



## Description

### Technical Field

**[0001]** The present invention relates to a refrigeration device and a refrigeration system.

**[0002]** Priority is claimed on Japanese Patent Application No. 2016-213257, filed October 31, 2016, the content of which is incorporated herein by reference.

### Background Art

**[0003]** For example, in stores or the like, a plurality of refrigerating and freezing devices, such as a refrigerator, a freezer, and a showcase, which store or display goods, such as food and a drink, in a refrigerated state or frozen state, are used. The plurality of refrigerating and freezing devices receive supply of a low-temperature low-pressure liquid refrigerant from a separately provided condensing unit. Each refrigerating and freezing device cools goods by supplying the liquid refrigerant to an internal heat exchanger.

**[0004]** The condensing unit is a so-called refrigeration device. The condensing unit includes a compressor, a cooler (gas cooler), an expansion valve, and a receiver (gas-liquid separator). In the condensing unit, the refrigerant warmed by the external refrigerating and freezing device is compressed by the compressor. The compressed refrigerant is expanded in the expansion valve and turned into a low-pressure low-temperature refrigerant after being cooled in the cooler. The refrigerant brought into a gas-liquid two-phase state through the expansion valve is separated into a gaseous phase (gas refrigerant) and a liquid phase (liquid refrigerant) by the receiver. The separated liquid refrigerant is supplied to the external refrigerating and freezing device. On the other hand, the separated gas refrigerant is sent into the compressor and compressed again.

**[0005]** In the refrigerating and freezing device to which the liquid refrigerant is supplied from the condensing unit, the control of adjusting a cooling temperature at which goods are actually cooled is individually performed in accordance with a set temperature. For this reason, the refrigerating and freezing device includes an adjusting valve that adjusts the amount of the refrigerant to be supplied to each heat exchanger, and a controller that controls an opening degree of the adjusting valve. In the refrigerating and freezing device, when the cooling temperature reaches the set temperature, the adjusting valve is closed by the controller to reduce the amount of supply of the refrigerant to the heat exchanger.

**[0006]** As such a condensing unit, PTL 1 discloses a refrigeration device including a throttle mechanism (expansion valve) on a heat source side (condensing unit side) and a throttle mechanism (expansion valve) on a use side (refrigerating and freezing device side) so as to expand the refrigerant in two steps. The refrigeration device sets a target value (hereinafter referred to as a target

high-pressure value) of a high-pressure refrigerant pressure to be discharged from the compressor on the basis of outside-air temperature and refrigerant temperature. In the refrigeration device, the throttling amount of each throttle mechanism (the opening degree of the expansion valve) is adjusted such that the high-pressure refrigerant pressure becomes the target high-pressure value.

### Citation List

#### Patent Literature

**[0007]** [PTL 1] Japanese Unexamined Patent Application Publication No. 2007-263383

### Summary of Invention

#### Technical Problem

**[0008]** Meanwhile, the target high-pressure value fluctuates in accordance with the outside-air temperature. Specifically, the target high-pressure value becomes low if the outside-air temperature is low, and conversely, becomes high if the outside-air temperature is high. If the refrigeration capacity load from the refrigerating and freezing device side is large in a case where the outside-air temperature is low, the high-pressure refrigerant pressure may exceed target high pressure. As a result, the opening degree of the expansion valve on the condensing unit side becomes large, and the pressure on a downstream side of the expansion valve becomes high. In a case where the expansion valve is brought into a fully-opened state in this way, pressure resistance design is required for a member provided on the downstream side of the expansion valve, for example, an injection circuit that sends a gas refrigerant from the receiver into the compressor, a pipe that connects refrigerating and freezing devices to each other, or the like, and this leads to a cost rise.

**[0009]** Additionally, if the refrigeration capacity load from the refrigerating and freezing device side is low in a case where the outside-air temperature is high, the high-pressure refrigerant pressure may fall below the target high-pressure. As a result, the opening degree of the expansion valve on the condensing unit becomes small, and the liquid refrigerant to be supplied from the condensing unit to the refrigerating and freezing device side decreases. In a case where the expansion valve is brought into the fully-closed state in this way, there is a possibility that the refrigerant may be insufficient on the refrigerating and freezing device side.

**[0010]** The invention provides a refrigeration device and a refrigeration system capable of making it difficult for an expansion valve to be brought into a fully-opened state or a fully-closed state.

## Solution to Problem

**[0011]** A refrigeration device related to a first aspect of the invention includes a compressor that compresses a refrigerant; a heat exchanger that condenses the refrigerant compressed in the compressor; an expansion valve that expands the refrigerant condensed in the heat exchanger; and a controller that adjusts an opening degree of the expansion valve such that a pressure of the refrigerant compressed in the compressor approaches a target high-pressure value set on the basis of an outside-air temperature, and that corrects the target high-pressure value in a case where the opening degree of the expansion valve exceeds a preset opening degree upper limit value or opening degree lower limit value.

**[0012]** According to such a configuration, by correcting the target high-pressure value, the opening degree of the expansion valve changes to an opening degree according to the corrected target high-pressure value. Specifically, by making a difference between the target high-pressure value and the pressure of the refrigerant compressed in the compressor small, the amount of adjustment of the opening degree of the expansion valve changes. Hence, by correcting the target high-pressure value, in a case where the opening degree of the expansion valve exceeds the opening degree upper limit value or the opening degree lower limit value, it is possible to suppress that the opening degree of the expansion valve changes greatly.

**[0013]** Additionally, in the refrigeration device related to a second aspect of the invention based on the first aspect, the controller may correct the target high-pressure value to be increased in a case where the opening degree of the expansion valve exceeds the opening degree upper limit value.

**[0014]** By adopting such a configuration, in a case where the opening degree of the expansion valve is large, the target high-pressure value can be increased and approach the pressure of the refrigerant compressed in the compressor. As a result, the difference between the target high-pressure value and the pressure of the refrigerant compressed in the compressor becomes relatively small, and the amount of adjustment of the opening degree of the expansion valve becomes small. Accordingly, the opening degree of the expansion valve is not easily brought into the fully-opened state after the opening degree thereof exceeds the opening degree upper limit value.

**[0015]** Additionally, in the refrigeration device related to a third aspect of the invention based on the first aspect or the second aspect, the controller may correct the target high-pressure value to be decreased in a case where the opening degree of the expansion valve exceeds the opening degree lower limit value.

**[0016]** By adopting such a configuration, in a case where the opening degree of the expansion valve is small, the target high-pressure value can be decreased and approach the pressure of the refrigerant compressed

in the compressor. As a result, the difference between the target high-pressure value and the pressure of the refrigerant compressed in the compressor becomes relatively small, and the amount of adjustment of the opening degree of the expansion valve becomes small. Accordingly, the opening degree of the expansion valve is not easily brought into the fully-closed state after the opening degree thereof falls below the opening degree lower limit value.

**[0017]** Additionally, in the refrigeration device related to a fourth aspect of the invention based on any one of the first aspect to the third aspect, the controller may repeatedly correct the target high-pressure value multiple times to be increased or decreased in a preset predetermined percentage multiple times.

**[0018]** By adopting such a configuration, by repeatedly correcting the target high-pressure value to be increased or decreased, the difference between the target high-pressure value and the pressure of the refrigerant compressed in the compressor becomes gradually small. As a result, the opening degree of the expansion valve is gradually adjusted, and the amount of adjustment at a time becomes small. This can prevent the opening degree of the expansion valve from being brought into the fully-opened state or the fully-closed state with high accuracy.

**[0019]** Additionally, in the refrigeration device related to a fifth aspect of the invention based on any one of the first aspect to the fourth aspect, the compressor may include a first-stage compression section and a second-stage compression section, a receiver that separates the refrigerant condensed in the expansion valve into a gas refrigerant and a liquid refrigerant, and an injection circuit that sends the gas refrigerant separated in the receiver into the second-stage compression section of the compressor.

**[0020]** In such a configuration, by making it difficult for the opening degree of the expansion valve to be brought into the fully-opened state, the pressure of a medium-pressure gas refrigerant to be sent into the compressor through the injection circuit can be suppressed. Accordingly, the pressure resistance performance required for a member through which the refrigerant flow is suppressed, and a cost rise can be suppressed.

**[0021]** Additionally, in the refrigeration device related to a sixth aspect of the invention based on any one of the first aspect to the fifth aspect, the refrigerant may be carbon dioxide.

**[0022]** Additionally, a refrigeration system related to a seventh aspect of the invention includes the refrigeration device of any one of the first aspect to the sixth aspect; and a loading apparatus that is connected to the refrigeration device and has a heat exchanger of the loading apparatus that exchanges heat with the refrigerant to be supplied from the refrigeration device.

**[0023]** Additionally, in the refrigeration system related to an eighth aspect of the invention based on the seventh aspect, the loading apparatus may further include a ex-

pansion valve of the loading apparatus that expands the refrigerant to be supplied from the refrigeration device.

**[0024]** By adopting such a configuration, the expansion valve on the refrigeration device side is not easily brought into the fully-opened state or the fully-closed state, and an expansion process is reliably performed even in the expansion valve of the loading apparatus. For that reason, it is possible to realize an efficient refrigeration cycle by expanding the refrigerant in two steps in the expansion valve on the refrigeration device side and the expansion valve of the loading apparatus.

**[0025]** Additionally, in the refrigeration system related to a ninth aspect of the invention based on the seventh aspect or the eighth aspect, a plurality of the loading apparatuses may be connected to the refrigeration device.

#### Advantageous Effects of Invention

**[0026]** According to the invention, by making it difficult for the expansion valve to be brought into the fully-opened state or fully-closed state, a cost rise and shortage of the amount of supply of the liquid refrigerant can be suppressed, and it is possible to enhance refrigeration cycle efficiency.

#### Brief Description of Drawings

##### **[0027]**

Fig. 1 is a schematic view illustrating the configuration of a refrigeration system and a refrigeration device related to an embodiment of the invention.

Fig. 2 is a view illustrating a circuit configuration of the above refrigeration device.

Fig. 3 is a flowchart illustrating a flow of target high-pressure value correction control performed in accordance with the opening degree of an expansion valve in the above refrigeration device.

Fig. 4 is a view illustrating an example of changes in the target high-pressure value and changes in the opening degree of an electronic expansion valve in a case where the target high-pressure value correction control is executed and in a case where the same correction control is not executed, in an actual condensing unit.

#### Description of Embodiments

**[0028]** Hereinafter, embodiments for carrying out a refrigeration device and a refrigeration system according to the invention will be described with reference to the accompanying drawings. However, the invention is not limited only to these embodiments.

**[0029]** As illustrated in Fig. 1, a refrigeration system 1 of the present embodiment includes a plurality (three in the present embodiment) loading apparatuses 2, and a condensing unit (refrigeration device) 3. In the present embodiment, the refrigeration system uses CO<sub>2</sub> (carbon

dioxide) 1 as a refrigerant.

**[0030]** Each loading apparatus 2 is a refrigerating and freezing device, such as a refrigerator or a freezer, which cools or refrigerates and store goods and a showcase that cools or refrigerates and displays goods. The loading apparatus 2 receives supply of a liquid refrigerant RL from the condensing unit 3. The loading apparatus 2 includes a heat exchanger 21 of the loading apparatus, a control valve (expansion valve of the loading apparatus) 22, a controller of the loading apparatus 23, and a temperature sensor 24.

**[0031]** The heat exchanger 21 of the loading apparatus exchanges heat with the liquid refrigerant RL supplied from the condensing unit 3, thereby cooling goods. The heat exchanger 21 of the loading apparatus returns the refrigerant after the heat exchange to the condensing unit 3.

**[0032]** The control valve 22 adjusts the flow rate of the liquid refrigerant RL supplied from the condensing unit 3, thereby adjusting the cooling temperature of goods.

**[0033]** On the basis of a set temperature set from the outside and a cooling temperature which is detected by the temperature sensor 24 and at which goods are actually cooled, the controller of the loading apparatus 23 adjusts the opening degree of the control valve 22 such that the internal cooling temperature approaches the set temperature.

**[0034]** As illustrated in Fig. 2, the condensing unit 3 mainly includes a compressor 31, a gas cooler (heat exchanger) 32, an electronic expansion valve (expansion valve) 33, a receiver 34, an injection circuit 38, an oil separator 39, a low-pressure sensor 40, a high-pressure sensor 41, an outside-air temperature sensor 43, and a controller 100. The compressor 31, the gas cooler 32, the electronic expansion valve 33, the receiver 34, and the oil separator 39 are coupled to each other by a refrigerant pipe 300.

**[0035]** The compressor 31 compresses the refrigerant supplied via an accumulator 35 by a suction pipe 302 from the loading apparatus 2. The compressor 31 discharges a high-pressure high-temperature refrigerant. In the present embodiment, CO<sub>2</sub> having a larger compression ratio than fluorocarbon or the like is used as the refrigerant. The compressor 31 is a two-stage compressor having a first-stage compression section 31a, and a second-stage compression section 31b. The compressor 31 has a temperature sensor 37 that detects the temperature of the refrigerant liquid and oil in the first-stage compression section 31a of the compressor 31.

**[0036]** The high-pressure high-temperature refrigerant is supplied to the gas cooler 32 via the oil separator 39 after being discharged from the compressor 31. The gas cooler 32 exchanges heat with the supplied high-pressure high-temperature refrigerant and the air sent by a blower (not illustrated), and condenses the refrigerant. In the present embodiment, a plurality of (two in the present embodiment) the gas coolers 32 are provided in parallel. The oil separator 39 recovered the lubricant oil

included in the refrigerant, respectively, and returns the lubricant oil to the compressor 31.

**[0037]** The electronic expansion valve 33 expands the refrigerant condensed in each gas cooler 32, and produces a low-pressure low-temperature refrigerant. The refrigerant expanded in the electronic expansion valve 33 is brought into a gas-liquid two-phase state.

**[0038]** The receiver 34 separates the refrigerant in the gas-liquid two-phase state expanded in the electronic expansion valve 33 into a gas refrigerant RG that is a gaseous-phase refrigerant, and a liquid refrigerant RL that is a liquid-phase refrigerant. In the present embodiment, a plurality of (two in the present embodiment) the receivers 34 are provided in parallel. Each receiver 34 has a tank 341 that contains the refrigerant in the gas-liquid phase state. A liquid sending pipe 301 and the injection circuit 38 are connected to the tank 341. The liquid refrigerant RL separated within the tank 341 is supplied to each external loading apparatus 2 through the liquid sending pipe 301.

**[0039]** Additionally, the gas refrigerant RG separated within the tank 341 of the receiver 34 is suctioned into the compressor 31 via the injection circuit 38. In the present embodiment, the injection circuit 38 is connected to the second-stage compression section 31b of the compressor 31. The injection circuit 38 supplies the gas refrigerant RG within the tanks 341 to the second-stage compression section 31b.

**[0040]** The injection circuit 38 is provided with an electromagnetic valve 36. The opening degree of the electromagnetic valve 36 is adjusted in accordance with the temperature of the refrigerant liquid and the oil detected in the temperature sensor 37, by the control of the controller 100. By opening and closing the electromagnetic valve 36, the flow rate of the gas refrigerant RG from the receiver 34 is adjusted.

**[0041]** The low-pressure sensor 40 measures the value (low-pressure value) of the pressure of a low-pressure refrigerant to be supplied to the compressor 31 via the loading apparatus 2. The low-pressure sensor 40 outputs the measurement result to the controller.

**[0042]** The high-pressure sensor 41 measures the value (high-pressure value) of the pressure of a high-pressure refrigerant discharged from the compressor 31. The high-pressure sensor 41 outputs the measurement result to the controller.

**[0043]** The outside-air temperature sensor 43 measures an outside-air temperature around the condensing unit 3. The outside-air temperature sensor 43 outputs the measurement result to the controller.

**[0044]** The controller 100 controls the operation ON/OFF and the rotation speed of the compressor 31, and the opening degree of the electronic expansion valve 33. The controller 100 of the present embodiment controls the opening degree of the electronic expansion valve 33 on the basis of the outside-air temperature, the low-pressure value, and the high-pressure value.

**[0045]** Hereinafter, the control contents of the control-

ler 100 will be described in detail. The controller 100 starts the compressor 31 if the condensing unit 3 is started. The controller 100 operates the compressor 31 between a predetermined upper limit rotation speed and a predetermined lower limit rotation speed.

**[0046]** Additionally, the controller 100 sets a target high-pressure value HP as a target value of the pressure of the high-pressure refrigerant to be discharged from the compressor 31, on the basis of the outside-air temperature detected by the outside-air temperature sensor 43. The controller 100 adjusts the opening degree of the electronic expansion valve 33, on the basis of the set target high-pressure value HP, and a high-pressure refrigerant pressure P that is an actual pressure value of the high-pressure refrigerant detected by the high-pressure sensor 41. The controller 100 adjusts and controls the opening degree of the electronic expansion valve 33 such that the high-pressure refrigerant pressure P approaches the target high-pressure value HP. The controller 100 corrects the target high-pressure value HP in a case where a preset opening degree upper limit value or a preset opening degree lower limit value is exceeded. The controller 100 repeatedly corrects the target high-pressure value HP multiple times while increasing or decreasing the target high-pressure value HP in a preset predetermined percentage.

**[0047]** Here, the target high-pressure value HP is a value determined depending on the outside-air temperature of the condensing unit 3. The target high-pressure value HP becomes larger the outside-air temperature becomes higher and becomes smaller as the outside-air temperature becomes lower. For example, in the condensing unit 3 of the present embodiment, the target high-pressure value HP falls within a range of 4 (Mpa·G) to 6 (Mpa·G) in a case where the outside-air temperature is 0°C or lower. Additionally, the target high-pressure value HP falls within a range of 6 (Mpa·G) to 8 (Mpa·G) in a case where the outside-air temperature is 0°C or higher and 30°C or lower. Additionally, the target high-pressure value HP falls within a range of 8 (Mpa·G) to 12 (Mpa·G) in a case where the outside-air temperature is 30°C or higher.

**[0048]** The controller 100 of the present embodiment adjusts the opening degree of the electronic expansion valve 33 through a PI control based on a deviation between the target high-pressure value HP and the high-pressure refrigerant pressure P.

**[0049]** In addition, it is preferable that the controller 100 performs the PI control via a primary delay for 3 seconds in order to reduce the influence of noise on the input of the high-pressure sensor 41.

**[0050]** Additionally, the opening degree range of the electronic expansion valve 33 is set to be within a preset range. In the present embodiment, the opening degree range of the electronic expansion valve 33 is set, for example, as follows:

Maximum opening degree (fully-opened state): 470

pulses

Minimum opening degree (fully-closed state): 10 pulses.

**[0051]** Moreover, the controller 100 performs the opening degree adjustment control of the electronic expansion valves 33 as described above after a certain period of time has elapsed since the operation of the compressor 31 is started and the operation rotation speed of the compressor 31 has reached a rated operation rotation speed. The controller 100 executes the correction control of the target high-pressure value HP in accordance with the opening degree of the electronic expansion valve 33 as illustrated in Fig. 3 at predetermined time intervals.

**[0052]** In the correction control of this target high-pressure value HP, the controller 100 controls the opening degree of the electronic expansion valve 33 such that the opening degree of the electronic expansion valve 33 so as not to be full opened or full closed on the basis of the target high-pressure value HP, and the high-pressure refrigerant pressure P of the refrigerant detected by the high-pressure sensor 41. For this reason, the opening degree upper limit value and the opening degree lower limit value of the electronic expansion valve 33 are set in advance by controller 100. In the present embodiment, the opening degree upper limit value of the electronic expansion valve 33 is set to 70% to 90% of the maximum opening degree. The opening degree lower limit value of the electronic expansion valve 33 is set to 5% to 20% of the maximum opening degree. Specifically, the opening degree upper limit value of the electronic expansion valve 33 of the present embodiment is set to, for example, 400 pulses, and the opening degree lower limit value is set to, for example, 80 pulses.

**[0053]** As illustrated in Fig. 3, in a case where the correction control is performed, first, the controller 100 sets the target high-pressure value HP on the basis of the outside-air temperature detected in the outside-air temperature sensor 43 (Step S101).

**[0054]** After the setting of the target high-pressure value HP, the controller 100 determines whether or not the opening degree of the electronic expansion valve 33 is equal to or more than the opening degree upper limit value (Step S102). The controller 100 determines whether or not the opening degree of the electronic expansion valve 33 is equal to or less than the opening degree lower limit value in a case where it is determined that the opening degree of the electronic expansion valve 33 is equal to or less than the opening degree upper limit value (Step S106). The controller 100 repeats the processing of Step S101, Step S102, and Step S106 at predetermined time intervals in a case where it is determined that the opening degree of the electronic expansion valve 33 is not equal to or less than the opening degree lower limit value.

**[0055]** The controller 100 maintains the opening degree of the electronic expansion valve 33 until a preset standby time has elapsed in a case where it is determined that the opening degree of the electronic expansion valve

33 is equal to or more than the opening degree upper limit value in Step S102 (Step S103). Here, the standby time is the time that is required until the value of the high-pressure refrigerant pressure P is stabilized after the opening degree of the electronic expansion valve 33 is maintained. Specifically, the standby time may be about 1 minute to 10 minutes, and preferably about 5 minutes.

**[0056]** After the standby time has elapsed, the controller 100 corrects the target high-pressure value HP set in Step S101 so as to increase the target high-pressure value HP (Step S104). Specifically, a pressure addition value that is the predetermined percentage is added to the target high-pressure value HP set in Step S101. In addition, the pressure addition value is an increased percentage when a correction determined in accordance with the target high-pressure value HP is performed. The pressure addition value of the present embodiment is, for example, 0.1 (MPa-G). In Step S104, the target high-pressure value HP is corrected so as to increase by the pressure addition value.

**[0057]** The controller 100 corrects the target high-pressure value HP in this way, and then, determines whether or not the target high-pressure value HP before the correction varies as the outside-air temperature detected in the outside-air temperature sensor 43 varies. Specifically, the controller 100 determines whether or not a measurement value input from the outside-air temperature sensor 43 varies (Step S105).

**[0058]** In a case where it is determined in Step S105 that the outside-air temperature varies, the controller 100 ends a series of correction processing. The controller 100 continues the opening degree control of an ordinary electronic expansion valve 33 that brings the high-pressure refrigerant pressure P close to the target high-pressure value HP.

**[0059]** Additionally, in a case where it is determined in Step S105 that the outside-air temperature does not vary, the controller 100 returned to Step S103 where the opening degree of the electronic expansion valve 33 is maintained until the preset standby time elapses. The controller 100 repeats Step S103 to Steps S105 multiple times, thereby gradually increasing the target high-pressure value (HP) multiple times by every pressure addition value.

**[0060]** The processing of increasing and correcting the target high-pressure value HP as in Step S103 and Step S104 can be repeated up to a predetermined number of times, for example, 5 times. In a case where the predetermined number of times has been reached, the controller 100 ends the processing of increasing and correcting the target high-pressure value HP regardless of a change situation of the outside-air temperature. Thereafter, the controller 100 continues the opening degree control of the ordinary electronic expansion valve 33 that brings the high-pressure refrigerant pressure P close to the target high-pressure value HP.

**[0061]** Additionally, the controller 100 maintains the opening degree of the electronic expansion valve 33 until

the preset standby time has elapsed in a case where it is determined that the opening degree of the electronic expansion valve 33 is equal to or less than the opening degree lower limit value in Step S106 (Step S107).

**[0062]** After the standby time has elapsed, the controller 100 corrects the target high-pressure value HP set in Step S101 so as to decrease the target high-pressure value HP (Step S108). For this, a pressure subtraction value that is a predetermined percentage is subtracted from the target high-pressure value HP set in Step S101. In addition, the pressure subtraction value is a decreased percentage when a correction determined in accordance with the target high-pressure value HP is performed. The pressure subtraction value of the present embodiment is, for example, 0.1 (MPa·G). Accordingly, the target high-pressure value HP is corrected so as to decrease by a pressure subtraction value.

**[0063]** The controller 100 corrects the target high-pressure value HP in this way, and then, determines whether or not the target high-pressure value HP before the correction varies as the outside-air temperature detected in the outside-air temperature sensor 43 varies. Specifically, the controller 100 determines whether or not a measurement value input from the outside-air temperature sensor 43 varies (Step S109).

**[0064]** In a case where it is determined in Step S109 that the outside-air temperature varies, the controller 100 ends a series of correction processing. The controller 100 continues the opening degree control of the ordinary electronic expansion valve 33 that brings the high-pressure refrigerant pressure P close to the target high-pressure value HP.

**[0065]** Additionally, in a case where it is determined in Step S109 that the outside-air temperature does not vary, the controller 100 returned to Step S107 where the opening degree of the electronic expansion valve 33 is maintained until the preset standby time elapses. The controller 100 repeats Step S107 to Steps S109 multiple times, thereby gradually decreasing the target high-pressure value (HP) multiple times by every pressure subtraction value.

**[0066]** The processing in which the target high-pressure value HP is corrected so as to be decreased as in Step S107 and Step S108 can be repeated up to a predetermined number of times, for example, 5 times. In a case where the predetermined number of times has been reached, the controller 100 ends the processing of decreasing and correcting the target high-pressure value HP regardless of a change situation of the outside-air temperature. Thereafter, the controller 100 continues the opening degree control of the ordinary electronic expansion valve 33 that brings the high-pressure refrigerant pressure P close to the target high-pressure value HP.

**[0067]** The following actions are obtained by repeatedly executing the processing of Steps S101 to S109 as described above at every predetermined time during the operation of the compressor 31 in the controller 100. For example, in a case where the outside-air temperature is

low, the target high-pressure value HP becomes low. On the other hand, if the refrigeration capacity load on the loading apparatus 2 side is large, the high-pressure refrigerant pressure P that is the pressure of the refrigerant discharged from the compressor 31 becomes high. For that reason, in a case where the outside-air temperature is low, the high-pressure refrigerant pressure P may exceed the target high-pressure value HP. In such a state, the opening degree of the electronic expansion valve 33 may be brought into the fully-opened state beyond the opening degree upper limit value by the opening degree of the electronic expansion valve 33 being adjusted by the controller 100. However, when the opening degree of the electronic expansion valve 33 approaches the fully-opened state beyond the opening degree upper limit value by the correction processing of increasing the target high-pressure value HP as described above being executed by the controller 100, the target high-pressure value HP is increased. For that reason, the target high-pressure value HP is corrected so as to approach the high-pressure refrigerant pressure P. If the difference between the target high-pressure value HP and the high-pressure refrigerant pressure P becomes small by such correction, the percentage of the opening degree of the electronic expansion valve 33 enlarged by the controller 100 become small, and the electronic expansion valve 33 is not easily brought into the fully-opened state.

**[0068]** Additionally, for example, in a case where the outside-air temperature is high, the target high-pressure value HP becomes high. On the other hand, if the refrigeration capacity load on the loading apparatus 2 side is small, the high-pressure refrigerant pressure P becomes low. For that reason, in a case where the outside-air temperature is high, the high-pressure refrigerant pressure P may fall below the target high-pressure value HP. In such the state, by the opening degree of the electronic expansion valve 33 being adjusted by the controller 100, the opening degree of the electronic expansion valve 33 may become equal to or less than the opening degree lower limit value and the electronic expansion valve 33 may be brought into the fully-closed state. However, when the opening degree of the electronic expansion valve 33 falls below the opening degree lower limit value and approaches the fully-closed state by the correction processing of decreasing the target high-pressure value HP as described above being executed by the controller 100, the target high-pressure value HP is decreased. For that reason, the target high-pressure value HP is corrected so as to approach the high-pressure refrigerant pressure P. By such correction, the opening degree of the electronic expansion valve 33 becomes large. Accordingly, if the difference between the target high-pressure value HP and the high-pressure refrigerant pressure P becomes small, the percentage of the opening degree of the electronic expansion valve 33 decreased by the controller 100 become small, and the electronic expansion valve 33 is not easily brought into the fully-closed state.

**[0069]** A specific example will be described with reference to Fig. 4. Fig. 4 is a view illustrating an example of changes in the target high-pressure value HP and changes in the opening degree of the electronic expansion valve in a case where the correction control of the target high-pressure value HP by the controller 100 as described above is executed and in a case where the correction control is not executed, in the actual condensing unit 3. In addition, Fig. 4 illustrates changes in a state where the high-pressure refrigerant pressure P exceeds the target high-pressure value HP because the outside-air temperature is low and the refrigeration load capacity from the loading apparatus 2 side is large. A two-dot chain line L2 represents the target high-pressure value HP in a case where when no correction is performed. A solid line L12 represents the target high-pressure value HP in a case where the correction of the present embodiment has been performed. A two-dot chain line L3 represents the opening degree of the electronic expansion valve 33 in a case where the correction of the target high-pressure value HP is not performed. A solid L13 represents the opening degree of the electronic expansion valve 33 in a case where the correction of the target high-pressure value HP has been performed.

**[0070]** In a case where the correction control of the target high-pressure value HP according to the opening degree of the electronic expansion valve 33 is not performed, as indicated by the two-dot chain line L2 in Fig. 4, the target high-pressure value HP that is not corrected remains constant as being set in accordance with the outside-air temperature at the beginning. Additionally, as indicated by the two-dot chain line L3 in Fig. 4, as a result of the electronic expansion valve 33 having performed the control of enlarging the opening degree such that the pressure of the refrigerant approaches the target high-pressure value HP in a state where the refrigeration load capacity from the loading apparatus 2 side is large, the opening degree is brought into the fully-opened state.

**[0071]** In contrast, in a case where the correction control of the target high-pressure value HP according to the opening degree of the electronic expansion valve 33 has been performed, as indicated by the solid line L12 in Fig. 4, the target high-pressure value HP is set in accordance with the outside-air temperature at the beginning, and then, increases stepwise as a result of the opening degree of the electronic expansion valve 33 having reached the opening degree upper limit value. Additionally, as indicated by the solid line L13 in Fig. 4, the electronic expansion valve 33 is brought into a constant state before the opening degree reaches the fully-opened state as a result of the target high-pressure value's HP increasing stepwise in a state where the refrigeration load capacity from the loading apparatus 2 side is large.

**[0072]** According to the condensing unit 3 and the refrigeration system 1 as described above, in a case where the opening degree of the electronic expansion valve 33 has exceeded the preset opening degree upper limit value or opening degree lower limit value, the target high-

pressure value HP is corrected so as to approach the high-pressure refrigerant pressure P. By correcting the target high-pressure value HP, the opening degree of the electronic expansion valve 33 changes to an opening degree according to the corrected target high-pressure value HP. Specifically, by making the difference between the target high-pressure value HP and the high-pressure refrigerant pressure P small, the amount of adjustment of the opening degree of the electronic expansion valve 33 becomes small. Hence, by correcting the target high-pressure value HP, in a case where the opening degree of the electronic expansion valve 33 has exceeded then opening degree upper limit value or the opening degree lower limit value, it is possible to suppress that the opening degree changes greatly, and the electronic expansion valve 33 is not easily brought into the fully-opened state or the fully-closed state.

**[0073]** Accordingly, it is possible to make it difficult for the refrigerant with excessively high pressure to flow into a portion where the high-pressure refrigerant discharged from the compressor 31 flows. The pressure resistance performance required for each part is suppressed is suppressed, and a cost rise can be suppressed.

**[0074]** Additionally, by making it difficult for the opening degree of the electronic expansion valve 33 to be brought into the fully-opened state, it is possible to prevent formation of a one-stage throttle configuration in which the electronic expansion valve 33 is brought into the fully-opened state, the refrigerant cannot be sufficiently expanded, and the refrigerant is expanded only by the control valve 22 that is an expansion valve on the loading apparatus 2 side. As a result, it is possible to suppress that the discharge temperature of the refrigerant rises and the refrigeration cycle efficiency decreases. Similarly, by making it difficult for the electronic expansion valve 33 to be brought into the fully-closed state, a throttle region in the control valve 22 becomes large. For that reason, it is possible to suppress that the discharge temperature of the refrigerant rises and the refrigeration cycle efficiency decreases. Accordingly, shortage of the amount of supply of the liquid refrigerant RL can be suppressed, and it is possible to enhance the refrigeration cycle efficiency.

**[0075]** More specifically, in a case where the opening degree of the electronic expansion valve 33 exceeds the opening degree upper limit value, the controller 100 corrects the target high-pressure value HP so as to increase the target high-pressure value HP. For that reason, in a case where the opening degree of the electronic expansion valve 33 is large, the target high-pressure value HP can be increased and approach the high-pressure refrigerant pressure P. As a result, the difference between the target high-pressure value HP and the high-pressure refrigerant pressure P becomes relatively small, and the amount of adjustment of the opening degree of the electronic expansion valve 33 becomes small. Accordingly, the electronic expansion valve 33 is not easily brought into the fully-opened state after the opening degree there-

of exceeds the opening degree upper limit value.

**[0076]** Additionally, in a case where the opening degree of the electronic expansion valve 33 exceeds the opening degree lower limit value, the controller 100 may correct the target high-pressure value HP so as to decrease the target high-pressure value HP. For that reason, in a case where the opening degree of the electronic expansion valve 33 is small, the target high-pressure value HP can be decreased and approach the high-pressure refrigerant pressure P. As a result, the difference between the target high-pressure value HP and the high-pressure refrigerant pressure P becomes relatively small, and the amount of adjustment of the opening degree of the electronic expansion valve 33 becomes small. Accordingly, the electronic expansion valve 33 is not easily brought into the fully-closed state after the opening degree thereof falls below the opening degree lower limit value.

**[0077]** Additionally, by repeatedly correcting the target high-pressure value HP to increase or decrease the target high-pressure value HP, the difference between the target high-pressure value HP and the high-pressure refrigerant pressure P becomes gradually small. As a result, the opening degree of the electronic expansion valve 33 is gradually adjusted, and the amount of adjustment at a time becomes small. This can prevent the opening degree of the electronic expansion valve 33 from being brought into the fully-opened state or the fully-closed state with high accuracy.

**[0078]** Additionally, by making it difficult for the opening degree of the electronic expansion valve 33 to be brought into the fully-opened state, the pressure of a medium-pressure gas refrigerant RG to be sent into the compressor 31 through the injection circuit 38 is suppressed. Hence, the pressure resistance performance required for a member, such as the injection circuit 38, through which the refrigerant flows can be suppressed, and a cost rise can be suppressed.

**[0079]** Additionally, by making it difficult for the electronic expansion valve 33 on the condensing unit 3 side to be brought into the fully-opened state or fully-closed state, an expansion process is reliably performed in both the electronic expansion valve 33 and the control valve 22. For that reason, it is possible to realize an efficient refrigeration cycle by expanding the refrigerant in two steps in the electronic expansion valve 33 on the condensing unit 3 side and the control valve 22.

(Modification Example of Embodiment)

**[0080]** Although the embodiment of the invention has been described above in detail with reference to the drawings, the respective components, combinations thereof, or the like in the embodiment are exemplary. Additions, omissions, substitutions, and other modifications of the components can be made without departing from the spirit of the invention. Additionally, the invention is not limited by the embodiment, and is limited only by the

scope of the claims.

**[0081]** For example, in the above embodiment, the refrigeration system 1 is one having a two-stage expansion process including the electronic expansion valve 33 and the expansion valve 22 of the loading apparatus. However, the invention is also applicable to a configuration including only one-stage expansion process.

**[0082]** Additionally, although the compressor 31 is configured to include the first-stage compression section 31a and the second-stage compression section 31b and compress the refrigerant in two stages, a case where only one-stage compression is performed may be adopted.

**[0083]** Generally, in the configuration of one-stage expansion and one-stage compression, if the electronic expansion valve 33 is brought into the fully-opened state in a case where the outside-air temperature becomes low and the high-pressure refrigerant pressure P becomes low, or in a case where pipe length is long, the control by the electronic expansion valve 33 does not function, and the liquid refrigerant RL easily returns to the compressor 31. Additionally, in the configuration of one-stage expansion and one-stage compression, if the electronic expansion valve 33 is brought into the fully-closed state in a case where the outside-air temperature is high and a pressure difference between the high-pressure refrigerant pressure and a load side is high, the amount of circulations of the refrigerant decreases and the performance becomes deficient.

**[0084]** In contrast, in the configuration of one-stage expansion and one-stage compression, it is possible to suppress that an inflow of the liquid refrigerant RL into the compressor 31 or a decrease in the amount of circulations of the refrigerant occurs by applying the correction control of the target high-pressure value HP in accordance with the opening degree of the electronic expansion valve 33 as shown in the above embodiment.

**[0085]** Additionally, the control by the controller 100 is not limited to one exemplified above, and the processing order may be changed or some kinds of processing may be omitted.

**[0086]** Additionally, in the above embodiment, the refrigeration system 1 includes the plurality of loading apparatuses 2 and the condensing unit 3. However, the number of loading apparatuses 2 is not limited at all. It is obvious that the plurality of loading apparatuses 2 may not need to be of the same type, and a plurality of types of loading apparatuses 2 may be provided in a mixed manner.

**[0087]** Moreover, the refrigeration system 1 may be a unit having the loading apparatuses 2 and the condensing unit 3 integrally. As such a unit, there are, for example, vending machines for beverages or the like. Additionally, the refrigeration system 1 may be applied to an air-conditioning system.

## Industrial Applicability

**[0088]** According to the above refrigeration device and the above refrigeration system, by making it difficult for the expansion valve to be brought into the fully-opened state or fully-closed state, a cost rise and shortage of the amount of supply of the liquid refrigerant can be suppressed, and it is possible to enhance the refrigeration cycle efficiency.

## Reference Signs List

**[0089]**

1: REFRIGERATION SYSTEM  
 2: LOADING APPARATUS  
 3: CONDENSING UNIT (REFRIGERATION DEVICE)  
 21: HEAT EXCHANGER OF LOADING APPARATUS  
 22: EXPANSION VALVE OF LOADING APPARATUS  
 23: CONTROLLER OF LOADING APPARATUS  
 24: TEMPERATURE SENSOR  
 31: COMPRESSOR  
 31a: FIRST-STAGE COMPRESSION SECTION  
 31b: SECOND-STAGE COMPRESSION SECTION  
 32: GAS COOLER (HEAT EXCHANGER)  
 33: ELECTRONIC EXPANSION VALVE (EXPANSION VALVE)  
 34: RECEIVER  
 35: ACCUMULATOR  
 36: ELECTROMAGNETIC VALVE  
 37: TEMPERATURE SENSOR  
 38: INJECTION CIRCUIT  
 39: OIL SEPARATOR  
 40: LOW-PRESSURE SENSOR  
 41: HIGH-PRESSURE SENSOR  
 43: OUTSIDE-AIR TEMPERATURE SENSOR  
 100: CONTROLLER  
 300: REFRIGERANT PIPE  
 301: LIQUID SENDING PIPE  
 302: SUCTION PIPE  
 341: TANK  
 HP: TARGET HIGH-PRESSURE VALUE  
 P: HIGH-PRESSURE REFRIGERANT PRESSURE  
 RG: GAS REFRIGERANT  
 RL: LIQUID REFRIGERANT

**Claims**

1. A refrigeration device comprising:

a compressor that compresses a refrigerant;  
 a heat exchanger that condenses the refrigerant compressed in the compressor;

an expansion valve that expands the refrigerant condensed in the heat exchanger; and  
 a controller that adjusts an opening degree of the expansion valve such that a pressure of the refrigerant compressed in the compressor approaches a target high-pressure value set on the basis of an outside-air temperature, and that corrects the target high-pressure value in a case where the opening degree of the expansion valve exceeds a preset opening degree upper limit value or opening degree lower limit value.

2. The refrigeration device according to Claim 1, wherein the controller corrects the target high-pressure value to be increased in a case where the opening degree of the expansion valve exceeds the opening degree upper limit value.

3. The refrigeration device according to Claim 1 or 2, wherein the controller corrects the target high-pressure value to be decreased in a case where the opening degree of the expansion valve exceeds the opening degree lower limit value.

4. The refrigeration device according to any one of Claims 1 to 3, wherein the controller repeatedly corrects the target high-pressure value to be increased or decreased in a preset predetermined percentage multiple times.

5. The refrigeration device according to any one of Claims 1 to 4, wherein the compressor includes a first-stage compression section and a second-stage compression section, a receiver that separates the refrigerant condensed in the expansion valve into a gas refrigerant and a liquid refrigerant, and an injection circuit that sends the gas refrigerant separated in the receiver into the second-stage compression section of the compressor.

6. The refrigeration device according to any one of Claims 1 to 5, wherein the refrigerant is carbon dioxide.

7. A refrigeration system comprising:

the refrigeration device according to any one of Claims 1 to 6; and  
 a loading apparatus that is connected to the refrigeration device and has a heat exchanger of the loading apparatus that exchanges heat with the refrigerant to be supplied from the refrigeration device.

8. The refrigeration system according to Claim 7, wherein the loading apparatus further includes an

expansion valve of the loading apparatus that expands the refrigerant to be supplied from the refrigeration device.

9. The refrigeration system according to Claim 7 or 8, wherein a plurality of the loading apparatuses are connected to the refrigeration device.

10

15

20

25

30

35

40

45

50

55

FIG. 1

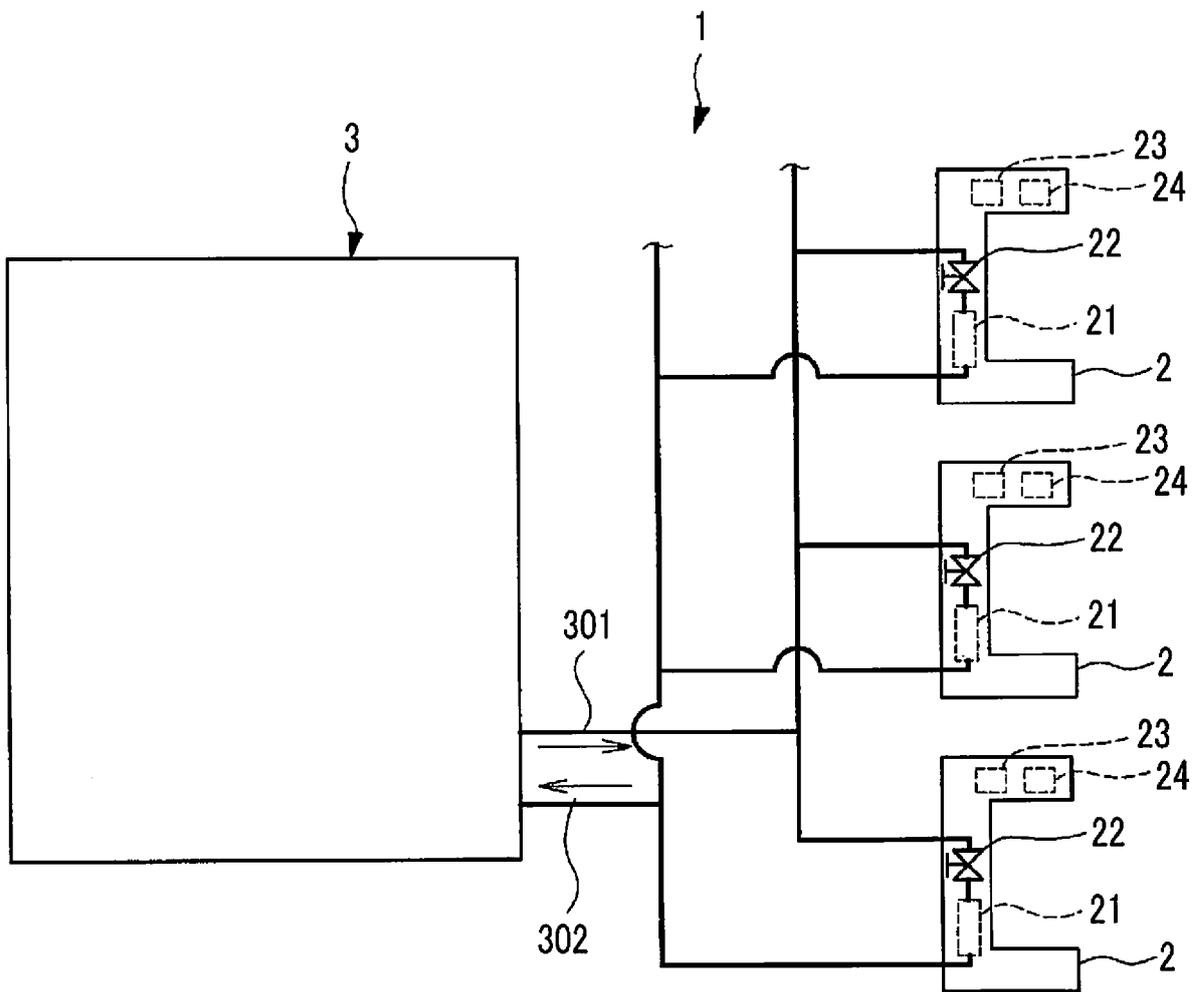




FIG. 3

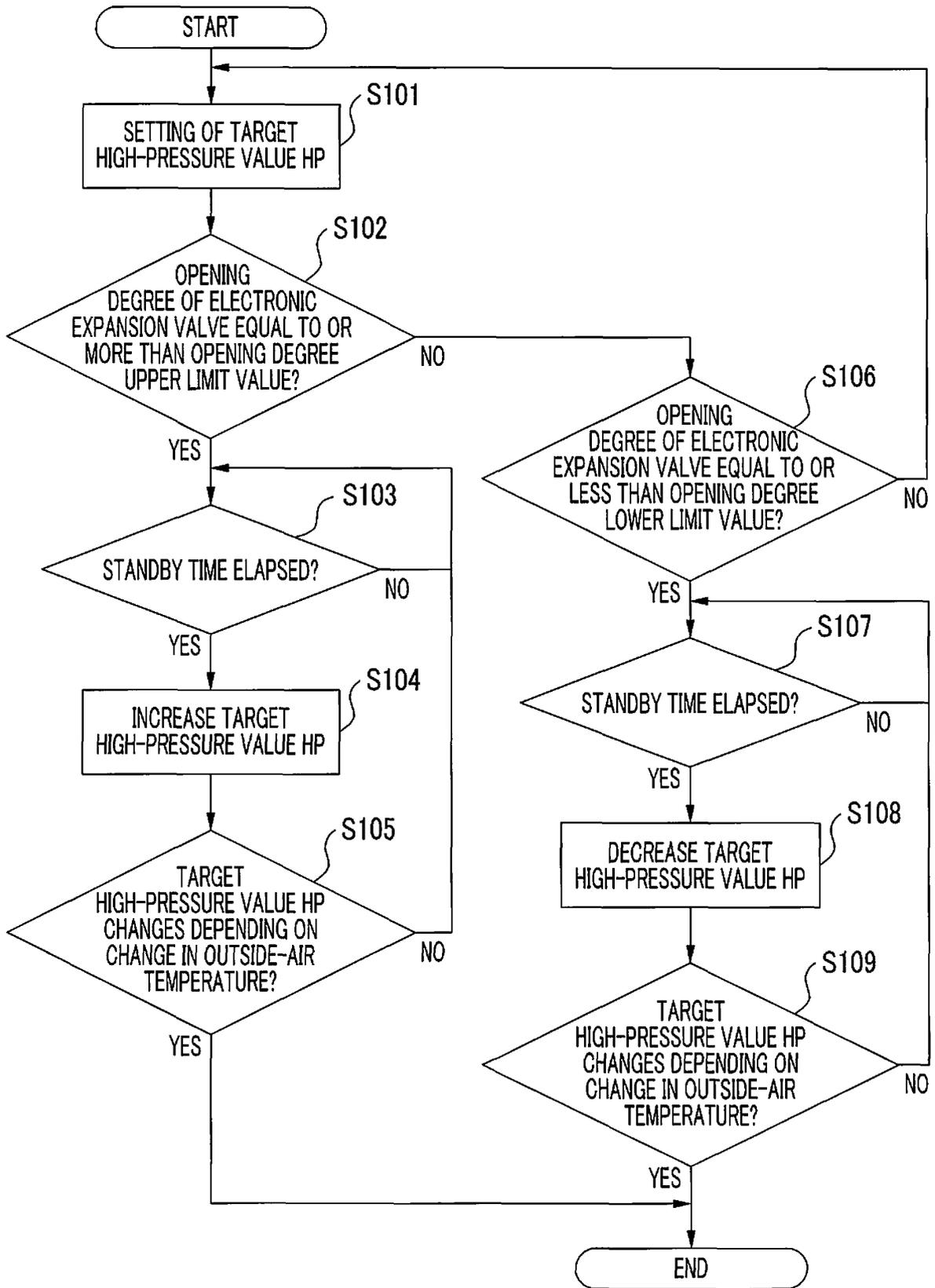
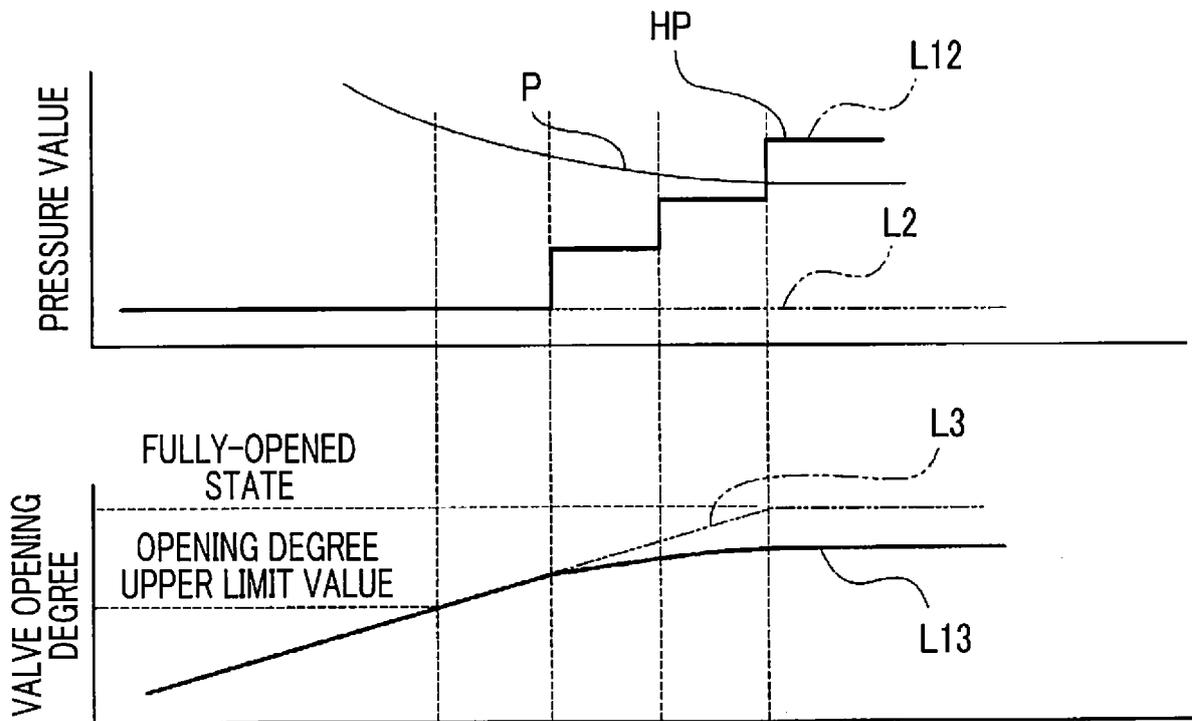


FIG. 4



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/036626

5	A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. F25B1/00 (2006.01) i, F25B1/10 (2006.01) i, F25B5/02 (2006.01) i	
	According to International Patent Classification (IPC) or to both national classification and IPC	
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int. Cl. F25B1/00, F25D11/00	
15	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 1971-2017 Registered utility model specifications of Japan 1996-2017 Published registered utility model applications of Japan 1994-2017	
	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Japio-GPG/FX & keywords: divergence, aim, revision, and related terms	
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
	Category*	Citation of document, with indication, where appropriate, of the relevant passages
25	A	JP 2007-263383 A (DAIKIN INDUSTRIES, LTD.) 11 October 2007, paragraphs [0132]-[0171], fig. 12-13, 15 & US 2009/0260380 A1, paragraphs [0167]-[0206], fig. 12-13, 15 & WO 2007/111303 A1 & EP 2006614 A2 & KR 10-1070566 B1 & CN 101410677 A
30	A	JP 2011-252622 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 15 December 2011, claim 1 (Family: none)
35		Relevant to claim No.
		1-9
		1
40	<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.	
45	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
50	Date of the actual completion of the international search	Date of mailing of the international search report
55	Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer  Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.  
PCT/JP2017/036626

5  
10  
15  
20  
25  
30  
35  
40  
45  
50  
55

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-156507 A (DAIKIN INDUSTRIES, LTD.) 15 July 2010, claim 1 (Family: none)	1
A	JP 2014-89006 A (DAIKIN INDUSTRIES, LTD.) 15 May 2014, claim 2 & EP 2918947 A1, claim 2 & WO 2014/068821 A1 & CN 104736944 A	1

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- JP 2016213257 A [0002]
- JP 2007263383 A [0007]