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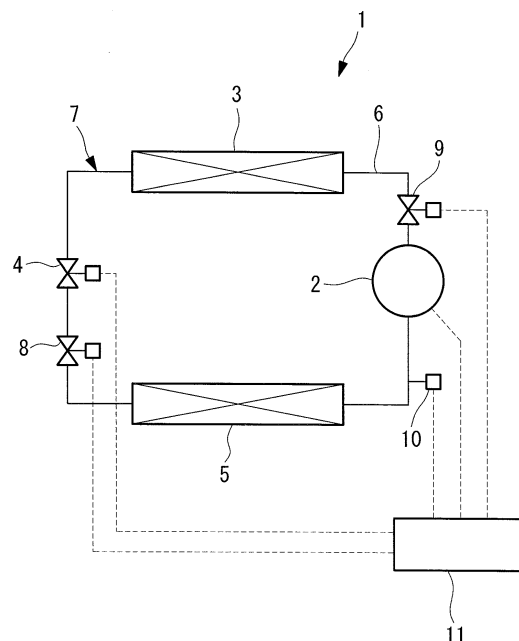
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(54) **REFRIGERATION DEVICE**

(57) An object is to provide a refrigeration unit capable of reducing refrigerant leakage by always maintaining a low pressure at a specified pressure or less while the operation thereof is stopped. A refrigeration unit (1) that performs a pump down operation by closing or narrowing down a refrigerant low-pressure line to stop the operation of a compressor (2), that stops the compressor (2) when a low pressure is reduced to a specified pressure or less, and that closes a refrigerant discharge line to maintain the low pressure, includes low-pressure monitoring means (11) that monitors the low pressure while the compressor (2) is stopped and that performs the pump down operation when the low pressure rises to the specified pressure or more to always maintain the low pressure at the specified pressure or less.

FIG. 1



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## Description

### Technical Field

**[0001]** The present invention relates to a refrigeration unit capable of reducing refrigerant leakage from a refrigerant circuit that includes a compressor as much as possible.

### Background Art

**[0002]** In a refrigeration unit, there is a minute amount of refrigerant leakage from connection parts between devices constituting a refrigeration cycle and refrigerant pipes, or from sealing parts in the devices. To reduce this refrigerant leakage, it is effective to perform a pump down operation to make the pressure in a lower pressure side low and then stop the refrigeration unit (stop a compressor) because the differential pressure relative to the atmospheric pressure can be reduced at the sealing parts etc.

**[0003]** On the other hand, Patent Literatures 1 and 2 describe refrigeration units that perform a pump down operation to stop the operation thereof, in which the pump down operation is performed while closing a solenoid valve or an electronic expansion valve in a refrigerant low-pressure line; refrigerant in the low-pressure line side is recovered to a condenser side; and the refrigerant is sealed in a high-pressure line side by closing a solenoid valve provided in a refrigerant discharge line.

### Citation List

#### Patent Literature

##### [0004]

PTL 1 Japanese Unexamined Patent Application, Publication No. 2000-249385

PTL 2 Japanese Unexamined Patent Application, Publication No. 2001-272118

### Summary of Invention

#### Technical Problem

**[0005]** In the refrigeration units described in Patent Literatures 1 and 2, to stop the operations thereof, the pump down operation is performed, and the solenoid valve in the refrigerant discharge line is closed, thereby making it possible to stop the operations thereof in a state where the low pressure is equal to or less than a specified pressure. Therefore, if the stopped period is short, the low pressure can be maintained at the specified pressure or less to reduce the differential pressure relative to the atmospheric pressure: thus a refrigerant-leakage reducing effect can be expected. However, if the stopped period is long, the low pressure naturally rises due to valve leak-

age or the like, increasing the differential pressure relative to the atmospheric pressure, thereby causing a problem in that the refrigerant-leakage reducing effect is reduced.

**[0006]** The present invention has been made in view of such a circumstance, and an object thereof is to provide a refrigeration unit capable of reducing refrigerant leakage by always maintaining the low pressure at a specified pressure or less while the operation thereof is stopped.

#### Solution to Problem

**[0007]** In order to solve the above-described problem, the refrigeration unit of the present invention employs the following solutions.

Specifically, one aspect of the present invention is a refrigeration unit that performs a pump down operation by closing or narrowing down a refrigerant low-pressure line to stop a compressor, that stops the compressor when a low pressure is reduced to a specified pressure or less, and that closes the refrigerant discharge line to maintain the low pressure, including low-pressure monitoring means that monitors the low pressure while the compressor is stopped and that performs the pump down operation when the low pressure rises to the specified pressure or more to always maintain the low pressure at the specified pressure or less.

**[0008]** According to this aspect of the present invention, the low-pressure monitoring means that monitors the low pressure while the compressor is stopped and that performs a pump down operation when the low pressure rises to the specified pressure or more to always maintain the low pressure at the specified pressure or less is provided, and, therefore, after the pump down operation is performed to make the low pressure equal to or less than the specified pressure and the operation of the compressor is stopped, the pump down operation is performed every time the low pressure rises to the specified pressure or more, thereby making it possible to always maintain the low pressure at the specified pressure or less. Therefore, even when the operation of the refrigeration unit is stopped for a long time, it is possible to maintain the low pressure at the specified pressure or less and to reduce refrigerant leakage as much as possible. Note that the pump down operation is performed by operating the compressor by closing or narrowing down the refrigerant low-pressure line and by pumping refrigerant in the refrigerant low-pressure line side to the refrigerant high-pressure line that includes a condenser.

**[0009]** Further, the refrigeration unit according to the above-described aspect may have a configuration in which the compressor is an open compressor driven by an external drive source.

**[0010]** According to the above-described configuration, in the refrigeration unit in which the compressor is an open compressor driven by an external drive source, it is possible to maintain the low pressure at the specified

pressure or less while the operation of the compressor is stopped and to reduce the possibility of refrigerant leakage from sealing parts in a compressor drive shaft. Therefore, it is possible to reduce refrigerant leakage in a refrigeration unit that uses an open compressor.

**[0011]** Further, any one of the above-described refrigeration units according to the above-described aspect may have a configuration in which an electronic expansion valve for a refrigeration cycle also serves as means for closing the refrigerant low-pressure line.

**[0012]** According to the above-described configuration, since the electronic expansion valve for the refrigeration cycle also serves as the means for closing the refrigerant low-pressure line, it is possible to fully close the electronic expansion valve to close the refrigerant low-pressure line during the pump down operation and during a stop state. Therefore, it is possible to eliminate a solenoid valve or the like used only to close the refrigerant low-pressure line, to simplify the refrigerant circuit configuration, and to reduce the cost thereof.

**[0013]** Furthermore, any one of the above-described refrigeration units according to the above-described aspect may have a configuration in which the means for closing the refrigerant discharge line is a solenoid valve or a check valve provided in the refrigerant discharge line extending from the compressor or in the compressor.

**[0014]** According to the above-described configuration, since the means for closing the refrigerant discharge line is a solenoid valve or a check valve provided in the refrigerant discharge line extending from the compressor or in the compressor, it is possible to close the refrigerant discharge line by the solenoid valve or the check valve after the pump down operation finishes, so as to prevent high-pressure refrigerant from flowing back from the refrigerant discharge line side to the compressor side. Therefore, it is possible to enhance a low-pressure maintaining effect at the refrigerant low-pressure line side and to reduce the leakage of refrigerant from the refrigerant circuit as much as possible.

#### Advantageous Effects of Invention

**[0015]** According to the present invention, after the pump down operation is performed to make the low pressure equal to or less than the specified pressure and the operation of the refrigeration unit is stopped, the pump down operation is performed every time the low pressure rises to the specified pressure or more, thereby making it possible to always maintain the low pressure at the specified pressure or less. Thus, even when the operation of the refrigeration unit is stopped for a long time, it is possible to maintain the low pressure at the specified pressure or less and to reduce the refrigerant leakage as much as possible.

#### Brief Description of Drawings

**[0016]**

Fig. 1 FIG. 1 is a configuration diagram of a refrigeration unit according to one embodiment of the present invention.

Fig. 2 FIG. 2 is a control flow diagram of the refrigeration unit according to the embodiment of the present invention.

#### Description of Embodiments

**[0017]** Embodiments of the present invention will be described below with reference to the drawings.

#### First Embodiment

**[0018]** A first embodiment of the present invention will be described below using FIGS. 1 and 2.

**[0019]** FIG. 1 shows a configuration diagram of a refrigeration unit according to the first embodiment of the present invention, and FIG. 2 shows a control flow diagram thereof.

**[0020]** A refrigeration unit 1 includes a closed-cycle refrigerant circuit (refrigeration cycle) 7 that connects, via refrigerant pipes 6, a compressor 2 for compressing low-pressure refrigerant gas, a condenser 3 for condensing high-temperature and high-pressure refrigerant gas compressed by the compressor 2, an expansion valve (electronic expansion valve) 4 for adiabatically expanding high-pressure liquid refrigerant condensed by the condenser 3, and an evaporator 5 for evaporating low-pressure gas-liquid two-phase refrigerant adiabatically-expanded by the expansion valve 4, in that order.

**[0021]** In the above-described refrigeration unit 1, the compressor 2 is a so-called open compressor that does not include a motor, that has a drive shaft protruding to the outside from a compressor housing and coupled to an external driving source, such as an engine or a motor, via a clutch or the like, and that is driven by the external driving source. Therefore, a sealing device, such as a mechanical seal and a lip seal, is provided at a protrusion part of the drive shaft to seal the part between the inside of the housing and air.

**[0022]** Further, in a refrigerant low-pressure line of the refrigerant circuit (refrigeration cycle) 7 between the expansion valve (electronic expansion valve) 4 and the evaporator 5, a solenoid valve 8 serving as means for closing the refrigerant low-pressure line during a pump down operation is provided. In a refrigerant discharge line between the compressor 2 and the condenser 3, a solenoid valve 9 serving as means for closing the refrigerant discharge line after the pump down operation is provided. Further, a pressure sensor 10 for detecting a low pressure is provided in a refrigerant low-pressure line between the evaporator 5 and the compressor 2.

**[0023]** The above-described refrigeration unit 1 also includes low-pressure monitoring means 11 that, in order to stop the operation (stop the compressor 2), performs the pump down operation with the solenoid valve 8 closed while continuously operating the compressor 2, that

stops the compressor 2 and closes the solenoid valve 9, thus entering a stop state, when the pressure in the refrigerant low-pressure line side reaches a specified pressure or less, and that monitors the low pressure such that the low pressure does not reach the specified pressure or more even during the stop state.

**[0024]** Specifically, as shown in FIG. 2, when a stop signal is input to the refrigeration unit 1 (the compressor 2) that is in an operating state (S1), the low-pressure monitoring means 11 performs a pump down operation (S2). This pump down operation (S2) is performed with the solenoid valve 8 closed while continuously operating the compressor 2. In this way, refrigerant in the refrigerant low-pressure line located on the downstream side of the solenoid valve 8 is pumped up by the compressor 2 into a refrigerant high-pressure line side that includes the condenser 3 and is recovered mainly by the condenser 3.

**[0025]** After the above-described refrigerant recovering operation is continuously performed for a predetermined period of time, most of the refrigerant in the refrigerant low-pressure line side is recovered by the refrigerant high-pressure line side that includes the condenser 3, and the pressure in the refrigerant low-pressure line is reduced. When a low pressure LP reaches the specified pressure or less, the pressure sensor 10 detects that state (S3), stops the compressor 2 (S4), and closes the expansion valve (electronic expansion valve) 4 and the solenoid valve 9 (S5) to seal the refrigerant in the condenser 3 side, so as to prevent high-pressure refrigerant from flowing back to the compressor 2 side. Thus, a stop state (S6) in which the low pressure LP in the refrigerant low-pressure line is the specified pressure or less can be maintained.

**[0026]** When the stop state (6) is maintained for a long time and the low pressure LP gradually rises to the specified pressure or more due to valve leakage or the like, the pressure sensor 10 detects that state (S7) and operates the compressor 2 only for a short time (S8) to perform the pump down operation again (S2). In this way, the low-pressure monitoring means 11 is configured to always maintain the pressure in the refrigerant low-pressure line at the low pressure LP that is equal to or less than the specified pressure while the refrigeration unit 1 (the compressor 2) is stopped.

**[0027]** According to this embodiment, with the configuration described above, the following advantages are afforded.

In the refrigeration unit 1, a refrigeration or air-conditioning operation is performed by repeating a cycle in which refrigerant compressed by the compressor 2 is condensed by the condenser 3; this refrigerant is adiabatically-expanded by the expansion valve (electronic expansion valve) 4 and is then supplied to the evaporator 5 for evaporation; and this refrigerant gas is sucked into the compressor 2 for recompression.

**[0028]** To stop this refrigeration or air-conditioning operation, the low-pressure monitoring means 11 performs the pump down operation and then stops the operation

of the compressor 2 in order to reduce the possibility of refrigerant leakage from the refrigeration unit during the stopped period as much as possible. The pump down operation is performed by closing the solenoid valve 8 while the compressor 2 is continuously operated. With the pump down operation, refrigerant in the refrigerant low-pressure line located on the downstream side of the solenoid valve 8 is recovered by the compressor 2 to the high-pressure line side that includes the condenser 3, and the pressure in the refrigerant low-pressure line side is reduced.

**[0029]** When the low pressure is reduced to the specified pressure, the pressure sensor 10 detects that state, stops the compressor 2 to finish the pump down operation, and closes the expansion valve (electronic expansion valve) 4 and the solenoid valve 9 to seal the refrigerant in the high-pressure line side that includes the condenser 3. In this way, the low pressure in the refrigerant low-pressure line side is maintained at a low pressure equal to or less than the specified pressure that is closer to the atmospheric pressure. Further, when the stopped period is long, the low pressure rises due to valve leakage or the like during that period, and the pressure sensor 10 detects that it reaches the specified pressure or more, the compressor 2 is operated for a short time to perform the pump down operation again. The identical operations are repeated thereafter.

**[0030]** Thus, in the refrigeration unit 1, the low pressure is always maintained at the specified pressure or less while the operation thereof is stopped. Therefore, even when the operation of the refrigeration unit 1 is stopped for a long time, the low pressure is maintained at the specified pressure or less, thereby reducing refrigerant leakage as much as possible. In the refrigeration unit 1 using the open compressor 2, the possibility of refrigerant leakage from a sealing part in the compressor drive shaft can be reduced while the operation of the compressor 2 is stopped. Therefore, it is possible to reduce refrigerant leakage in the refrigeration unit 1 using the open compressor 2.

**[0031]** Further, the solenoid valve 9 is provided in the refrigerant discharge line and closes the refrigerant discharge line when the pump down operation finishes, thereby preventing high-pressure refrigerant from flowing back to the compressor 2 side. Therefore, it is possible to enhance a low-pressure maintaining effect at the refrigerant low-pressure line side and to reduce the leakage of refrigerant from the refrigerant circuit 7 as much as possible.

## Second Embodiment

**[0032]** Next, a second embodiment of the present invention will be described with reference to FIG. 1.

**[0033]** This embodiment differs from the above-described first embodiment in that the electronic expansion valve 4 also serves as means for closing the refrigerant low-pressure line.

**[0034]** Specifically, this embodiment uses a configuration in which the low-pressure monitoring means 11 fully closes or narrows down the electronic expansion valve 4 to close or narrow down the refrigerant low-pressure line during a pump down operation and fully closes the electronic expansion valve 4 during a stop state after the pump down operation finishes. In this way, it is possible to make the electronic expansion valve 4 also work as the above-described solenoid valve 8.

**[0035]** As described above, since the electronic expansion valve 4 is fully closed or narrowed down to close or narrow down the refrigerant low-pressure line during a pump down operation, and the electronic expansion valve 4 is fully closed to close the refrigerant low-pressure line during the stop state after the pump down operation finishes, the above-described solenoid valve 8 can be omitted. Therefore, according to this embodiment, in addition to the same effect as in the first embodiment, an effect is afforded in that it is possible to simplify the configuration of the refrigerant circuit 7 and to reduce the cost thereof, by omitting the solenoid valve 8.

**[0036]** Note that the present invention is not limited to the invention according to the above-described embodiments, and appropriate modifications can be made without departing from the scope thereof. For example, although a description has been given of an example in which the solenoid valve 9 is provided as means for closing the refrigerant discharge line in the above-described embodiments, a similar advantage can be obtained even by using a check valve instead of the solenoid valve 9. Note that, since a valve control circuit is not required when a check valve is used, the configuration of the control means can be simplified. The above-described solenoid valve 9 or a check valve may be provided inside the compressor 2.

**[0037]** In the above-described embodiments, although a description has been given of the refrigeration unit in which one compressor 2, one condenser 3, and one evaporator 5 are connected, the present invention can naturally be applied to a multi-type refrigeration unit in which, in addition to the above-described configuration, at least one compressor 2, at least one condenser 3, and/or at least one evaporator 5 are further connected. Further, although an example in which the pressure sensor 10 is provided in the refrigerant low-pressure line in order to detect a low pressure has been described in the above-described embodiments, the present invention also includes an embodiment in which the pressure can be detected from the saturation temperature of refrigerant detected by a temperature sensor.

**[0038]** Furthermore, although the present invention is suitably applied to an engine-driven heat pump air-conditioning unit using the open compressor 2 driven by an engine or a motor serving as an external drive source, and to a vehicle refrigeration unit or a vehicle air-conditioning unit that is driven by a sub-engine or a driving engine, the present invention is not necessarily limited to those refrigeration units, and it is needless to say that

the present invention can be similarly applied to electrically-powered refrigeration units, electrically-powered heat pump air-conditioning units, and the like.

Further, if the unit has a starter motor for starting an engine, the pump down operation performed for a short time to maintain a low pressure during a stop state can be performed by driving the starter motor for a short time and, if a hybrid-type unit has both an engine and a motor, by driving the motor for a short time.

#### Reference Signs List

#### [0039]

- |    |    |  |
|----|----|--|
| 15 | 1  | refrigeration unit   |
|    | 2  | compressor (open compressor)                                 |
|    | 4  | expansion valve (electronic expansion valve)                 |
|    | 7  | refrigerant circuit (refrigeration cycle)                    |
|    | 8  | solenoid valve (refrigerant low-pressure line closing means) |
| 20 | 9  | solenoid valve (refrigerant discharge line closing means)    |
|    | 11 | low-pressure monitoring means                                |

#### Claims

1. A refrigeration unit that performs a pump down operation by closing or narrowing down a refrigerant low-pressure line to stop a compressor, that stops the compressor when a low pressure is reduced to a specified pressure or less, and that closes the refrigerant discharge line to maintain the low pressure, comprising low-pressure monitoring means that monitors the low pressure while the compressor is stopped and that performs the pump down operation when the low pressure rises to the specified pressure or more to always maintain the low pressure at the specified pressure or less.
2. A refrigeration unit according to claim 1, wherein the compressor is an open compressor driven by an external drive source.
3. A refrigeration unit according to claim 1 or 2, wherein an electronic expansion valve for a refrigeration cycle also serves as means for closing the refrigerant low-pressure line.
4. A refrigeration unit according to one of claims 1 to 3, wherein the means for closing the refrigerant discharge line is a solenoid valve or a check valve provided in the refrigerant discharge line extending from the compressor or in the compressor.

FIG. 1

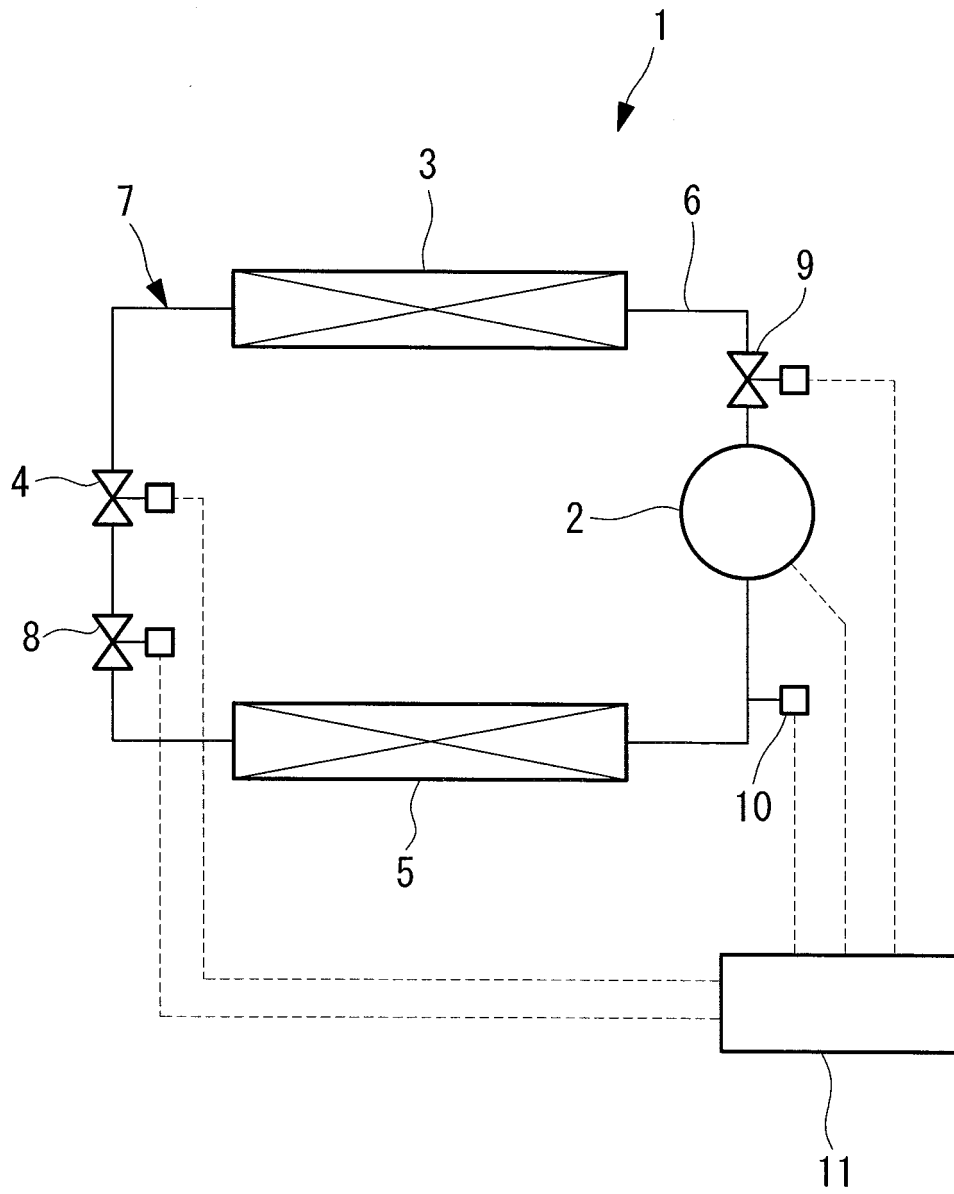
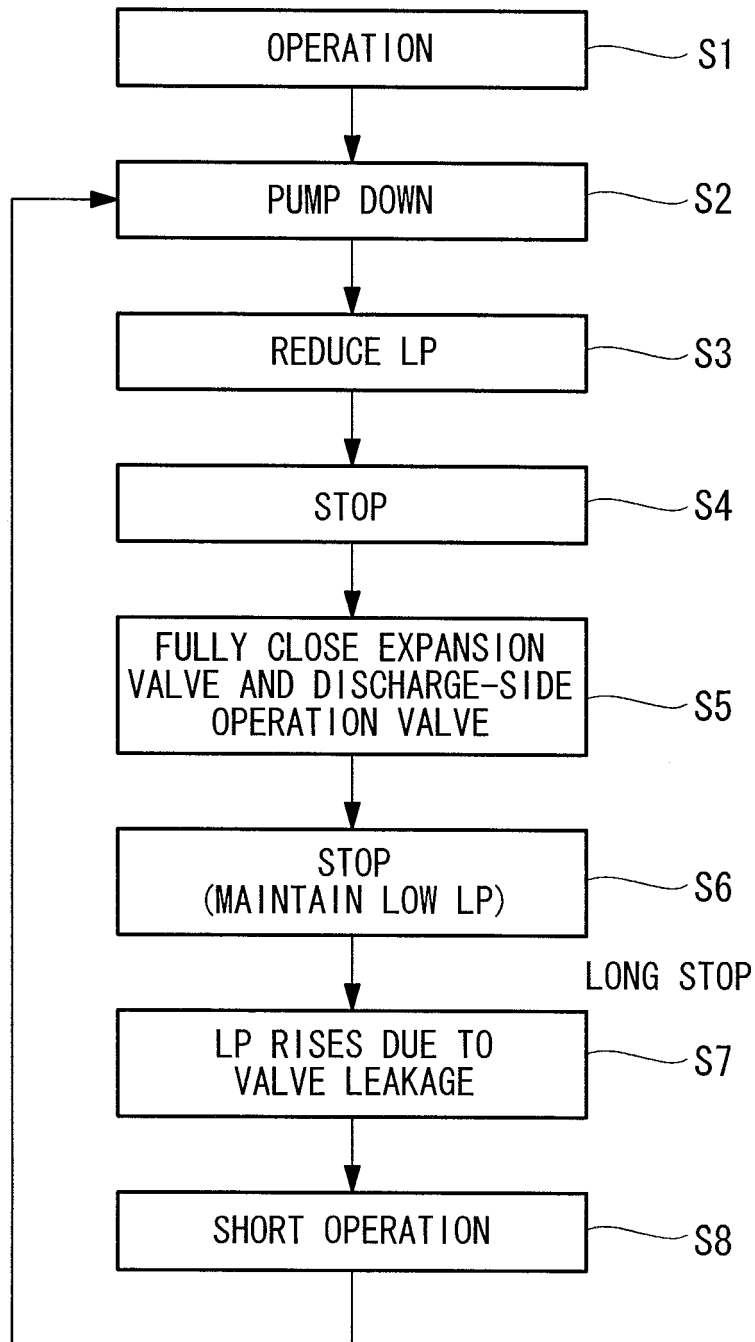


FIG. 2



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**INTERNATIONAL SEARCH REPORT**

International application No.  
PCT/JP2009/060645

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> <i>F25B1/00(2006.01) i, F24F11/02(2006.01) i</i>		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) <i>F25B1/00, F24F11/02</i>		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2001-272118 A (Daikin Industries, Ltd.), 05 October, 2001 (05.10.01), Par. Nos. [0017] to [0034]; Figs. 1 to 3 (Family: none)	1-4
Y	JP 2000-249385 A (Daikin Industries, Ltd.), 12 September, 2000 (12.09.00), Par. Nos. [0002] to [0005], [0047]; Figs. 1 to 4 (Family: none)	1-4
Y	JP 5-280812 A (Daikin Industries, Ltd.), 29 October, 1993 (29.10.93), Par. Nos. [0006], [0042] to [0053]; Figs. 4 to 8 (Family: none)	1-4
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* 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	
Date of the actual completion of the international search 04 August, 2009 (04.08.09)		Date of mailing of the international search report 18 August, 2009 (18.08.09)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2000249385 A [0004]
- JP 2001272118 A [0004]