromethane as the refrigerant component.
10. The refrigeration cycle device according to any one of claims 1 to 9, wherein the working medium further contains a saturated hydrocarbon.
11. The refrigeration cycle device according to any one of claims 1 to 10, wherein the working medium contains a haloalkane with 1 or 2 carbon atoms as a disproportionation inhibitor for suppressing a disproportionation reaction of the ethylene-based fluoroolefin.
12. The refrigeration cycle device according to claim 10, wherein the saturated hydrocarbon contains n-propane.

Fig. 1

1

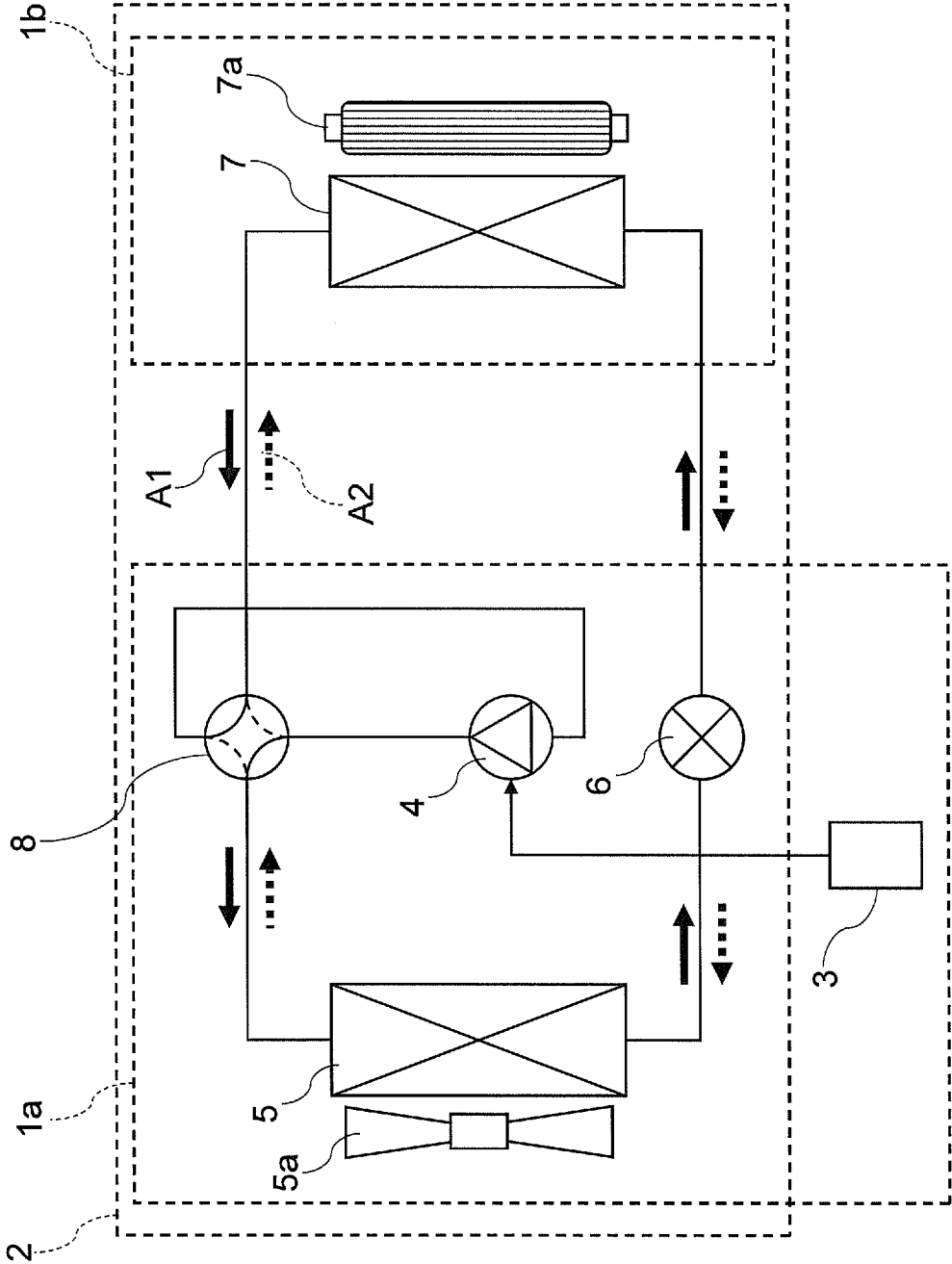


Fig. 2

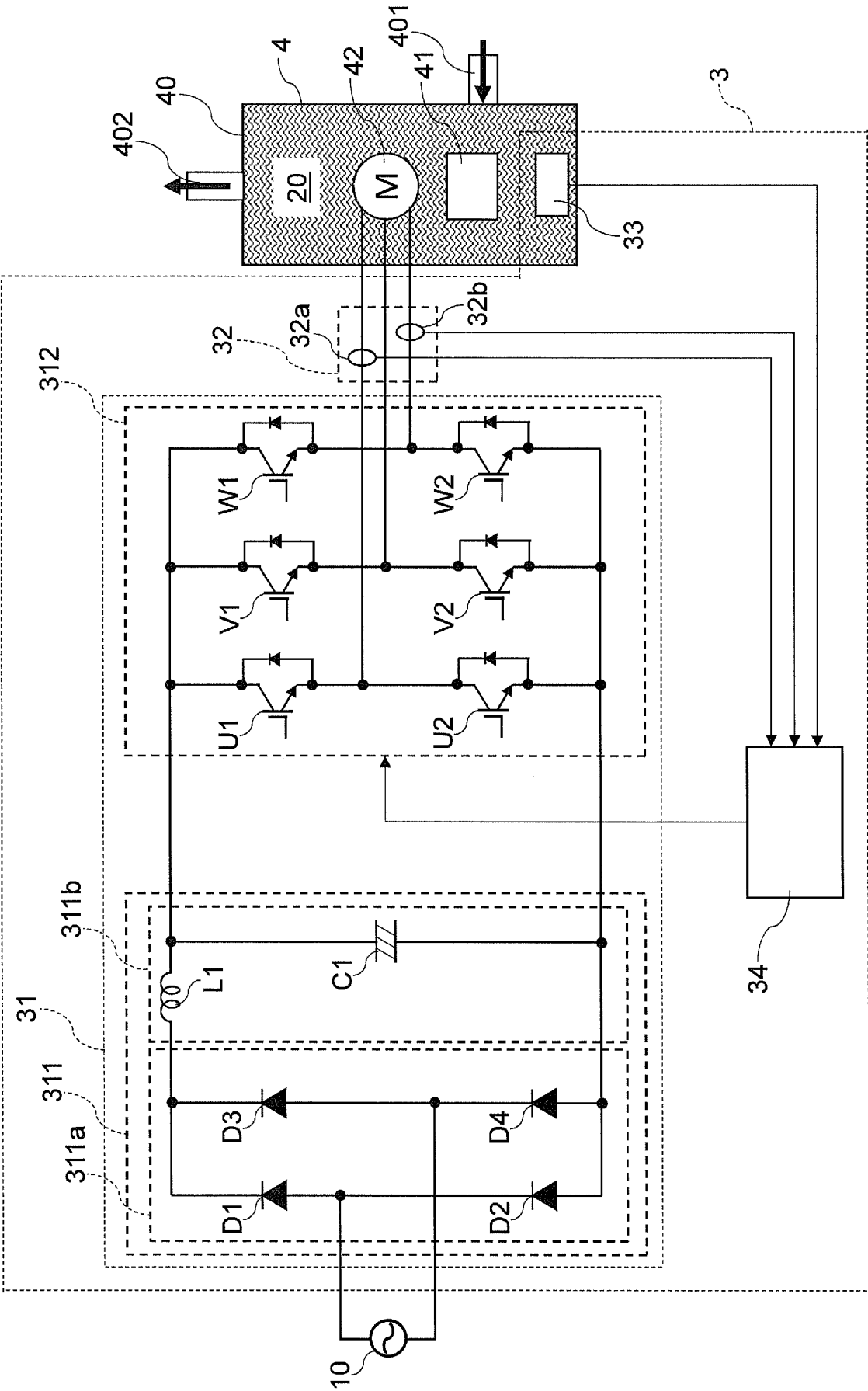


Fig. 3

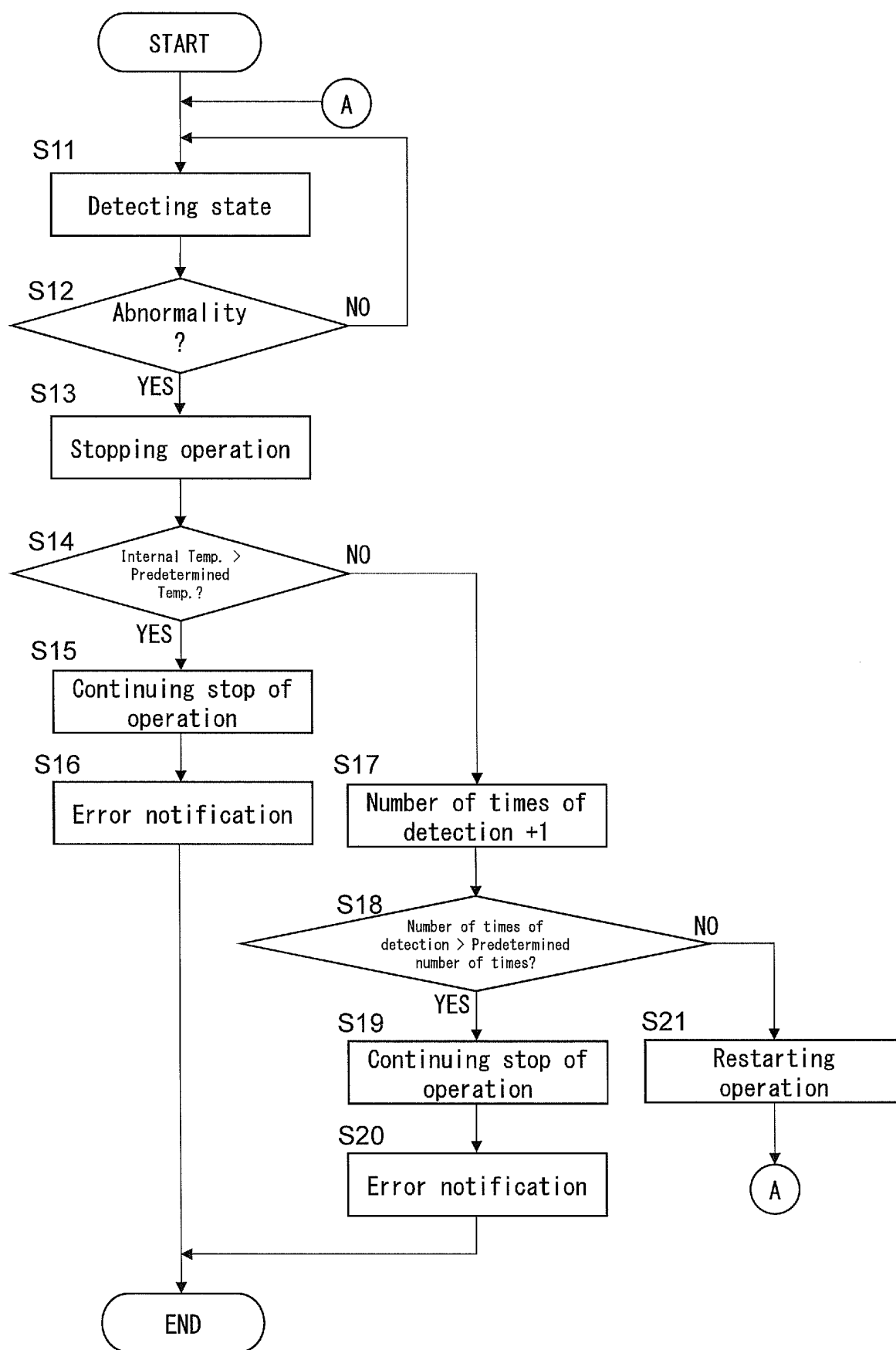


Fig. 4

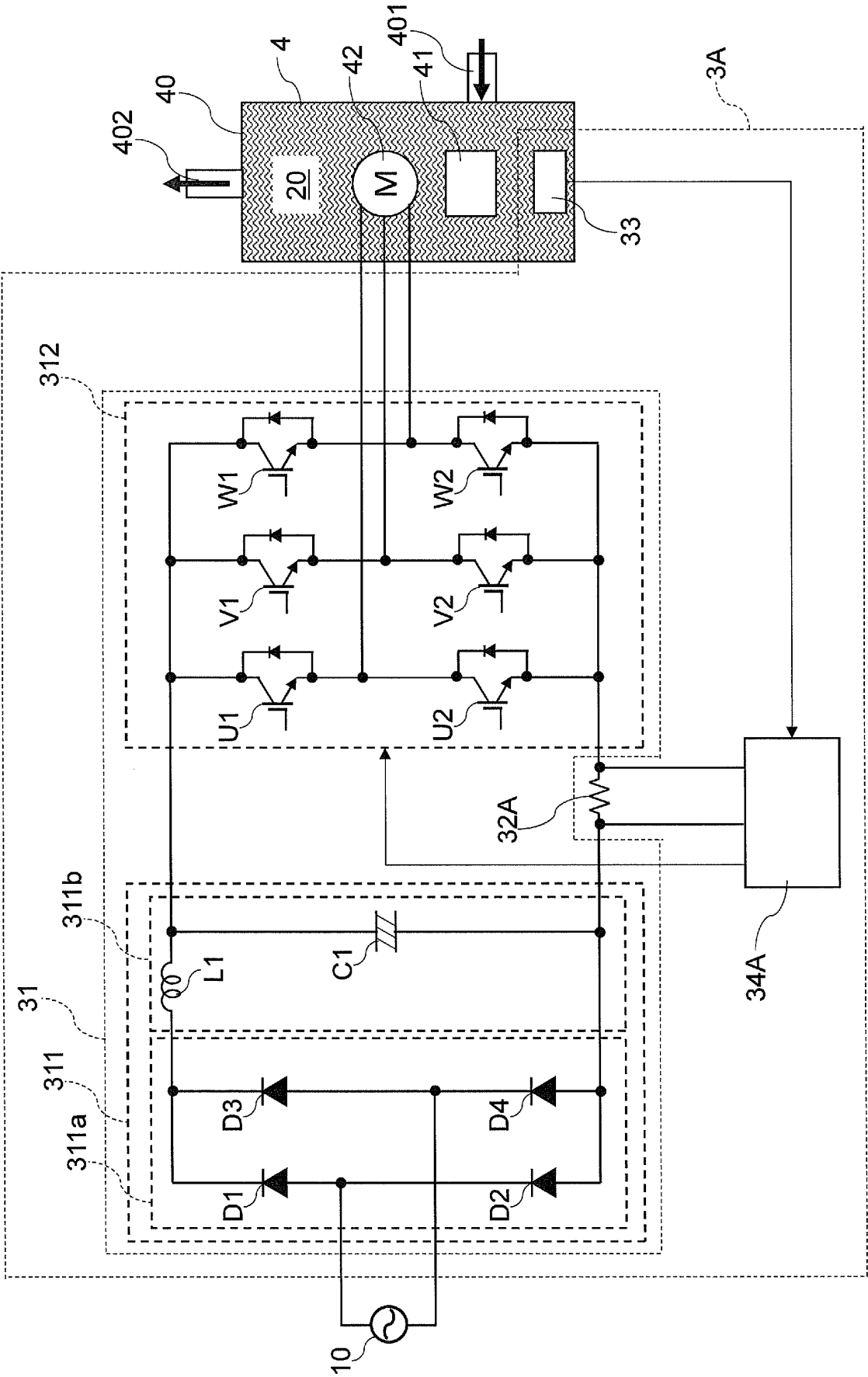


Fig. 5

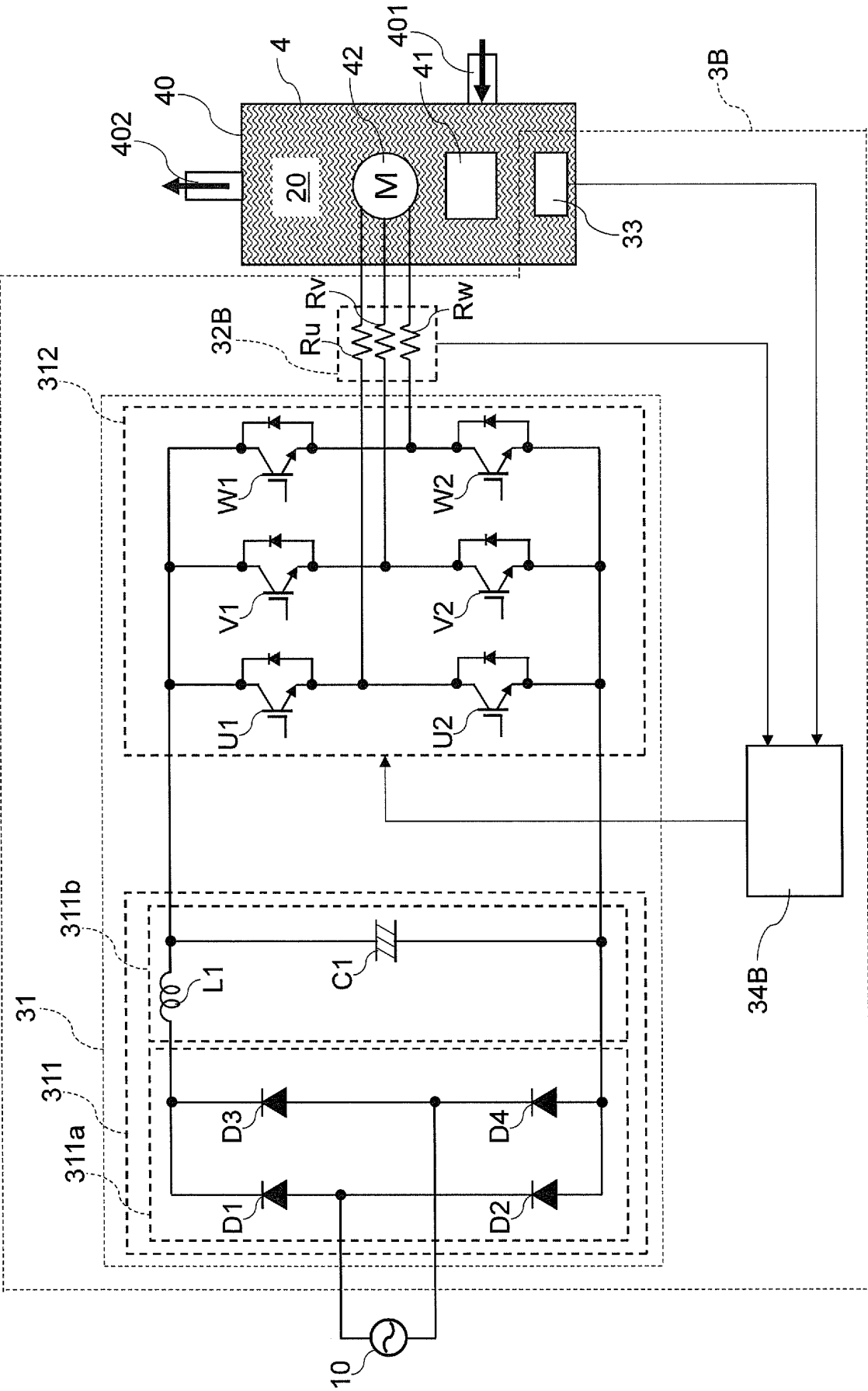
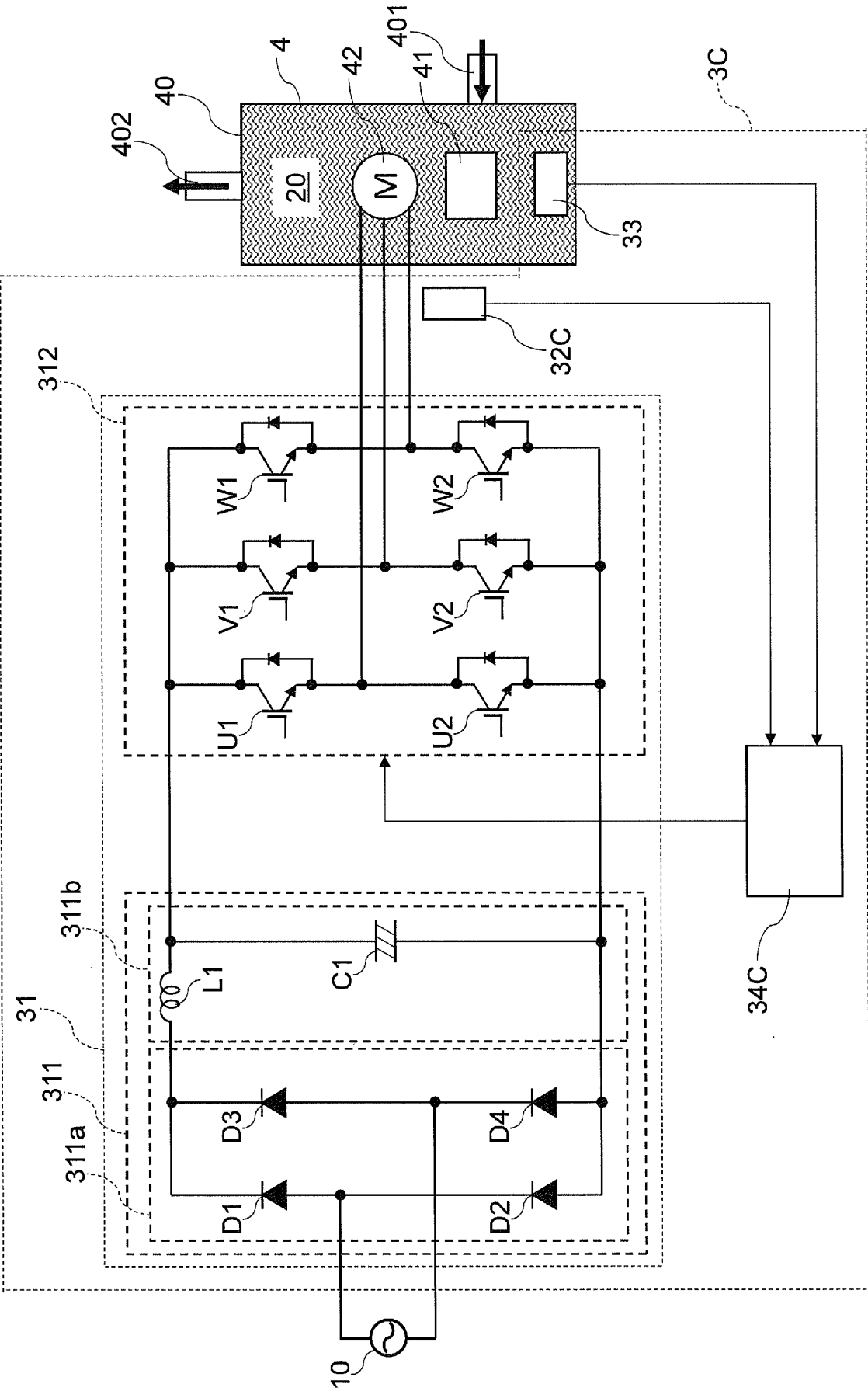


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/015491

A. CLASSIFICATION OF SUBJECT MATTER

F25B 49/02(2006.01)i; **F25B 1/00**(2006.01)i; **F25B 31/02**(2006.01)i
 FI: F25B49/02 570A; F25B1/00 396U; F25B1/00 396Z; F25B31/02 Z

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)

F25B49/02; F25B1/00; F25B31/02

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

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2023
 Registered utility model specifications of Japan 1996-2023
 Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2019-32108 A (PANASONIC IP MAN CORP) 28 February 2019 (2019-02-28) paragraphs [0051]-[0085], fig. 2	1-12
Y	JP 2019-19984 A (FUJITSU GENERAL LTD) 07 February 2019 (2019-02-07) paragraphs [0032]-[0037]	1-12
Y	JP 2019-194310 A (DAIKIN IND LTD) 07 November 2019 (2019-11-07) paragraph [0010]	1-12
Y	JP 2021-166568 A (HOSHIZAKI CORP) 21 October 2021 (2021-10-21) paragraphs [0058]-[0059]	2-12
Y	WO 2020/035993 A1 (MITSUBISHI HEAVY IND THERMAL SYSTEMS LTD) 20 February 2020 (2020-02-20) paragraphs [0047]-[0049]	4-12
Y	JP 2018-177969 A (PANASONIC IP MAN CORP) 15 November 2018 (2018-11-15) paragraph [0010]	5-12

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"&" document member of the same patent family

Date of the actual completion of the international search

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Date of mailing of the international search report

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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.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/015491

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2022-44019 A (DAIKIN IND LTD) 16 March 2022 (2022-03-16) paragraph [0023]	8-12
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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JP 2019-19984 A	07 February 2019	(Family: none)	
JP 2019-194310 A	07 November 2019	US 2021/0079279 A1 paragraph [0010] CN 112004909 A paragraph [0013]	
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JP 2018-177969 A	15 November 2018	(Family: none)	
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REFERENCES CITED IN THE DESCRIPTION

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