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JP 2010230258 A
JP 2008249203 A
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JP 202091079

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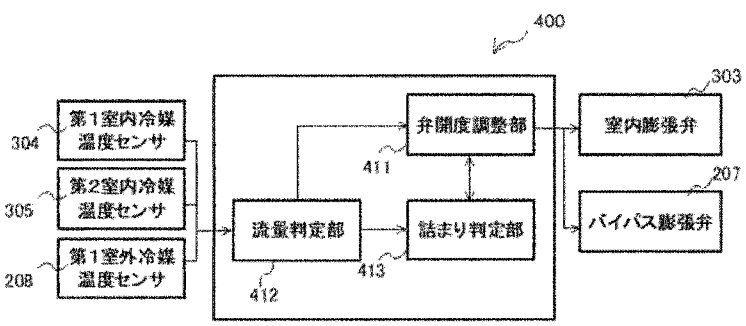
Other: **Public JP utililty model applns (examined 1922-1996),(unexamined 1971-2020); JP utility models (regst specs 1996-2020),(public regst applns 1994-2020)**

(54) Title of the Invention: **Air conditioning apparatus**
Abstract Title: **Air conditioning apparatus**

(57) An air conditioning apparatus having an expansion valve. This air conditioning apparatus comprises: a refrigerant circuit in which a compressor, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger are connected by piping; and a control device that controls the valve aperture of the expansion valve. The control device has: a valve aperture adjustment unit that generates a control signal for controlling the valve aperture of the expansion valve; a flow rate determination unit that compares the refrigerant flow rate downstream from the expansion valve and a threshold value for the refrigerant flow rate downstream from the expansion valve; and a clogging determination unit that, in cases where the control signal in the valve aperture adjustment unit is for controlling the valve aperture of the expansion valve so as to be constant or so as to close and where the refrigerant flow rate downstream from the expansion valve is equal to or greater than the threshold value for the refrigerant flow rate downstream from the expansion valve according to the results of comparison by the flow rate determination unit, assesses whether the expansion valve is clogged with foreign matter.



207 Bypass expansion valve
208 First outdoor refrigerant temperature sensor
303 Indoor expansion valve
304 First indoor refrigerant temperature sensor
305 Second indoor refrigerant temperature sensor
411 Valve aperture adjustment unit
412 Flow rate determination unit
413 Clogging determination unit

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FIG. 1

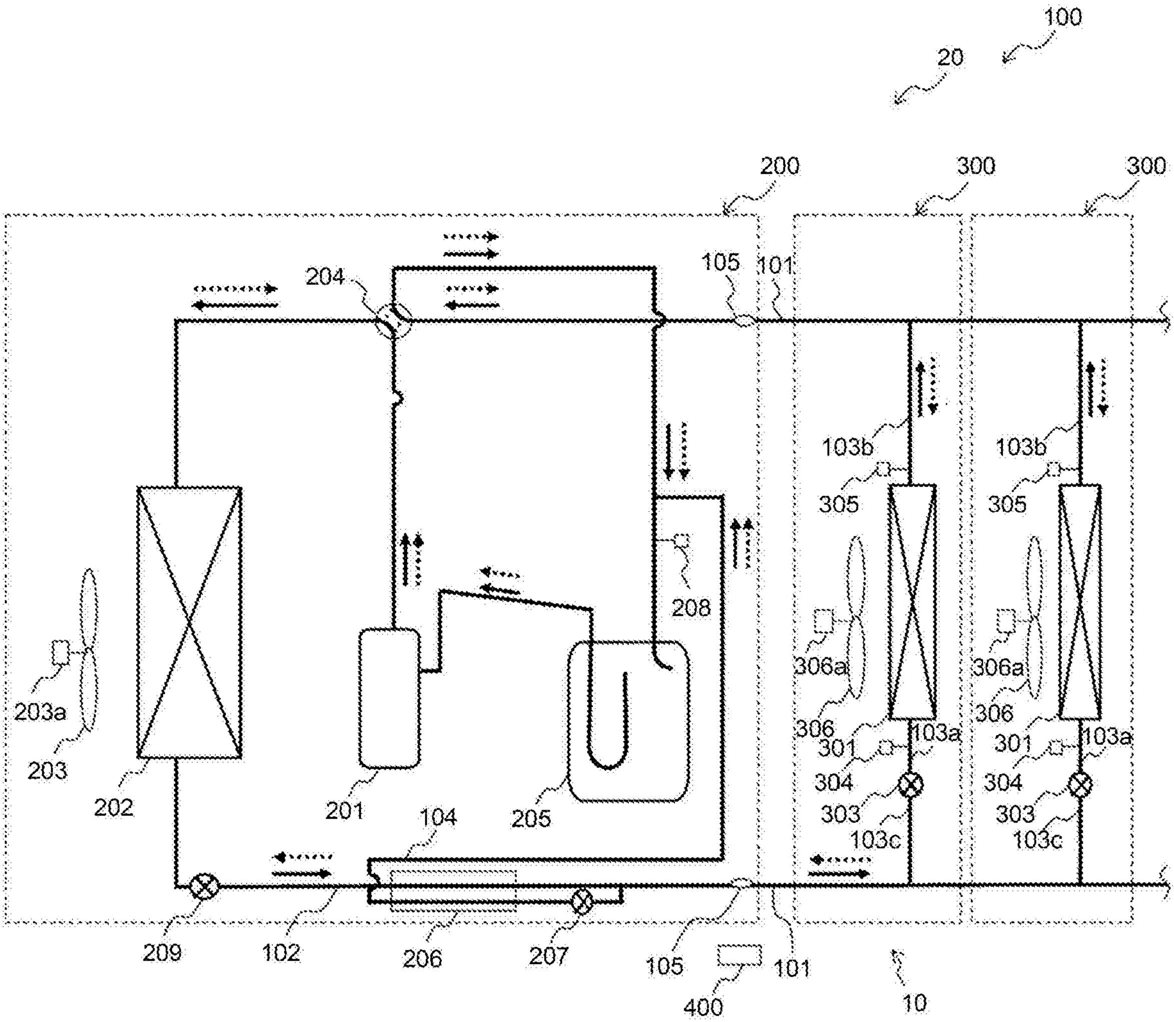

100
20
200
300
300
204
105
101
103b
305
208
306a
203a
203
202
201
205
306
301
304
103a
303
103c
104
209
102
206
207
105
400
101
10

FIG. 2

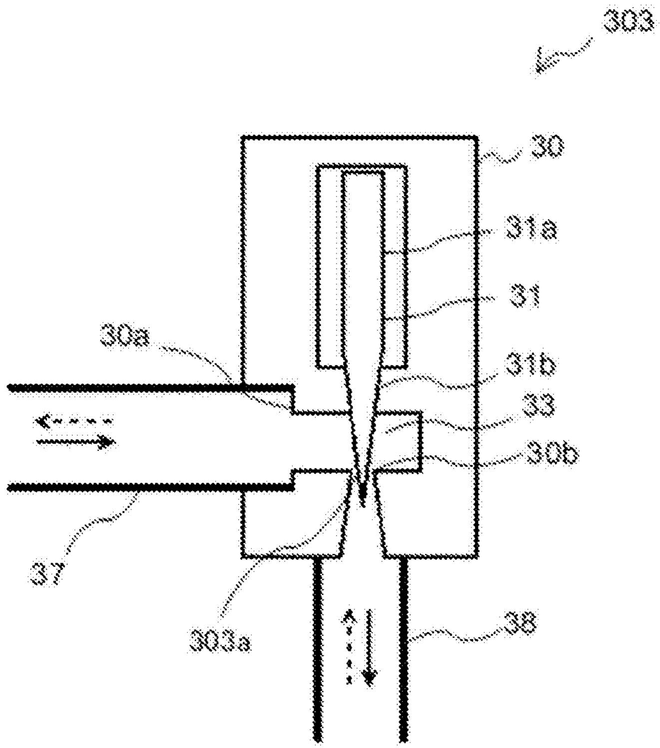


FIG. 3

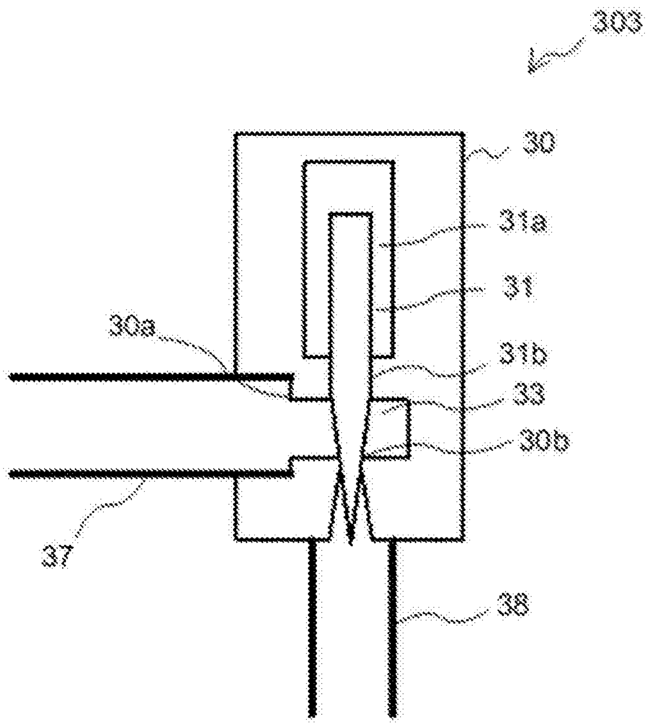


FIG. 4

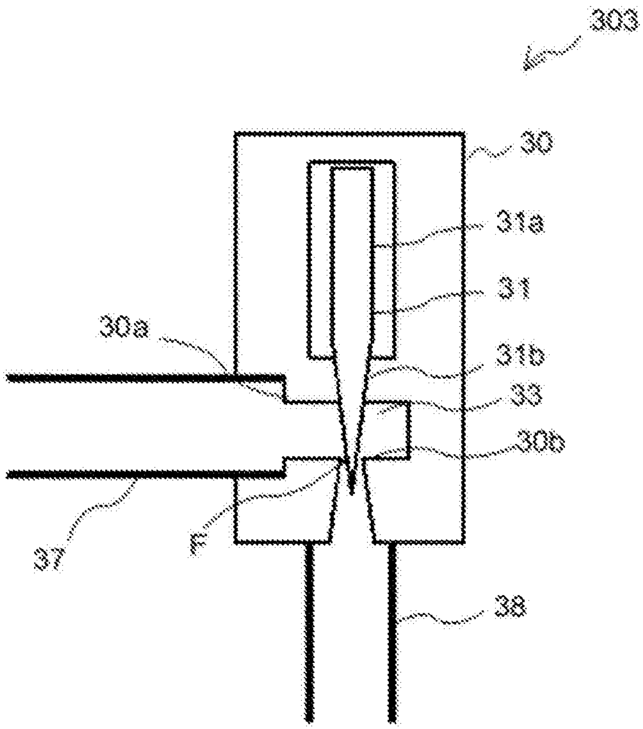


FIG. 5

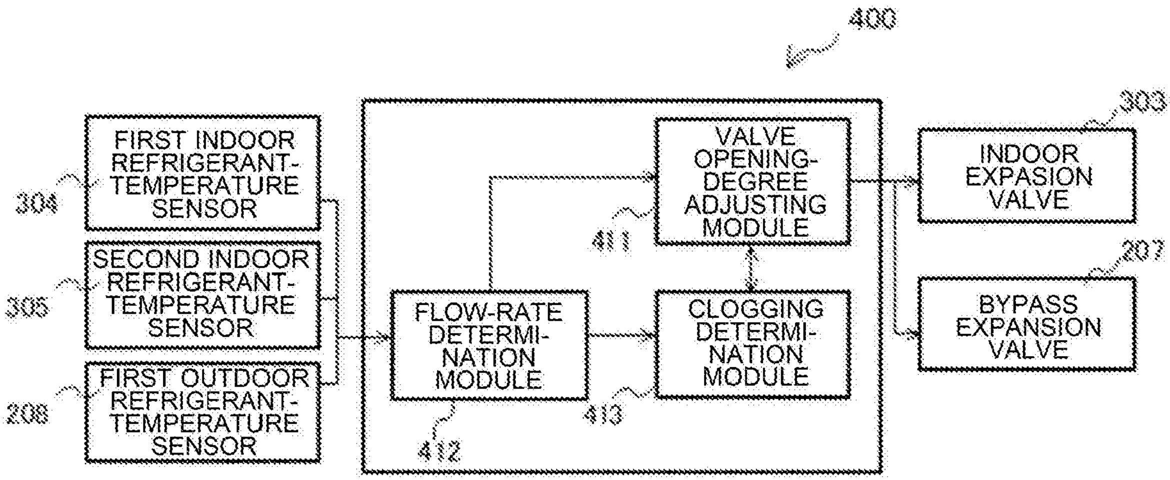

400
FIRST INDOOR REFRIGERANT-TEMPERATURE SENSOR
304
SECOND INDOOR REFRIGERANT-TEMPERATURE SENSOR
305
FIRST OUTDOOR REFRIGERANT-TEMPERATURE SENSOR
208
VALVE OPENING-DEGREE ADJUSTING MODULE
411
FLOW-RATE DETERMI-NATION MODULE
412
CLOGGING DETERMI-NATION MODULE
413
INDOOR EXPASION VALVE
303
BYPASS EXPANSION VALVE
207

FIG. 6

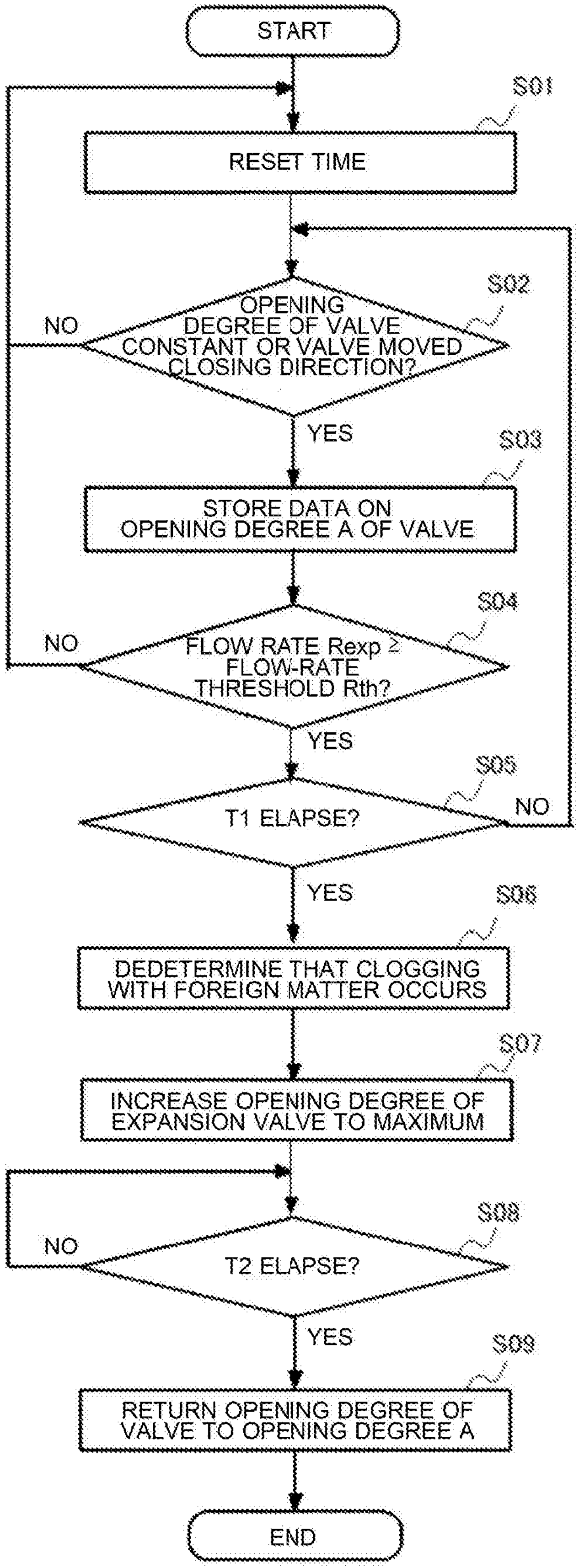

START
S01
RESET TIME
S02
OPENING DEGREE OF VALVE CONSTANT OR VALVE MOVED CLOSING DIRECTION?
NO
YES
S03
STORE DATA ON OPENING DEGREE A OF VALVE
S04
FLOW RATE Rexp ≥ FLOW-RATE THRESHOLD Rth?
NO
YES
S05
T1 ELAPSE?
NO
YES
S06
DEDETERMINE THAT CLOGGING WITH FOREIGN MATTER OCCURS
S07
INCREASE OPENING DEGREE OF EXPANSION VALVE TO MAXIMUM
S08
T2 ELAPSE?
NO
YES
S09
RETURN OPENING DEGREE OF VALVE TO OPENING DEGREE A
END

FIG. 7

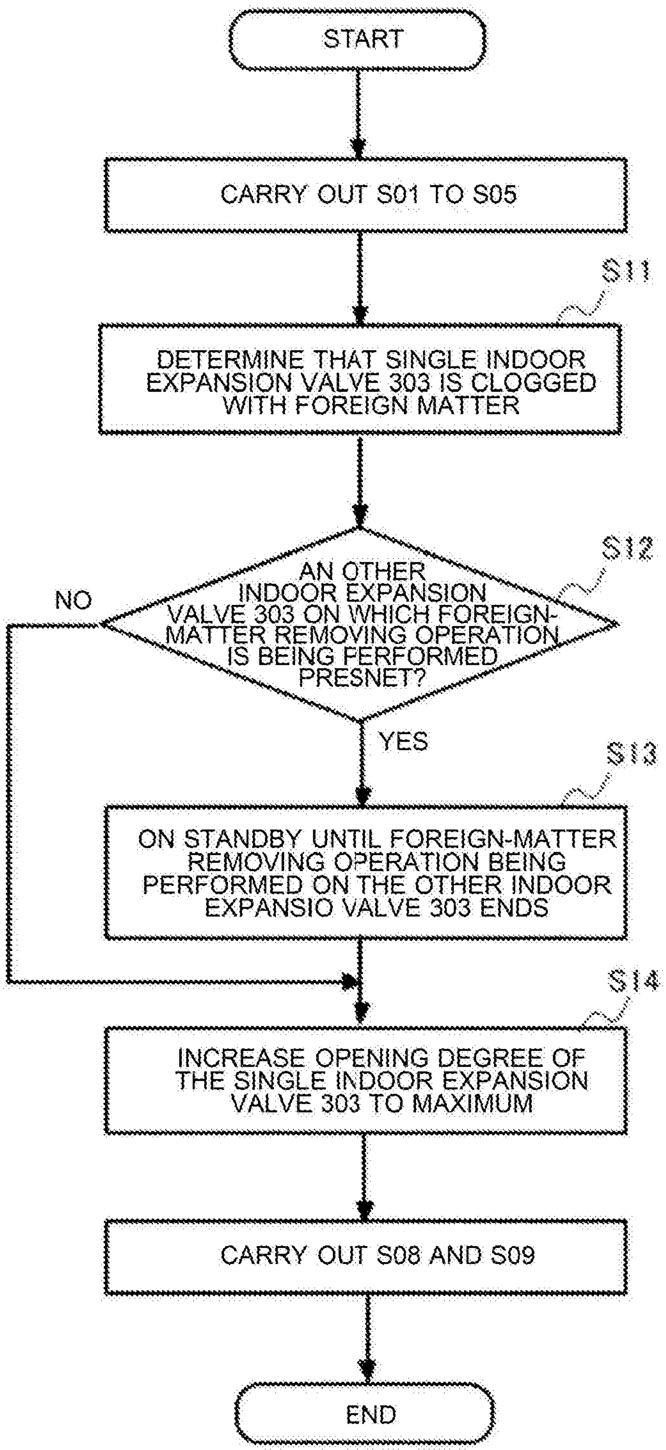

START
CARRY OUT S01 TO S05
S11
DETERMINE THAT SINGLE INDOOR EXPANSION VALVE 303 IS CLOGGED WITH FOREIGN MATTER
S12
AN OTHER INDOOR EXPANSION VALVE 303 ON WHICH FOREIGN-MATTER REMOVING OPERATION IS BEING PERFORMED PRESNET?
NO
YES
S13
ON STANDBY UNTIL FOREIGN-MATTER REMOVING OPERATION BEING PERFORMED ON THE OTHER INDOOR EXPANSIO VALVE 303 ENDS
S14
INCREASE OPENING DEGREE OF THE SINGLE INDOOR EXPANSION VALVE 303 TO MAXIMUM
CARRY OUT S08 AND S09
END

FIG. 8

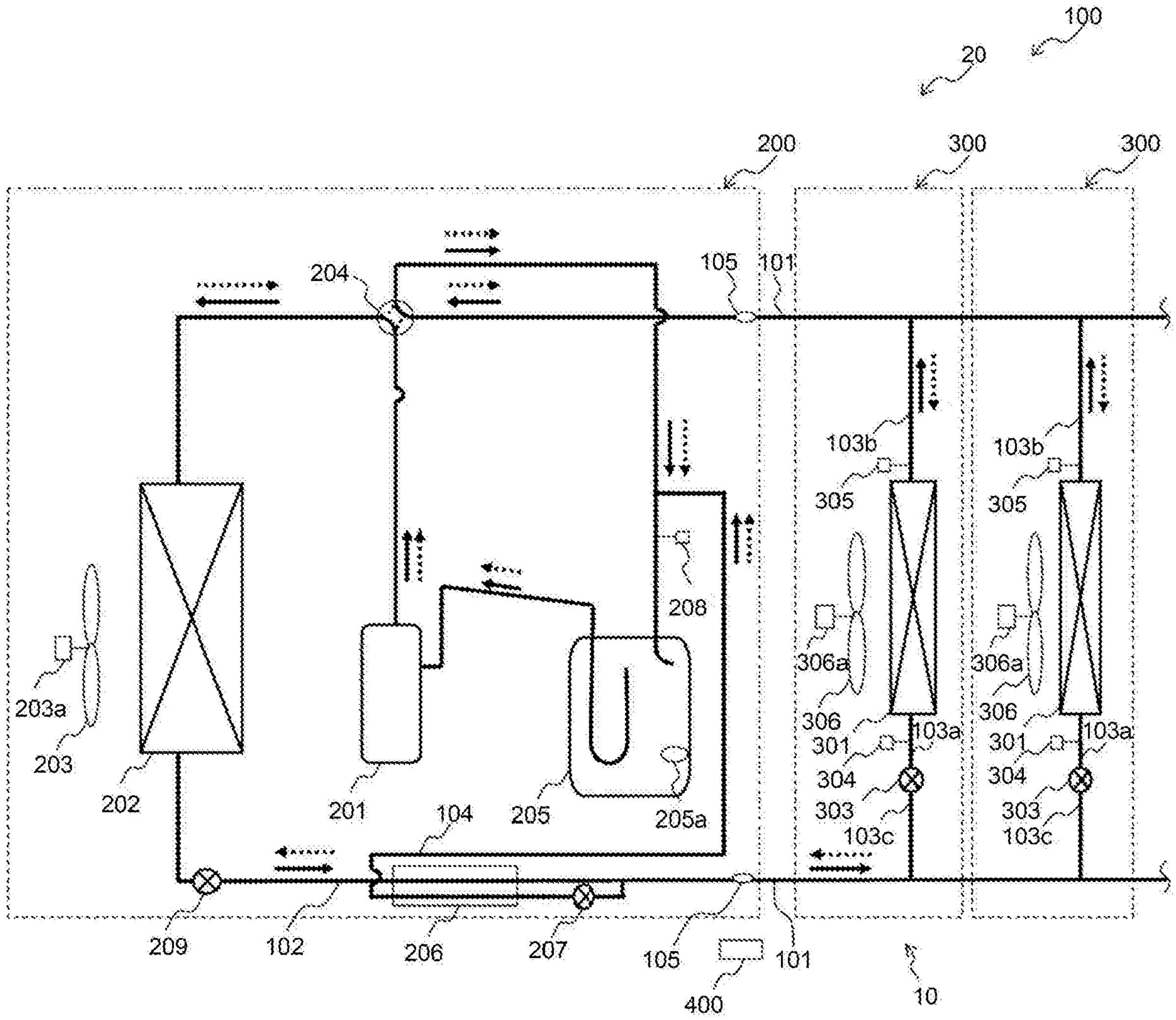
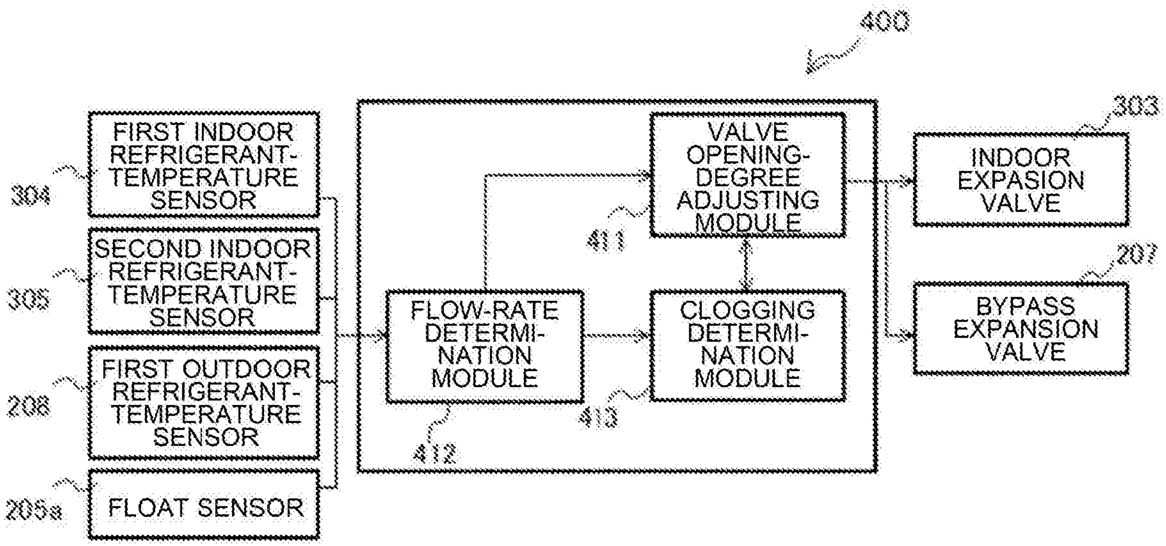

100
20
200
300
300
204
105
101
103b
103b
305
305
208
306a
306a
203a
306
306
301
103a
301
103a
203
304
304
202
201
104
205
205a
303
103c
303
103c
209
102
206
207
105
400
101
10

FIG. 9


400
FIRST INDOOR REFRIGERANT-TEMPERATURE SENSOR
304
SECOND INDOOR REFRIGERANT-TEMPERATURE SENSOR
305
FIRST OUTDOOR REFRIGERANT-TEMPERATURE SENSOR
208
FLOAT SENSOR
205a
VALVE OPENING-DEGREE ADJUSTING MODULE
411
FLOW-RATE DETERMI-NATION MODULE
412
CLOGGING DETERMI-NATION MODULE
413
INDOOR EXPASION VALVE
303
BYPASS EXPANSION VALVE
207

DESCRIPTION

Title of Invention

AIR-CONDITIONING APPARATUS

Technical Field

[0001]

The present disclosure relates to an air-conditioning apparatus including an expansion valve.

Background Art

[0002]

In air-conditioning apparatuses, for example, as described in Patent Literature 1, refrigerant pipes for an outdoor unit are connected to refrigerant pipes for an indoor unit by extension pipes, whereby a refrigerant circuit is provided. The extension pipes are connected to the refrigerant pipes for the outdoor unit or the indoor unit by welding at the time of installing the outdoor unit or the indoor unit at a designated place.

Citation List

Patent Literature

[0003]

Patent Literature: International Publication 2019/030885

Summary of Invention

Technical Problem

[0004]

At the time of installing, for example, the air-conditioning apparatus described in Patent Literature 1, when the extension pipe and the refrigerant pipe are welded together, foreign matter may enter the extension pipe or the refrigerant pipe, which are included in the refrigerant circuit. If foreign matter enters the refrigerant circuit, an expansion valve connected to the refrigerant pipe may be clogged with the foreign matter. As a result, in some cases, the expansion valve does not operate appropriately. If not operating appropriately, the expansion valve cannot appropriately adjust the flow rate of refrigerant. Consequently, refrigerant sucked by a compressor does not completely evaporate, and returns to the compressor in a liquid state. That is, a liquid backflow occurs. If this phenomenon occurs, the compressor cannot normally compress refrigerant and is damaged, and in addition the efficiency of the air-conditioning apparatus is greatly lowered.

[0005]

The present disclosure is applied to solve the above problem, and relates to an air-conditioning apparatus that can prevent a liquid backflow that will occur when an expansion valve is clogged with foreign matter.

Solution to Problem

[0006]

An air-conditioning apparatus according to the present disclosure includes: a refrigerant circuit in which a compressor, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger are connected by pipes; and a controller configured to control an opening degree of the expansion valve. The controller includes: a valve opening-degree adjusting module configured to produce a control signal for control of the opening degree of the expansion valve; a flow-rate determination module configured to compare a flow rate of refrigerant on a downstream side of the expansion valve with a threshold for the flow rate of the refrigerant on the downstream side of the expansion valve; and a clogging determination module configured to determine that the expansion valve is clogged with foreign matter, when the control signal produced by the valve opening-degree adjusting module is a control signal to control the expansion valve such that the opening degree of the expansion valve is made constant or such that the expansion valve is moved in a closing direction in which the expansion valve is closed, and a result of comparison by the flow-rate determination module indicates that the flow rate of the refrigerant on the downstream side of the expansion valve is higher than or equal to the threshold for the flow rate of the refrigerant on the downstream side of the expansion valve.

Advantageous Effects of Invention

[0007]

In the air-conditioning apparatus according to the present disclosure, the clogging determination module determines whether the expansion valve is closed with foreign matter or not based on the control signal produced by the valve opening-degree adjusting module and the result of the comparison by the flow-rate determination module. Thus, it is possible to handle clogging with the foreign matter in the expansion valve early, and prevent liquid back that would be caused by the clogging with the foreign matter in the expansion valve.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a circuit diagram of a refrigerant circuit in an air-conditioning apparatus 100 according to Embodiment 1.

[Fig. 2] Fig. 2 is a schematic view illustrating an opened state of an indoor expansion valve according to Embodiment 1.

[Fig. 3] Fig. 3 is a schematic view illustrating a closed state of the indoor expansion valve according to Embodiment 1.

[Fig. 4] Fig. 4 is a schematic view illustrating a state in which the indoor expansion valve according to Embodiment 1 is clogged with foreign matter.

[Fig. 5] Fig. 5 is a function block diagram of a controller according to Embodiment 1.

[Fig. 6] Fig. 6 is a flowchart of a foreign-matter clogging elimination operation according to Embodiment 1.

[Fig. 7] Fig. 7 is a flowchart of the foreign-matter clogging elimination operation in a modification of the foreign-matter clogging elimination operation in an air-conditioning apparatus of a modification of Embodiment 1.

[Fig. 8] Fig. 8 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 2.

[Fig. 9] Fig. 9 is a function block diagram of the controller according to Embodiment 2.

Description of Embodiments

[0009]

An air-conditioning apparatus according to each of embodiments will be described. It should be noted that in figures to be referred to below, relationships in size between components may be different from actual ones. Also, in each of the figures, components that are the same as or equivalent to those in a previous figure or previous figures are denoted by the same reference signs. The same is true of the entire text of the specification. Furthermore, the configurations of components that are described in the entire text of the specification are merely examples, that is, their descriptions are not limiting.

[0010]

Embodiment 1

<Configuration of Air-Conditioning Apparatus 100>

Fig. 1 is a circuit diagram of a refrigerant circuit in an air-conditioning apparatus 100 according to Embodiment 1. In Fig. 1, solid arrows indicate the flows of refrigerant during cooling operation, and dashed arrows indicate the flows of refrigerant during heating operation. As illustrated in Fig. 1, the air-conditioning apparatus 100 includes an outdoor unit 200 and a plurality of indoor units 300. Operations of the outdoor unit 200 and the plurality of indoor units 300 are controlled by, for example, a controller 400.

[0011]

The outdoor unit 200 and the plurality of indoor units 300 are connected by extension pipes 101. The plurality of indoor units 300 are connected to the outdoor unit 200, and are also connected parallel to each other. A refrigerant circuit 20 is provided in which refrigerant is circulated in the outdoor unit 200 and the plurality of indoor units 300. The refrigerant circuit 20 includes pipes 10 that include refrigerant pipes 102, a bypass pipe 104, first refrigerant pipes 103a, second refrigerant pipes 103b, third refrigerant pipes 103c, and the extension pipes 101.

[0012]

The controller 400 is, for example, a dedicated hardware or a CPU which executes a program stored in a memory. The CPU is also referred to as a central processing unit, a processing unit, an arithmetic device, a microprocessor, a microcomputer, or a processor.

[0013]

<Configuration of Outdoor Unit 200>

The outdoor unit 200 is installed, for example, outside a room that is an air-conditioning target space. The outdoor unit 200 includes a compressor 201, an outdoor heat exchanger 202, a flow switching device 204, an accumulator 205, an outdoor expansion valve 209, a refrigerant heat exchanger 206, and a bypass expansion valve 207. The compressor 201, the outdoor heat exchanger 202, the flow switching device 204, the accumulator 205, the outdoor expansion valve 209, and the refrigerant heat exchanger 206 are connected by the refrigerant pipes 102. The bypass expansion valve 207 is connected to the bypass pipe 104, which branches off from the refrigerant pipe 102. The bypass expansion valve 207 will be described in detail later. The outdoor unit 200 also houses an outdoor fan 203 and a first outdoor refrigerant-temperature sensor 208.

[0014]

The compressor 201 sucks low-temperature and low-pressure refrigerant, compresses the sucked refrigerant to change it into high-temperature and high-pressure refrigerant, and discharges the high-temperature and high-pressure refrigerant. The compressor 201 is, for example, an inverter compressor whose capacity can be controlled. The compressor 201 is controlled by, for example, the controller 400.

[0015]

The outdoor heat exchanger 202 is, for example, a fin tube heat exchanger that includes a plurality of fins and a plurality of tubes. The outdoor heat exchanger 202 causes heat exchange to be performed between outdoor air and refrigerant that flows in the outdoor heat exchanger 202. The outdoor heat exchanger 202 operates as a condenser during the cooling operation, and operates as an evaporator during the heating operation. The outdoor heat exchanger 202 is not limited to the fin tube heat exchanger, and may be, for example, a plate heat exchanger.

[0016]

The outdoor fan 203 is a device that sends air to the outdoor heat exchanger 202. The outdoor fan 203 is driven by a motor 203a to rotate. The motor 203a is controlled by, for example, the controller 400.

[0017]

The flow switching device 204 switches the flow direction of refrigerant that flows through the refrigerant pipe 102, between a plurality of flow directions, and is, for example, a four-way valve. The flow switching device 204 is connected to a discharge side of the compressor 201, the outdoor heat exchanger 202, the extension pipes 101, and the accumulator 205 by the refrigerant pipes 102. The flow switching device 204 is controlled by, for example, the controller 400.

[0018]

The accumulator 205 is provided in a refrigerant circuit provided between the flow switching device 204 and a suction side of the compressor 201. The accumulator 205 stores surplus refrigerant that is transiently generated when the operation is changed to, for example, the cooling operation or the heating operation.

[0019]

The refrigerant heat exchanger 206 causes heat exchange to be performed between refrigerant that flows in the refrigerant pipe 102 and refrigerant that flows in the bypass pipe 104, which branches off from the refrigerant pipe 102. The refrigerant heat exchanger 206 is, for example, a plate heat exchanger.

[0020]

A strainer 105 is provided at connection part between the extension pipe 101 and the refrigerant pipe 102 in the outdoor unit 200. The strainer 105 is provided to catch foreign matter that mixes into the refrigerant.

[0021]

<Configuration of Indoor Unit 300>

The plurality of indoor units 300 are provided in respective rooms that are air-conditioning target spaces. One of the plurality of indoor units 300 will be described as follows.

[0022]

The indoor unit 300 includes an indoor heat exchanger 301 and an indoor expansion valve 303. The indoor heat exchanger 301 and the indoor expansion valve 303 are connected to a refrigerant circuit 20 that includes the first refrigerant pipe 103a, the second refrigerant pipe 103b, and the third refrigerant pipes 103c. The indoor unit

300 also houses an indoor fan 306, a first indoor refrigerant-temperature sensor 304, and a second indoor refrigerant-temperature sensor 305.

[0023]

The indoor heat exchanger 301 is, for example, a fin tube heat exchanger that includes a plurality of fins and a plurality of tubes. The indoor heat exchanger 301 is connected to the first refrigerant pipe 103a and the second refrigerant pipe 103b. The first refrigerant pipe 103a is a pipe that extends from the indoor heat exchanger 301 to the indoor expansion valve 303. The second refrigerant pipes 103b is a pipe that extends from the indoor heat exchanger 301 to the extension pipe 101. The indoor heat exchanger 301 causes heat exchange to be performed between refrigerant that flows in the indoor heat exchanger 301 and air in the air-conditioning target space. The indoor heat exchanger 301 operates as an evaporator during the cooling operation, and operates as a condenser during the heating operation. The indoor heat exchanger 301 is not limited to the fin tube heat exchanger, and may be, for example, a flat heat exchanger.

[0024]

The indoor fan 306 produces an air current in the air around the indoor heat exchanger 301. The indoor fan 306 is driven by a motor 306a to rotate. The motor 306a is controlled by, for example, the controller 400.

[0025]

The indoor expansion valve 303 is a pressure reduction valve or an expansion valve that decompresses the refrigerant to expand the refrigerant. The indoor expansion valve 303 is connected between the first refrigerant pipe 103a and the third refrigerant pipe 103c. The first refrigerant pipe 103a is a pipe that extends from the indoor expansion valve 303 to the indoor heat exchanger 301. The third refrigerant pipe 103c is a pipe that extends from the indoor expansion valve 303 to the extension pipe 101. The indoor expansion valve 303 will be described in detail later.

[0026]

The first indoor refrigerant-temperature sensor 304 and the second indoor refrigerant-temperature sensor 305 are each provided to detect the temperature of the refrigerant. The first indoor refrigerant-temperature sensor 304 and the second indoor refrigerant-temperature sensor 305 each transmits the detected temperature to the controller 400. The first indoor refrigerant-temperature sensor 304 is provided at the first refrigerant pipe 103a which connects the indoor heat exchanger 301 and the indoor expansion valve 303. The second indoor refrigerant-temperature sensor 305 is provided at the second refrigerant pipe 103b which extends from the indoor heat exchanger 301.

[0027]

It should be noted that Fig. 1 illustrates an example in which the strainer 105 is provided at the connection part between the refrigerant pipe 102 and the extension pipe 101, and the location of the strainer 105 is not limited. For example, the strainer 105 can be provided at any of connection parts between the locations of the following components: the first refrigerant pipe 103a; the second refrigerant pipes 103b; the third refrigerant pipes 103c; and the extension pipes 101.

[0028]

<Operation of Air-Conditioning Apparatus 100>

In the air-conditioning apparatus 100, in the cooling operation, high-temperature and high-pressure gas refrigerant obtained through compression by the compressor 201 flows into the outdoor heat exchanger 202 through the flow switching device 204. The gas refrigerant that has flowed into the outdoor heat exchanger 202 exchanges heat with outdoor air that passes through the outdoor heat exchanger 202 to change into high-pressure liquid refrigerant, and the high-pressure liquid refrigerant then flows out of the outdoor heat exchanger 202. The high-pressure liquid refrigerant that has flowed out of the outdoor heat exchanger 202 flows into the indoor units 300, then flows through the third refrigerant pipes 103c, and is decompressed by the indoor expansion valves 303 to change into low-pressure two-phase gas-liquid refrigerant. The low-pressure two-phase gas-liquid refrigerant flows into the indoor heat exchangers 301 through the first refrigerant pipes 103a and exchanges heat with indoor air that passes through the indoor heat exchangers 301 to change into low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant flows out of the indoor units 300 through the second refrigerant pipe 103b, and the gas refrigerant that has flowed out of one of the indoor units 300 and the gas refrigerant that has flowed out of the other indoor unit 300 join each other in the outdoor unit 200. Then, the refrigerant is re-sucked into the compressor 201 through the flow switching device 204 and the accumulator 205.

[0029]

In the air-conditioning apparatus 100, in the heating operation, high-temperature and high-pressure gas refrigerant obtained through compression by the compressor 201 passes through the flow switching device 204, and flows into the indoor heat exchangers 301 in the indoor units 300 through the second refrigerant pipes 103b therein. The gas refrigerant that has flowed into the indoor heat exchangers 301 exchanges heat with indoor air that passes through the indoor heat exchangers 301 to change into high-pressure liquid refrigerant. The high-pressure liquid refrigerant passes through the first refrigerant pipes 103a, and is decompressed by the indoor expansion valves 303 to change into low-pressure two-phase gas liquid refrigerant. The low-pressure two-phase gas liquid refrigerant passes through the third refrigerant pipes 103c, the low-pressure two-phase gas liquid refrigerant that flows out of one of the third refrigerant pipes 103c and the low-pressure two-phase gas liquid refrigerant that flows out of the other third refrigerant pipe 103c in the extension pipe 101 join each other to combine into single low-pressure two-phase gas liquid refrigerant, and the single low-pressure two-phase gas liquid refrigerant flows into the outdoor unit 200. Then, the low-pressure two-phase gas liquid refrigerant flows into the outdoor heat exchanger 202 and exchanges heat with outdoor air that passes through the outdoor heat exchanger 202 to change into low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant flows out of the outdoor heat exchanger 202, and is re-sucked by the compressor 201 through the flow switching device 204 and the accumulator 205. The bypass pipe 104 supercools the refrigerant using the bypass expansion valve 207 and the refrigerant heat exchanger 206 when it is necessary to supercool the refrigerant in the cooling operation, and then supplies the refrigerant to the indoor unit 300.

[0030]

<Configuration of Indoor Expansion Valve 303>

Fig. 2 is a schematic view illustrating an opened state of the indoor expansion valve 303 according to Embodiment 1. Fig. 3 is a schematic view illustrating a closed state of the indoor expansion valve 303 according to Embodiment 1. In Fig. 2, sold arrows indicate the flow direction of the refrigerant during the cooling operation, and broken arrows indicate the flow direction of the refrigerant in the heating operation, as in Fig. 1. The indoor expansion valve 303 causes the refrigerant to change it into low-temperature and low-pressure refrigerant because of passage of the refrigerant through a narrow space in the expansion valve 303, and automatically adjusts the flow rate and temperature of the refrigerant. The indoor expansion valve 303 is, for example, an electronic expansion valve that uses electromagnetic force produced when current flows a coil.

[0031]

In the case where the indoor heat exchanger 301 operates as an evaporator, the indoor expansion valve 303 is moved in an opening direction in which the indoor expansion valve 303 is opened, when the second indoor refrigerant-temperature sensor 305 located downstream of the indoor heat exchanger 301 detects that the temperature of the refrigerant rises.

[0032]

In the case where the indoor heat exchanger 301 operates as an evaporator, the indoor expansion valve 303 is moved in a closing direction in which the indoor expansion valve 303 is closed, when the second indoor refrigerant-temperature sensor 305 located downstream of the indoor heat exchanger 301 detects that the temperature of the refrigerant drops.

[0033]

As illustrated in Figs. 2 and 3, the indoor expansion valve 303 includes a main body 30 and a valve body 31 movably provided in the main body 30. The main body 30 has a cylindrical shape and is formed by performing cutting on a foundry piece made of brass.

[0034]

In the main body 30, a valve chamber 33 is formed. The valve body 31 penetrates the valve chamber 33 and is provided movable in the axial direction of the main body 30. A first through hole 30a is formed in a side surface of the main body 30. Also, a second through hole 30b is formed on an imaginary line that extends in the moving direction of the valve body 31 in the main body 30.

[0035]

To the first through hole 30a, a first joint pipe 37 is attached. One end of the first joint pipe 37 communicates with the valve chamber 33 through the first through hole 30a. The other end of the first joint pipe 37 is connected with the third refrigerant pipe 103c. The third refrigerant pipes 103c is a pipe that extends to the extension pipe 101.

[0036]

To the second through hole 30b, a second joint pipe 38 is attached. One end of the second joint pipe 38 communicates with the valve chamber 33 through the second through hole 30b. The other end of the second joint pipe 38 is connected with the first refrigerant pipe 103a. The first refrigerant pipe 103a is a pipe that extends to the indoor heat exchanger 301.

[0037]

A peripheral edge portion of the second through hole 30b that adjoins the valve chamber 33 serves as a valve seat. Between the first joint pipe 37 and the second joint pipe 38, a flow passage is provided for refrigerant that flows in the valve chamber 33.

[0038]

The valve body 31 includes a cylindrical portion 31a that forms a shaft portion and a conical portion 31b that is provided at one end of the cylindrical portion 31a. The cylindrical portion 31a and the conical portion 31b are formed integral with each other. The valve body 31 is located such that a distal end of the conical portion 31b faces the second through hole 30b and is movable in the axial direction of the cylindrical portion 31a.

[0039]

As illustrated in Fig. 3, when being driven, the valve body 31 is moved such that the distal end of the conical portion 31b is deeply inserted into the second through hole 30b and an opening 303a defined by an outer peripheral portion of the conical portion 31b and the second through hole 30b is decreased. When the conical portion 31b is brought into contact with the second through hole 30b, the indoor expansion valve 303 is fully closed.

[0040]

As illustrated in Fig. 2, when being driven, the valve body 31 is moved such that the outer peripheral portion of the conical portion 31b is separated from the second through hole 30b and the area of the opening 303a defined by the outer peripheral portion of the conical portion 31b and the second through hole 30b is increased. When the area of the opening 303a defined by the outer peripheral portion of the conical portion 31b and the second through hole 30b is increased to the maximum, the indoor expansion valve 303 is fully opened.

[0041]

When the valve body 31 is moved in the axial direction of the cylindrical portion 31a, the area of the opening 303a defined by the outer peripheral portion of the conical portion 31b and the second through hole 30b is increased or decreased, and the opening degree of the indoor expansion valve 303 is changed. The opening degree of the indoor expansion valve 303 is changed under the control by the controller 400.

[0042]

<Operation of Indoor Expansion Valve>

The opening degree of the indoor expansion valve 303 is controlled such that a flow rate Rexp of refrigerant on a downstream side of the indoor expansion valve 303 reaches a target flow rate Rt. The target flow rate Rt is the flow rate of refrigerant that flows in the indoor heat exchanger 301.

[0043]

When the flow rate Rexp is higher than the target flow rate Rt, the opening degree of the indoor expansion valve 303 is controlled such that the area of the opening 303a defined by the outer peripheral portion of the conical portion 31b and the second through hole 30b is reduced. As a result, the flow rate of the refrigerant on the downstream side of the indoor expansion valve 303 is reduced, and the flow rate of the refrigerant that flows in the indoor heat exchanger 301 is thus reduced, and approaches the target flow rate Rt.

[0044]

By contrast, when the flow rate of the refrigerant that flows in the indoor heat exchanger 301 falls below the target flow rate Rt, the opening degree of the indoor expansion valve 303 is increased by the control, and the flow rate of the refrigerant that flows in the indoor heat exchanger 301 is increased and re-approaches the target flow rate Rt. In such a manner, the indoor expansion valve 303 is automatically adjusted as the need arises such that the flow rate Rexp of the refrigerant that flows in the indoor heat exchanger 301 approaches the target flow rate Rt.

[0045]

Fig. 4 is a schematic view illustrating a state in which the indoor expansion valve 303 according to Embodiment 1 is clogged with foreign matter F. As illustrated in Fig. 4, when the indoor expansion valve 303 is clogged with the foreign matter F, the opening 303a defined by the outer peripheral portion of the conical portion 31b and the second through hole 30b is closed.

[0046]

Even when the opening degree of the indoor expansion valve 303 is controlled to be moved in the closing direction, and then when the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is continuously higher than or equal to a flow-rate threshold Rth, a foreign-matter clogging elimination operation that is an operation of eliminating clogging with foreign matter is performed. The flow-rate threshold Rth is, for example, a value higher than the target flow rate Rt. The case where the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is higher than or equal to the flow-rate threshold Rth corresponds to the case where the flow rate of the refrigerant that flows in the indoor heat exchanger 301 is not decreased, and is kept higher than or equal to the flow-rate threshold Rth.

[0047]

In the foreign-matter clogging elimination operation, the opening degree of the indoor expansion valve 303 is controlled to be increased to the maximum. When the opening degree of the indoor expansion valve 303 is increased to the maximum, the area of the opening 303a defined by the outer peripheral portion of the conical portion 31b and the second through hole 30b is increased to the maximum. When the area of the opening 303a defined by the outer peripheral portion of the conical portion 31b and the second through hole 30b is increased to the maximum, the flow rate of refrigerant that flows into the opening 303a is increased, the foreign matter F with which the opening 303a is clogged is pushed out and flows to the downward side of the indoor expansion valve 303. Thus, clogging with the foreign matter can be eliminated.

[0048]

When the foreign-matter clogging elimination operation ends, the opening degree of the indoor expansion valve 303 is returned to an opening degree that is set by the controller 400 before the foreign-matter clogging elimination operation is performed, and a normal operation is performed. The foreign matter F with which the opening 303a is clogged is caught by the strainer 105 located on the downstream side. As a result, the opening degree of the indoor expansion valve 303 is returned from the opening degree of the valve being in an abnormal state in which the valve is clogged with the foreign matter and has not yet been subjected to the foreign-matter clogging elimination operation to the opening degree of the valve being in a normal state.

[0049]

<Method of Determining Whether Flow Rate Is Higher Than Or Equal to Flow-Rate Threshold Rth>

Whether the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is higher than or equal to the flow-rate threshold Rth can be determined from the degree of superheat at the indoor heat exchanger 301, for example, in the case where the air-conditioning apparatus 100 is in the cooling operation.

[0050]

In the cooling operation, the indoor heat exchanger 301 operates as an evaporator, and refrigerant that flows out of the indoor expansion valve 303 flows into the indoor heat exchanger 301. When the flow rate of the refrigerant that flows in the indoor heat exchanger 301 is low, the degree of superheat at the indoor heat exchanger 301 is increased, and the difference between the temperature detected by the first indoor refrigerant-temperature sensor 304 and the temperature detected by the second indoor refrigerant-temperature sensor 305 is also increased. By contrast, when the flow rate of the refrigerant that flows in the indoor heat exchanger 301 is high, the degree of superheat at the indoor heat exchanger 301 is decreased, and the difference between the temperature detected by the first indoor refrigerant-temperature sensor 304 and the temperature detected by the second indoor refrigerant-temperature sensor 305 is also decreased.

[0051]

Therefore, it is possible to determine whether the flow rate Rexp is higher than or equal to the flow-rate threshold Rth or not by determining whether the degree of superheat that is calculated from the difference between the temperature detected by the first indoor refrigerant-temperature sensor 304 and the temperature detected by the second indoor refrigerant-temperature sensor 305 is less than a degree-of-superheat threshold or not.

[0052]

Furthermore, whether the flow rate Rexp is higher than or equal to the flow-rate threshold Rth or not can be determined from the degree of supercooling at the indoor heat exchanger 301 in the case where the air-conditioning apparatus 100 is in the heating operation.

[0053]

In the heating operation, the indoor heat exchanger 301 operates as a condenser, and refrigerant that flows into the indoor heat exchanger 301 then flows into the indoor expansion valve 303. When the flow rate of the refrigerant that flows in the indoor heat exchanger 301 is low, the degree of supercooling at the indoor heat exchanger 301 is increased, and the difference between the temperature detected by the first indoor refrigerant-temperature sensor 304 and the temperature detected by the second indoor refrigerant-temperature sensor 305 is also increased. By contrast, when the flow rate of the refrigerant that flows in the indoor heat exchanger 301 is high, the degree of supercooling at the indoor heat exchanger 301 is decreased, and the difference between the temperature detected by the first indoor refrigerant-temperature sensor 304 and the temperature detected by the second indoor refrigerant-temperature sensor 305 is also decreased.

[0054]

Therefore, it is possible to determine whether the flow rate Rexp is higher than or equal to the flow-rate threshold Rth or not by determining whether the degree of supercooling that is calculated from the difference between the temperature detected by the first indoor refrigerant-temperature sensor 304 and the temperature detected by the second indoor refrigerant-temperature sensor 305 is less than a degree-of-supercooling threshold or not.

[0055]

<Configuration of Bypass Expansion Valve 207>

The bypass expansion valve 207, as well as the indoor expansion valve 303, includes a first joint pipe 37 and a second joint pipe 38. The bypass expansion valve 207 is moved in the opening direction, when the first outdoor refrigerant-temperature sensor 208, which is provided downstream of the refrigerant heat exchanger 206, detects a temperature rise.

[0056]

The first joint pipe 37 of the bypass expansion valve 207 is connected to a bypass pipe 104 that extends to the refrigerant pipe 102, and the second joint pipe 38 of the bypass expansion valve 207 is connected to a bypass pipe 104 that extends to the refrigerant heat exchanger 206. The other configuration of the bypass expansion valve 207 is the same as that of the indoor expansion valve 303, and its description will thus be omitted.

[0057]

<Operation of Bypass Expansion Valve 207>

The bypass expansion valve 207, as well as the indoor expansion valve 303, is controlled in operation degree such that the flow rate Rexp of refrigerant at part of the bypass pipe 104 that is located downstream of the bypass expansion valve 207 reaches the target flow rate Rt. Furthermore, even when the bypass expansion valve 207 is controlled in opening degree to be moved in the closing direction, and when the flow rate Rexp of refrigerant on the downstream side of the bypass expansion valve 207 is continuously higher than or equal to the flow-rate threshold Rth, the foreign-matter clogging elimination operation is performed.

[0058]

Whether the flow rate Rexp of the refrigerant at the bypass expansion valve 207 is higher than or equal to the flow-rate threshold Rth or not can be determined by determination, for example, on whether the degree of superheat of suction gas at the compressor 201 is less than the degree-of-superheat threshold for the suction gas or not. Therefore, it is possible to determine whether the flow rate Rexp of the refrigerant on the downstream side of the bypass expansion valve 207 is higher than or equal to the flow-rate threshold Rth or not from the degree of superheat of suction gas at the compressor 201 that is based on a detection value obtained by detection by the first outdoor refrigerant-temperature sensor 208. The degree of superheat of the suction gas can be determined from, for example, the difference between the temperature detected by the first outdoor refrigerant-temperature sensor 208 and an evaporation temperature at the evaporator.

[0059]

<Control in Foreign-Matter Clogging Elimination Operation>

Fig. 5 is a function block diagram of the controller 400 according to Embodiment 1. As illustrated in Fig. 5, the controller 400 includes a valve opening-degree adjusting module 411, a flow-rate determination module 412, and a clogging determination module 413. To the flow-rate determination module 412, the first indoor refrigerant-temperature sensor 304, the second indoor refrigerant-temperature sensor 305, and the first outdoor refrigerant-temperature sensor 208 are connected. The valve opening-degree adjusting module 411 is connected to the indoor expansion valve 303.

[0060]

The valve opening-degree adjusting module 411 produces a control signal for control of the opening degree of the indoor expansion valve 303. Based on the control signal produced by the valve opening-degree adjusting module 411, the indoor expansion valve 303 is driven. The control signal for control of the opening degree is determined, for example, based on a set temperature set at the indoor unit 300.

[0061]

The flow-rate determination module 412 compares the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 with the flow-rate threshold Rth. The comparison between the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 and the flow-rate threshold Rth is made, for example, based on the temperatures detected by the first indoor refrigerant-temperature sensor 304 and the second indoor refrigerant-temperature sensor 305.

[0062]

The clogging determination module 413 determines whether the opening 303a of the indoor expansion valve 303 is clogged with foreign matter or not based on the control signal produced by the valve opening-degree adjusting module 411 and the result of the comparison by the flow-rate determination module 412.

[0063]

More specifically, the clogging determination module 413 receives a control signal for causing the opening degree of the indoor expansion valve 303 to be constant, and determines that clogging with foreign matter occurs, when continuously receiving for first time period T1, a control signal indicating that the flow rate Rexp is higher than or equal to the flow-rate threshold Rth. Furthermore, the clogging determination module 413 receives a control signal for controlling the indoor expansion valve 303 to be moved in the closing direction, and determines that clogging with foreign matter occurs, when continuously receiving for first time period T1, a control signal indicating that the flow rate Rexp is higher than or equal to the flow-rate threshold Rth. The first time period T1 is an example of a certain time period.

[0064]

The valve opening-degree adjusting module 411 performs the foreign-matter clogging elimination operation, when the clogging determination module 413 determines that clogging with foreign matter occurs. In the foreign-matter clogging elimination operation, the valve opening-degree adjusting module 411 produces a control signal for controlling the opening degree of the indoor expansion valve 303 to be increased to the maximum. Based on the control signal produced by the valve opening-degree adjusting module 411, the indoor expansion valve 303 is driven such that the opening degree thereof is increased to the maximum, and the foreign-matter clogging elimination operation is performed. The foreign-matter clogging elimination operation is continuously performed for second time period T2 that is determined in advance.

[0065]

Regarding the first time period T1 and the second time period T2, time is measured by a clock module such as a timer, which is provided at the controller 400. The clock module is not illustrated. The first time period T1 is, for example, five minutes, and the second time period T2 is, for example, 1 minute.

[0066]

It should be noted that although Fig. 5 illustrates by way of example the valve opening-degree adjusting module 411 connected to the indoor expansion valve 303, the valve opening-degree adjusting module 411 can control any expansion valve such as the indoor expansion valve 303 or the bypass expansion valve 207.

[0067]

<Flowchart of Foreign-Matter Clogging Elimination Operation>

Fig. 6 is a flowchart of the foreign-matter clogging elimination operation according to Embodiment 1. As illustrated in Fig. 6, in the processing of the foreign-matter clogging elimination operation, first, in step S01, the controller 400 resets the clock module (not illustrated).

[0068]

In step S02, the valve opening-degree adjusting module 411 determines whether or not the indoor expansion valve 303 is controlled such that the opening degree of the indoor expansion valve 303 is constant or is controlled to be moved in the closing direction. The determination on whether the opening degree of the indoor expansion valve 303 is controlled constant or the indoor expansion valve 303 is controlled to be moved in the closing direction is made based on the control signal produced by the valve opening-degree adjusting module 411. In step S02, when the valve opening-degree adjusting module 411 of the controller 400 determines that the opening degree of the indoor expansion valve 303 is not constant or the indoor expansion valve 303 is not moved in the closing direction, the processing returns to step S01 (No in step S02). By contrast, in step S02, when the valve opening-degree adjusting module 411 of the controller 400 determines that the opening degree of the indoor expansion valve 303 is constant or the indoor expansion valve 303 is moved in the closing direction, the processing proceeds to step S03 (Yes in step S02).

[0069]

In step S03, the controller 400 stores data on a valve opening degree A, and the processing proceeds to step S04. The valve opening degree A is a valve opening degree to be set originally.

[0070]

In step S04, the flow-rate determination module 412 determines whether or not the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is higher than or equal to the flow-rate threshold Rth.

[0071]

In step S04, when the flow-rate determination module 412 determines that the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is less than the flow-rate threshold Rth, the processing returns to step S01 (NO in step S04).

[0072]

In step S04, when the flow-rate determination module 412 determines that the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is higher than or equal to the flow-rate threshold Rth, the processing proceeds to step S05 (YES in step S04).

[0073]

In step S05, the controller 400 determines whether the first time period T1 elapses or not. When the first time period T1 does not elapse, the processing returns to step S02 (NO in step S05). In step S05, when the controller 400 determines that the first time period T1 elapses, the processing proceeds to step S06 (YES in step S05).

[0074]

In step S06, the clogging determination module 413 determines that the indoor expansion valve 303 is clogged with foreign matter, and the processing proceeds to step S07. That is, when the control signal is a signal for controlling the indoor expansion valve 303 to be constant in opening degree or to be moved in the closing direction, and continuously indicates that the flow rate Rexp is higher than or equal to the flow-rate threshold Rth, for the first time period T1, the clogging determination module 413 determines that clogging with foreign matter occurs.

[0075]

In step S07, the valve opening-degree adjusting module 411 instructs the indoor expansion valve 303 to be moved such that the opening degree thereof is increased to the maximum, and the processing proceeds to step S08.

[0076]

In step S08, the controller 400 determines whether the second time period T2 elapses or not, and when the second time period T2 does not elapse, the controller 400 continues to instruct the indoor expansion valve 303 to be moved such that the opening degree thereof is increased to the maximum, until the second time period T2 elapses (No in step S08). By contrast, when the controller 400 determines in step S08 that the second time period T2 elapses, the processing proceeds to step S09 (Yes in step S08).

[0077]

In step S09, the valve opening-degree adjusting module 411 instructs the indoor expansion valve 303 to be moved such that the opening degree thereof is returned to the valve opening degree A. Thus, the processing of the foreign-matter clogging elimination operation ends.

[0078]

It should be noted that the foreign-matter clogging elimination operation at the bypass expansion valve 207 is performed in the same manner as at the indoor expansion valve 303. In this case, the comparison between the flow rate Rexp of the refrigerant on the downstream side of the bypass expansion valve 207 and the flow-rate threshold Rth is made based on the degree of superheat of suction gas at the compressor 201 that is based on a detection value obtained by detection by the first outdoor refrigerant-temperature sensor 208. The other controls are the same as those in the foreign-matter clogging elimination operation at the indoor expansion valve 303.

[0079]

In the air-conditioning apparatus 100 according to Embodiment 1 as described above, the clogging determination module 413 determines that clogging with foreign matter occurs, based on the control signal produced by the valve opening-degree adjusting module 411 and the result of the comparison by the flow-rate determination module 412. That is, the control of the opening degree of the indoor expansion valve 303 is performed such that the opening degree thereof is made constant or the indoor expansion valve 303 is moved in the closing direction, by the valve opening-degree adjusting module 411 and the flow-rate determination module 412, and it is determined whether or not the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 continues to be higher than or equal to the flow-rate threshold Rth. When it is determined that the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 continues to be higher than or equal to the flow-rate threshold Rth, it is determined that the indoor expansion valve 303 is clogged with foreign matter. Thus, in Embodiment 1, it is possible to early eliminate clogging with foreign matter, prevent a liquid back that would be caused by the clogging with foreign matter, and reduce damage to the compressor 201.

[0080]

When the degree of superheat at the indoor heat exchanger 301 is less than the degree-of-superheat threshold, the clogging determination module 413 determines that the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is higher than or equal to the flow-rate threshold Rth. The degree of superheat at the indoor heat exchanger 301 can be determined from the difference between the temperature detected by the first indoor refrigerant-temperature sensor 304 and that by the second indoor refrigerant-temperature sensor 305. Thus, an additional structure is not required, and it is possible to determine whether clogging with foreign matter occurs or not based on detection values obtained by the provided sensors.

[0081]

When the degree of supercooling at the indoor heat exchanger 301 is less than a degree-of-supercooling threshold, the clogging determination module 413 determines that the flow rate Rexp of the refrigerant on the downstream side of the indoor expansion valve 303 is higher than or equal to the flow-rate threshold Rth. The degree of supercooling at the indoor heat exchanger 301 can be determined from the temperatures detected by the first indoor refrigerant-temperature sensor 304 and the second indoor refrigerant-temperature sensor 305. Thus, an additional structure is not required, and it is possible to determine whether clogging with foreign matter occurs or not based on detection values obtained by the provided sensors.

[0082]

When the degree of superheat of the suction gas at the compressor 201 based on a detection value obtained by the first outdoor refrigerant-temperature sensor 208 is less than the degree-of-superheat threshold, the clogging determination module 413 determines that the flow rate Rexp of the refrigerant on the downstream side of the bypass expansion valve 207 is higher than or equal to the flow-rate threshold Rth. Thus, an addition structure is not required, and it is possible to determine whether clogging with foreign matter occurs or not based on values obtained by detection by the provided detectors.

[0083]

Furthermore, when the clogging determination module 413 determines that clogging with foreign matter occurs, the valve opening-degree adjusting module 411 controls the indoor expansion valve 303 such that the opening degree thereof is increased to the maximum. Thus, the amount of refrigerant that flows into the indoor expansion valve 303 is increased and the foreign matter is pushed out by the refrigerant. It is therefore possible to clear the foreign matter with which the indoor expansion valve 303 is cogged.

[0084]

<Modification>

Fig. 7 is a flowchart of the foreign-matter clogging elimination operation in a modification of the foreign-matter clogging elimination operation in an air-conditioning apparatus 100 of a modification of Embodiment 1. In the air-conditioning apparatus 100, in each of the plurality of indoor units 300, there is a possibility that the indoor expansion valve 303 may be clogged with foreign matter.

[0085]

When it is determined that clogging with foreign matter occurs in the plurality of indoor units 300, the controller 400 causes the indoor expansion valves 303 of the plurality of indoor units 300 to be successively subjected to the foreign-matter clogging elimination operation from a first one of the indoor expansion valves that is first determined to be clogged with foreign matter. In the foreign-matter clogging elimination operation, the opening degree of each of the indoor expansion valves 303 is increased to the maximum.

[0086]

As illustrated in Fig. 7, the clogging determination module 413 executes the processes of step S01 to step S05 as indicated in Fig. 6. The clogging determination module 413 executes the processes of step S01 to step S05 on the indoor expansion valves 303 of the plurality of indoor units 300 in parallel.

[0087]

In step S11, when the clogging determination module 413 determines that one of the indoor expansion valves 303 is clogged with foreign matter, the processing proceeds to step S12.

[0088]

In step S12, the controller 400 determines, of the indoor expansion valves 303 of the plurality of indoor units 300, whether an indoor expansion valve 303 that is other than the above one indoor expansion valve 303 clogged with foreign matter and that is being subjected to the foreign-matter clogging elimination operation is present or not.

[0089]

In step S12, the controller 400 determines that an indoor expansion valve 303 that is other than the above one indoor expansion valve 303 and that is being subjected to the foreign-matter clogging elimination operation is present, the processing proceeds to step S13 (YES in step S12). In step S13, the controller 400 is on standby until the foreign-matter clogging elimination operation on the above other indoor expansion valve 303 ends, and the processing proceeds to step S14 after the foreign-matter clogging elimination operation ends.

[0090]

By contrast, in step S12, when the controller 400 determines that an indoor expansion valve 303 that is other than the above one indoor expansion valve 303 and that is being subjected to the foreign-matter clogging elimination operation is not present, the processing proceeds to step S14 (No in step S12).

[0091]

In step S14, the valve opening-degree adjusting module 411 controls the above one indoor expansion valve 303 such that the opening degree thereof is increased to the maximum, executes the processes of step S08 to step S09 as indicated in Fig. 9, and ends the processing.

[0092]

In the air-conditioning apparatus 100 of the modification as described above, when the clogging determination module 413 determines that the plurality of indoor expansion valves 303 are clogged with foreign matter, the valve opening-degree adjusting module 411 controls the indoor expansion valves 303 in turn such that the opening degrees thereof are increased to the maximum. Thus, since the indoor expansion valves 303 are not subjected to the foreign-matter clogging elimination operation at the same time, it is possible to reduce lowering of the operation performance of air-conditioning apparatus 100 during the foreign-matter clogging elimination operation.

[0093]

Embodiment 2

<Configuration of Air-Conditioning Apparatus 100>

Fig. 8 is a refrigerant circuit diagram of an air-conditioning apparatus 100 according to Embodiment 2. As illustrated in Fig. 8, in the air-conditioning apparatus 100, the accumulator 205 is provided with a float sensor 205a. In this regard, Embodiment 2 is different from Embodiment 1. In Embodiment 2, the other configurations are the same as those in Embodiment 1, their descriptions will thus be omitted, and components that are the same as or equivalent to those in Embodiment 1 will be denoted by the same reference signs.

[0094]

Fig. 9 is a function block diagram of the controller 400 according to Embodiment 2. As illustrated in Fig. 9, the float sensor 205a is connected to the flow-rate determination module 412 which is provided in the controller 400 and to which the first indoor refrigerant-temperature sensor 304, the second indoor refrigerant-temperature sensor 305, and the first outdoor refrigerant-temperature sensor 208 are connected. Fig. 9 illustrates the bypass expansion valve 207, which is one of expansion valves whose opening degrees are adjusted by the valve opening-degree adjusting module 411.

[0095]

The float sensor 205a provided in the accumulator 205 is configured to detect the amount of refrigerant that is stored in the accumulator 205, as a refrigerant amount. The refrigerant amount detected by the float sensor 205a is transmitted to the controller 400.

[0096]

When the refrigerant amount detected by the float sensor 205a is increased by a certain amount for a certain time period, the flow-rate determination module 412 determines that the flow rate is higher than or equal to the flow-rate threshold Rth. When the valve opening-degree adjusting module 411 controls the indoor expansion valve 303 such that the opening degree thereof is made constant or the indoor expansion valve 303 is moved in the closing direction, and the flow-rate determination module 412 determines that the flow rate is higher than or equal to the flow-rate threshold Rth, the clogging determination module 413 determines that the bypass expansion valve 207 is clogged with foreign matter. Then, the valve opening-degree adjusting module 411 controls the bypass expansion valve 207 such that the opening degree thereof is increased to the maximum, and performs the foreign-matter clogging elimination operation. In such a manner, it is possible to determine whether or not to perform the foreign-matter clogging elimination operation on the bypass expansion valve 207 on the basis of the foreign-matter clogging elimination operation when an increased amount of the refrigerant amount detected by the float sensor 205a is higher than or equal to a refrigerant-amount threshold that is a threshold for the refrigerant amount.

[0097]

In the air-conditioning apparatus 100 according to Embodiment 2 as described above, the float sensor 205a determines that the flow rate Rexp on the downstream side of the bypass expansion valve 207 is higher than or equal to the flow-rate threshold Rth. In such a manner, in the case where the air-conditioning apparatus 100 includes the float sensor 205a, an additional structure is not required, and it is possible to determine that clogging with foreign matter occurs, using the value obtained by the detection by the provided sensor.

[0098]

It should be noted that Embodiments 1 and 2 may be combined.

Reference Signs List

[0099]

10: pipe, 20: refrigerant circuit, 30: main body, 30a: first through hole, 30b: second through hole, 31: valve body, 31a: cylindrical portion, 31b:conical portion, 33: valve chamber, 37: first joint pipe, 38: second joint pipe, 100: air-conditioning apparatus, 101: extension pipe, 102: refrigerant pipe, 103a: first refrigerant pipe, 103b: second refrigerant pipe, 103c: third refrigerant pipe, 104: bypass pipe, 105: strainer, 200: outdoor unit, 201: compressor, 202: outdoor heat exchanger, 203: outdoor fan, 203a:

motor, 204: flow switching device, 205: accumulator, 205a: float sensor, 206: refrigerant heat exchanger, 207: bypass expansion valve, 208: first outdoor refrigerant-temperature sensor, 209: outdoor expansion valve, 300: indoor unit, 301: indoor heat exchanger, 303: indoor expansion valve, 303a: opening, 304: first indoor refrigerant-temperature sensor, 305: second indoor refrigerant-temperature sensor, 306: indoor fan, 306a: motor, 400: controller, 411: valve opening-degree adjusting module, 412: flow-rate determination module, 413 clogging determination module

CLAIMS

[Claim 1]

An air-conditioning apparatus comprising:

a refrigerant circuit in which a compressor, an outdoor heat exchanger, an expansion valve, and an indoor heat exchanger are connected by pipes; and

a controller configured to control an opening degree of the expansion valve,

wherein the controller includes,

a valve opening-degree adjusting module configured to produce a control signal for control of the opening degree of the expansion valve,

a flow-rate determination module configured to compare a flow rate of refrigerant on a downstream side of the expansion valve with a threshold for the flow rate of the refrigerant on the downstream side of the expansion valve, and

a clogging determination module configured to determine that the expansion valve is clogged with foreign matter, when the control signal produced by the valve opening-degree adjusting module is a control signal to control the expansion valve such that the opening degree of the expansion valve is made constant or such that the expansion valve is moved in a closing direction in which the expansion valve is closed, and a result of comparison by the flow-rate determination module indicates that the flow rate of the refrigerant on the downstream side of the expansion valve is higher than or equal to the threshold for the flow rate of the refrigerant on the downstream side of the expansion valve.

[Claim 2]

The air-conditioning apparatus of claim 1, wherein

the flow-rate determination module is configured to compare a degree of superheat at the indoor heat exchanger with a degree-of-superheat threshold, thereby comparing the flow rate of the refrigerant on the downstream side of the expansion valve with the threshold for the flow rate of the refrigerant on the downstream side of the expansion valve, and

the clogging determination module is configured to determine that the flow rate of the refrigerant on the downstream side of the expansion valve is higher than or equal to the threshold for the flow rate of the refrigerant on the downstream side of the expansion valve, when the result of the comparison by the flow-rate determination module indicates that the degree of superheat at the indoor heat exchanger is less than the degree-of-superheat threshold.

[Claim 3]

The air-conditioning apparatus of claim 1 or 2, wherein

the flow-rate determination module is configured to compare a degree of supercooling at the indoor heat exchanger with a degree-of-supercooling threshold, thereby comparing the flow rate of the refrigerant on the downstream side of the expansion valve with the threshold for the flow rate of the refrigerant on the downstream side of the expansion valve, and

the clogging determination module is configured to determine that the flow rate of the refrigerant on the downstream side of the expansion valve is higher than or equal to the threshold for the flow rate of the refrigerant on the downstream side of the expansion valve, when the result of the comparison by the flow-rate determination module indicates that the degree of supercooling at the indoor heat exchanger is less than the degree-of-supercooling threshold.

[Claim 4]

The air-conditioning apparatus of any one of claims 1 to 3, wherein

the expansion valve includes a bypass expansion valve provided at a bypass pipe that branches off from the pipe connecting the outdoor heat exchanger and the expansion valve and that joins the pipe connected to a suction side of the compressor,

the flow-rate determination module is configured to compare a degree of superheat of suction gas with a threshold for the degree of superheat of the suction gas, thereby comparing the flow rate of the refrigerant on a downstream side of the bypass expansion valve with a threshold for the flow rate of the refrigerant on the downstream side of the bypass expansion valve, and

the clogging determination module is configured to determine that the flow rate of the refrigerant on the downstream side of the bypass expansion valve is higher than or equal to the threshold for the flow rate of the refrigerant on the downstream side of the bypass expansion valve, when the result of the comparison by the flow-rate determination module indicates that the degree of superheat of the suction gas is less than the threshold for the degree of superheat of the suction gas.

[Claim 5]

The air-conditioning apparatus of any one of claims 1 to 4, further comprising an accumulator connected to the refrigerant circuit, wherein

the expansion valve includes a bypass expansion valve provided at a bypass pipe that branches off from the pipe connecting between the outdoor heat exchanger and the expansion valve and that joins the pipe connected to a suction side of the compressor,

the flow-rate determination module is configured to compare an increased amount of an amount of refrigerant in the accumulator with a refrigerant-amount threshold that is a threshold for the amount of the refrigerant, thereby comparing the flow rate of the refrigerant on a downstream side of the bypass expansion valve with a threshold for the flow rate of the refrigerant on the downstream side of the bypass expansion valve, and

the clogging determination module is configured to determine that the flow rate of the refrigerant on the downstream side of the bypass expansion valve is higher than or equal to the threshold for the flow rate of the refrigerant on the downstream side of the bypass expansion valve, when the result of the comparison by the flow-rate determination module indicates that the increased amount of the amount of the refrigerant in the accumulator is higher than or equal to the refrigerant-amount threshold.

[Claim 6]

The air-conditioning apparatus of any one of claims 1 to 5, wherein the valve opening-degree adjusting module is configured to control the expansion valve in such a manner as to increase the opening degree of the expansion valve to the maximum, when the clogging determination module determines that the expansion valve is clogged with the foreign matter.

[Claim 7]

The air-conditioning apparatus of any one of claims 1 to 6, wherein

a plurality of expansion valves identical to the expansion valve are provided, and

the valve opening-degree adjusting module is configured to control the plurality of expansion valves in turn in such a manner as to increase the opening degree of each of the plurality of expansion valves to the maximum for a time period determined in advance, when the clogging determination module determines that the plurality of expansion valves are clogged with foreign matter.

[Claim 8]

The air-conditioning apparatus of any one of claims 1 to 7, wherein the clogging determination module is configured to determine that the expansion valve is clogged with the foreign matter, when the control signal produced by the valve opening-degree adjusting module is a control signal to control the expansion valve such that the opening degree of the expansion valve is made constant or the expansion valve is moved in the closing direction, and the result of the comparison by the flow-rate determination module indicates that the flow rate of the refrigerant on the downstream side of the expansion valve continues to be higher than or equal to the threshold for the flow rate of the refrigerant on the downstream side of the expansion valve for a certain time period.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/027281

A. CLASSIFICATION OF SUBJECT MATTER
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FI: F24F11/38, F24F11/49

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F24F11/38, F24F11/49

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 1971-2020
Registered utility model specifications of Japan 1996-2020
Published registered utility model applications of Japan 1994-2020

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 A	JP 07-055299 A (MITSUBISHI ELECTRIC CORP.) 03 March 1995, paragraphs [0018], [0022], [0037], [0038], [0043], fig. 19, 24	1-3, 6-8 4-5
Y	WO 2014/203356 A1 (MITSUBISHI ELECTRIC CORP.) 24 December 2014, paragraphs [0069], [0075]	1-3, 6-8
Y	JP 2010-230258 A (SANYO ELECTRIC CO., LTD.) 14 October 2010, paragraphs [0006], [0012], [0013]	1-3, 6-8
Y	JP 2016-84969 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 19 May 2016, paragraphs [0055], [0056]	1-3, 6-8
A	JP 2008-249203 A (SANYO ELECTRIC CO., LTD.) 16 October 2008	1-8

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

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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 2010-65982 A (MITSUBISHI ELECTRIC CORP.) 25 March 2010	1-8
A	JP 2020-91079 A (MITSUBISHI ELECTRIC CORP.) 11 June 2020	1-8

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/027281

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JP 07-055299 A	03.03.1995	(Family: none)	
WO 2014/203356 A1	24.12.2014	EP 3012556 A1 paragraphs [0079], [0087]	
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JP 2020-91079 A	11.06.2020	(Family: none)	