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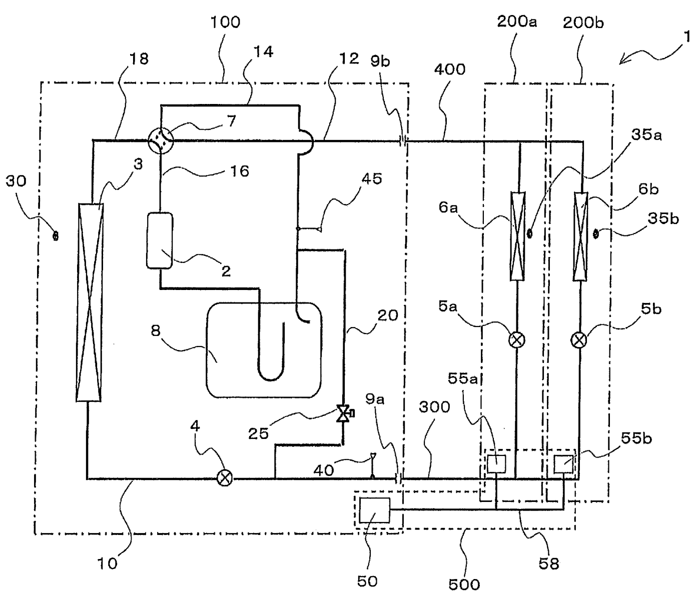
(54) AIR-CONDITIONING DEVICE AND OPERATION CONTROL DEVICE

(57) An air-conditioning apparatus (1) includes a controller (500) (operation control device). During a cooling operation, when an outside air temperature of outdoor air supplied to a heat source-side heat exchanger (3) exceeds a reference outside air temperature, and when a total load capacity of at least one load-side unit (first load-side unit 200a and/or second load-side unit 200b) is reduced over time, the controller (500) (operation control device) adjusts an opening degree of a pressure reducing device (heat source-side pressure reducing device 4) in accordance with a reduction amount of the total load capacity.

FIG. 1



EP 3 306 214 A1

Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus capable of reusing existing pipes and an operation control device capable of controlling the air-conditioning apparatus.

Background Art

[0002] Hitherto, an air-conditioning apparatus capable of reusing existing pipes has been known which controls a parameter such as the operating frequency of a compressor or the opening degree of a pressure reducing device, for example, to prevent the pressure of refrigerant in the existing pipes from exceeding a pressure-withstanding reference value (Patent Literature 1, for example).

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2002-162126

Summary of Invention

Technical Problem

[0004] According to the air-conditioning apparatus of Patent Literature 1, however, when a load capacity (operation capacity) of an indoor unit is reduced during a cooling operation in an environment in which an outside air temperature is higher than that in a normal environment (hereinafter referred to as "high outside air temperature environment"), the reduction increases the possibility that the pressure of the refrigerant in the existing pipes increases to be higher than that in a normal cooling operation. With an increase in possibility that the pressure of the refrigerant in the existing pipes exceeds the pressure-withstanding reference value, therefore, the frequency of abnormal stop of the air-conditioning apparatus due to pressure anomaly is increased in the air-conditioning apparatus of Patent Literature 1, thereby raising an issue of difficulty in maintaining reliability of the air-conditioning apparatus.

[0005] The present invention has been made to solve the above-described issue, and aims to provide an air-conditioning apparatus and an operation control device, which are capable of controlling the pressure of the refrigerant in existing pipes to have a value less than a pressure-withstanding reference value even during a cooling operation in a high outside air temperature environment.

Solution to Problem

[0006] According to one embodiment of the present invention, there is provided an air-conditioning apparatus, including: a refrigeration cycle including a compressor, a heat source-side heat exchanger, a pressure reducing device, and a load-side heat exchanger connected via refrigerant pipes to allow refrigerant to circulate through the refrigeration cycle to perform at least a cooling operation with the heat source-side heat exchanger functioning as a radiator and the load-side heat exchanger functioning as an evaporator; a heat source-side unit housing the compressor, the heat source-side heat exchanger, and the pressure reducing device; at least one load-side unit housing the load-side heat exchanger, and being connected to the heat source-side unit via existing refrigerant pipes; and a controller configured to control the refrigeration cycle. During the cooling operation, when an outside air temperature of outdoor air supplied to the heat source-side heat exchanger exceeds a reference outside air temperature, and when a total load capacity of the at least one load-side unit is reduced over time, the controller adjusts an opening degree of the pressure reducing device in accordance with a reduction amount of the total load capacity.

[0007] Further, according to one embodiment of the present invention, there is provided an operation control device, which is configured to control an air-conditioning apparatus including a refrigeration cycle including a compressor, a heat source-side heat exchanger, a pressure reducing device, and a load-side heat exchanger connected via refrigerant pipes to allow refrigerant to circulate through the refrigeration cycle to perform at least a cooling operation with the heat source-side heat exchanger functioning as a radiator and the load-side heat exchanger functioning as an evaporator, the compressor, the heat source-side heat exchanger, and the pressure reducing device being housed in a heat source-side unit, the load-side heat exchanger being housed in at least one load-side unit connected to the heat source-side unit via existing refrigerant pipes. During the cooling operation, when an outside air temperature of outdoor air supplied to the heat source-side heat exchanger exceeds a reference outside air temperature, and when a total load capacity of the at least one load-side unit is reduced over time, the operation control device adjusts an opening degree of the pressure reducing device in accordance with a reduction amount of the total load capacity.

Advantageous Effects of Invention

[0008] According to one embodiment of the present invention, it is possible to adjust the opening degree of the heat source-side pressure reducing device in accordance with the reduction in total load capacity of the at least one load-side unit, thereby being capable of controlling the pressure of the refrigerant in the existing pipe to have a value equal to or less than a pressure-withstanding reference value. Accordingly, according to one embodiment of the present invention, it is possible to provide a reliable air-conditioning apparatus and a reliable operation control device, which are capable of reducing the frequency of abnormal stop of the air-conditioning apparatus due to pressure anomaly.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a schematic refrigerant circuit diagram for illustrating an example of an air-conditioning apparatus 1 according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a flowchart for illustrating an example of control processing performed by a controller 500 of the air-conditioning apparatus 1 according to Embodiment 1 of the present invention during a cooling operation.

[Fig. 3] Fig. 3 is a flowchart for illustrating an example of control processing performed by the controller 500 of the air-conditioning apparatus 1 according to Embodiment 2 of the present invention during the cooling operation.

Description of Embodiments

Embodiment 1

[0010] An air-conditioning apparatus 1 (refrigerating and air-conditioning apparatus) according to Embodiment 1 of the present invention is described. Fig. 1 is a schematic refrigerant circuit diagram for illustrating an example of the air-conditioning apparatus 1 according to Embodiment 1. In the following drawings including Fig. 1, the dimensional relationships between component members and the shapes of the component members may be different from actual ones.

[0011] As illustrated in Fig. 1, the air-conditioning apparatus 1 includes a heat source-side unit 100 (heat source unit), which is an outdoor unit, and a first load-side unit 200a and a second load-side unit 200b, which are indoor units arranged in parallel to the heat source-side unit 100. The heat source-side unit 100 is connected to each of the first load-side unit 200a and the second load-side unit 200b by a first extension refrigerant pipe 300 (liquid pipe) and a second extension refrigerant pipe 400 (gas pipe), which are existing pipes. Although, in Fig. 1, there is illustrated a configuration having two load-side units connected to the heat source-side unit 100, the number of load-side units connected to the heat source-side unit 100 may be one, or may be three or a greater number.

[0012] The air-conditioning apparatus 1 of Embodiment 1 includes a single-system refrigeration cycle (refrigerant circuit) configured to sequentially circulate refrigerant through a compressor 2, a heat source-side heat exchanger 3, a heat source-side pressure reducing device 4, a first load-side pressure reducing device 5a and a second load-side pressure reducing device 5b, a first load-side heat exchanger 6a and a second load-side heat exchanger 6b, a refrigerant flow switching device 7, and an accumulator 8.

[0013] The compressor 2 is a frequency-changeable fluid machine housed in the heat source-side unit 100 to compress sucked low-pressure refrigerant and discharge the compressed refrigerant as high-pressure refrigerant. For example, a scroll compressor having a rotation frequency controlled by an inverter may be employed as the compressor 2.

[0014] The heat source-side heat exchanger 3 (outdoor unit heat exchanger) is a heat exchanger functioning as a radiator (condenser) during a cooling operation and functioning as an evaporator during a heating operation, and is housed in the heat source-side unit 100. The heat source-side heat exchanger 3 is configured to exchange heat between the refrigerant flowing through the heat source-side heat exchanger 3 and outside air (outdoor air, for example) sent by a heat source-side heat exchanger fan (not shown). The heat source-side heat exchanger 3 may be configured as a fin-and-tube heat exchanger of a cross-fin type formed of a heat transfer tube and a plurality of fins, for example.

[0015] A first heat source-side refrigerant pipe 10 (outdoor unit liquid line) is housed in the heat source-side unit 100, and has one terminal end portion connected to the heat source-side heat exchanger 3. The other terminal end portion of the first heat source-side refrigerant pipe 10 is connected to the first extension refrigerant pipe 300 with a first extension refrigerant pipe connecting valve 9a (liquid operation valve) provided on the first heat source-side refrigerant pipe 10. The first extension refrigerant pipe connecting valve 9a is formed of a two-way valve, such as a bidirectional solenoid valve, which is capable of switching between the open state and the closed state, for example.

[0016] The heat source-side pressure reducing device 4 expands high-pressure liquid refrigerant flowing from the heat source-side heat exchanger 3 during the cooling operation to reduce the pressure of the refrigerant, and allows the refrigerant to flow into the first extension refrigerant pipe 300, which is an existing pipe. The heat source-side pressure reducing device 4 is housed in the heat source-side unit 100 and provided to the first heat source-side refrigerant pipe 10. For example, an electronic expansion valve, such as a linear electronic expansion valve (LEV), which has an opening degree adjustable to multiple levels or continuously adjustable, is employed as the heat source-side pressure reducing device 4, and is configured as an outdoor electronic expansion valve. The heat source-side pressure reducing device 4 may be configured to further expand intermediate-pressure liquid refrigerant or two-phase refrigerant flowing into the first heat source-side refrigerant pipe 10 from the first extension refrigerant pipe 300 during the heating operation to reduce the pressure of the refrigerant, and allow the refrigerant to flow into the heat source-side heat exchanger 3.

[0017] The first load-side pressure reducing device 5a and the second load-side pressure reducing device 5b further expand the intermediate-pressure liquid refrigerant or the two-phase refrigerant flowing from the first extension refrigerant pipe 300 during the cooling operation to reduce the pressure of the refrigerant, and allow the refrigerant to flow into the first load-side heat exchanger 6a and the second load-side heat exchanger 6b, respectively. The first load-side pressure reducing device 5a is housed in the first load-side unit 200a, and the second load-side pressure reducing device 5b is housed in the second load-side unit 200b. For example, an electronic expansion valve, such as a linear electronic expansion valve, which has an opening degree adjustable to multiple levels or continuously adjustable, is employed as each of the first load-side pressure reducing device 5a and the second load-side pressure reducing device 5b, and is configured as an indoor electronic expansion valve.

[0018] When the cooling operation or the heating operation of the first load-side unit 200a are stopped, the first load-side pressure reducing device 5a is adjusted to be closed. Similarly, when the cooling operation or the heating operation of the second load-side unit 200b are stopped, the second load-side pressure reducing device 5b is adjusted to be closed. Further, the first load-side pressure reducing device 5a may be configured to expand high-pressure liquid refrigerant flowing from the first load-side heat exchanger 6a during the heating operation to reduce the pressure of the refrigerant, and allow the refrigerant to flow into the first extension refrigerant pipe 300, which is an existing pipe. Similarly, the second load-side pressure reducing device 5b may be configured to expand high-pressure liquid refrigerant flowing from the second load-side heat exchanger 6b during the heating operation to reduce the pressure of the refrigerant, and allow the refrigerant to flow into the first extension refrigerant pipe 300, which is an existing pipe.

[0019] Each of the first load-side heat exchanger 6a and the second load-side heat exchanger 6b (outdoor unit heat exchangers) is a heat exchanger functioning as an evaporator during the cooling operation and functioning as a radiator during the heating operation. The first load-side heat exchanger 6a and the second load-side heat exchanger 6b are configured to exchange heat between the refrigerant flowing through the first load-side heat exchanger 6a and the second load-side heat exchanger 6b and outside air (indoor air, for example). Each of the first load-side heat exchanger 6a and the second load-side heat exchanger 6b may be configured as a fin-and-tube heat exchanger of a cross-fin type formed of a heat transfer tube and a plurality of fins, for example.

[0020] The first load-side heat exchanger 6a is housed in the first load-side unit 200a, and the second load-side heat exchanger 6b is housed in the second load-side unit 200b. Further, the air-conditioning apparatus 1 of Embodiment 1 may be configured to supply the outside air to the first load-side heat exchanger 6a and the second load-side heat exchanger 6b through air-sending by respective load-side heat exchanger fans (not shown).

[0021] The refrigerant flow switching device 7 switches the flow direction of the refrigerant in the refrigeration cycle in switching between the cooling operation and the heating operation, and is housed in the heat source-side unit 100. For example, a four-way valve is employed as the refrigerant flow switching device 7.

[0022] A fifth heat source-side refrigerant pipe 18 is connected between the refrigerant flow switching device 7 and the heat source-side heat exchanger 3. A third heat source-side refrigerant pipe 14 (pre-accumulator pipe) is connected between the refrigerant flow switching device 7 and a refrigerant inflow port of the accumulator 8. A fourth heat source-side refrigerant pipe 16 is connected between the refrigerant flow switching device 7 and a discharge port of the compressor 2. A second heat source-side refrigerant pipe 12 is connected between the refrigerant flow switching device 7 and the second extension refrigerant pipe 400.

[0023] The refrigerant flow switching device 7 is configured to allow the refrigerant to flow from the second heat source-side refrigerant pipe 12 into the third heat source-side refrigerant pipe 14 and from the fourth heat source-side refrigerant pipe 16 into the fifth heat source-side refrigerant pipe 18 during the cooling operation. The refrigerant flow switching device 7 is further configured to allow the refrigerant to flow from the fifth heat source-side refrigerant pipe 18 into the third heat source-side refrigerant pipe 14 and from the fourth heat source-side refrigerant pipe 16 into the second heat source-side refrigerant pipe 12 during the heating operation.

[0024] The second heat source-side refrigerant pipe 12, the third heat source-side refrigerant pipe 14, the fourth heat source-side refrigerant pipe 16, and the fifth heat source-side refrigerant pipe 18 are housed in the heat source-side unit 100. Further, the second heat source-side refrigerant pipe 12 is connected to the second extension refrigerant pipe 400 with a second extension refrigerant pipe connecting valve 9b (gas operation valve) provided on the second heat source-side refrigerant pipe 12. The second extension refrigerant pipe connecting valve 9b is formed of a two-way valve, such as a bidirectional solenoid valve, which is capable of switching between the open state and the closed state, for example.

[0025] The accumulator 8 has a refrigerant storage function of storing excess refrigerant and a gas-liquid separation function of retaining liquid refrigerant temporarily generated at a time of change in the operating state to prevent influx of a large amount of liquid refrigerant into the compressor 2. The accumulator 8 is arranged on a suction pipe side of the compressor 2 and housed in the heat source-side unit 100.

[0026] A description is now given of a configuration of a bypass refrigerant circuit of the heat source-side unit 100 provided in the air-conditioning apparatus 1 according to Embodiment 1.

[0027] The heat source-side unit 100 includes a bypass refrigerant pipe 20 (high-low pressure bypass pipe) branching from the first heat source-side refrigerant pipe 10 at a position between the heat source-side pressure reducing device 4 and the first extension refrigerant pipe connecting valve 9a. The bypass refrigerant pipe 20 has a terminal end portion connected to the third heat source-side refrigerant pipe 14 at a position between the refrigerant flow switching device 7 and the accumulator 8. That is, the bypass refrigerant pipe 20 is a refrigerant pipe serving as a bypass between the first heat source-side refrigerant pipe 10, which is a refrigerant pipe on the refrigerant outflow port side of the heat source-side pressure reducing device 4, and the third heat source-side refrigerant pipe 14, which is a refrigerant pipe connected to the refrigerant inflow port side of the accumulator 8.

[0028] The bypass refrigerant pipe 20 is provided with a solenoid valve 25, which is a valve configured to open or close a passage with power supply to the valve or the stop of power supply to the valve. The solenoid valve 25 allows the refrigerant flowing into the first heat source-side refrigerant pipe 10 to flow into the accumulator 8. The solenoid valve 25 has a capacity coefficient (CV value) that enables the pressure of high-pressure or intermediate-pressure refrigerant flowing into the first heat source-side refrigerant pipe 10 to be reduced to a low pressure. The solenoid valve 25 is formed of a two-way valve, such as a bidirectional solenoid valve, which is capable of switching between the open state and the closed state, for example.

[0029] Sensors arranged in the air-conditioning apparatus 1 according to Embodiment 1 are now described.

[0030] The air-conditioning apparatus 1 according to Embodiment 1 includes a first temperature sensor 30, a second temperature sensor 35a, a first pressure sensor 40, and a second pressure sensor 45.

[0031] The first temperature sensor 30 is an outside air temperature sensor (outdoor temperature sensor) configured to detect the temperature of the outside air (outdoor air) sucked and sent to the heat source-side heat exchanger 3 by a heat source-side air-sending fan (not shown). The first temperature sensor 30 is arranged on the upstream side of the heat source-side air-sending fan (not shown), for example. The second temperature sensor 35a may serve as an outside air temperature sensor (indoor unit suction temperature sensor) configured to detect the temperature of the indoor air sucked and sent to the first load-side heat exchanger 6a by a corresponding load-side air-sending fan (not shown) housed in the first load-side unit 200a, for example. When the second temperature sensor 35a is configured as an outside air temperature sensor, the second temperature sensor 35a is arranged on the upstream side of the corresponding load-side air-sending fan (use-side air-sending device), for example. A third temperature sensor 35b may serve as an outside air temperature sensor (indoor unit suction temperature sensor) configured to detect the temperature of the indoor air sucked and sent to the second load-side heat exchanger 6b by a corresponding load-side air-sending fan (not shown) housed in the second load-side unit 200b, for example. When the third temperature sensor 35b is configured as an outside air temperature sensor, the third temperature sensor 35b is arranged on the upstream side of the corresponding load-side air-sending fan (use-side air-sending device), for example.

[0032] The first pressure sensor 40 is a pressure sensor (intermediate-pressure sensor) configured to detect a pressure P of the refrigerant flowing through the first heat source-side refrigerant pipe 10 on the refrigerant outflow port side of the heat source-side pressure reducing device 4 during the cooling operation. That is, the first pressure sensor 40 is arranged on the first heat source-side refrigerant pipe 10 at a position between the heat source-side pressure reducing device 4 and the first extension refrigerant pipe connecting valve 9a. The second pressure sensor 45 is a pressure sensor (low-pressure-side pressure sensor) configured to detect a low-pressure-side pressure of a mixture of the refrigerant flowing from an outlet of the first load-side heat exchanger 6a and the refrigerant flowing from an outlet of the second load-side heat exchanger 6b during the cooling operation. During the heating operation, the second pressure sensor 45 detects the pressure of the refrigerant flowing from an outlet of the heat source-side heat exchanger 3. The second pressure sensor 45 is arranged on the third heat source-side refrigerant pipe 14.

[0033] A material such as a semiconductor (thermistor, for example) or a metal (resistance temperature detector, for example) is employed as the material of the first temperature sensor 30, the second temperature sensor 35a, and the third temperature sensor 35b. Further, a device such as a quartz piezoelectric pressure sensor, a semiconductor sensor, or a pressure transducer is employed as the first pressure sensor 40 and the second pressure sensor 45. The first temperature sensor 30, the second temperature sensor 35a, and the third temperature sensor 35b may be made of the same material, or may be made of different materials. Further, the first pressure sensor 40 and the second pressure sensor 45 may be formed of the same type of devices, or may be formed of different types of devices.

[0034] A description is now given of a controller 500 (operation control device) configured to control the entirety of the air-conditioning apparatus 1 according to Embodiment 1.

[0035] The controller 500 according to Embodiment 1 includes a first control unit 50 (outdoor unit-side control device) configured to control the operating state of the heat source-side unit 100, a second control unit 55a (indoor unit-side control device) configured to control the operating state of the first load-side unit 200a, and a third control unit 55b (indoor unit-side control device) configured to control the operating state of the second load-side unit 200b.

[0036] Each of the first control unit 50, the second control unit 55a, and the third control unit 55b includes a microcomputer including components such as a CPU, memories (ROM and RAM, for example), and an I/O port. The controller 500 is configured such that the first control unit 50 is connected to each of the second control unit 55a and the third control unit 55b by a communication line 58 to enable mutual communication therebetween, such as transmission and reception of control signals therebetween. The controller 500 may be configured to enable wireless communication between the first control unit 50 and the second control unit 55a and between the first control unit 50 and the third control unit 55b.

[0037] The first control unit 50 is configured to perform control of the operating state, such as the start and stop of the operation of the heat source-side unit 100, the adjustment of the opening degree of the heat source-side pressure reducing device 4, the opening and closing of the solenoid valve 25, and the adjustment of the operating frequency of the compressor 2. The first control unit 50 is further configured to include a storage unit (not shown) capable of storing a variety of data such as control target values. The first control unit 50 is further configured to receive electrical signals of temperature information detected by the first temperature sensor 30 and electrical signals of pressure information detected by the first pressure sensor 40 and the second pressure sensor 45.

[0038] The second control unit 55a is configured to perform control of the operating state, such as the start and stop of the operation of the first load-side unit 200a and the adjustment of the opening degree of the first load-side pressure reducing device 5a. The second control unit 55a is configured to measure a load capacity Q1 (operation capacity) of the first load-side unit 200a at predetermined intervals (every one minute, for example). The second control unit 55a is further configured to receive electrical signals of temperature information detected by the second temperature sensor 35a.

[0039] The third control unit 55b is configured to perform control of the operating state, such as the start and stop of the operation of the second load-side unit 200b and the adjustment of the opening degree of the second load-side pressure reducing device 5b. The third control unit 55b is configured to measure a load capacity Q2 of the second load-side unit 200b at predetermined intervals (every one minute, for example). The second control unit 55a is configured to receive electrical signals of temperature information detected by the third temperature sensor 35b.

[0040] The load capacity Q1 of the first load-side unit 200a measured by the second control unit 55a and the load capacity Q2 of the second load-side unit 200b measured by the third control unit 55b are transmitted to the first control unit 50 via the communication line 58. The first control unit 50 calculates a total load capacity Q of the first load-side unit 200a and the second load-side unit 200b with equation (1) given below, and stores the total load capacity Q in the storage unit of the first control unit 50.

$$Q = Q1 + Q2 \cdots (1)$$

[0041] An operation of the air-conditioning apparatus 1 according to Embodiment 1 during a normal cooling operation is now described.

[0042] High-temperature and high-pressure gas refrigerant discharged from the compressor 2 flows into the heat source-side heat exchanger 3. The high-temperature and high-pressure gas refrigerant flowing into the heat source-side heat exchanger 3 transfers heat to a low-temperature medium such as the outdoor air to exchange heat therewith, and turns into high-pressure liquid refrigerant. The high-pressure liquid refrigerant is expanded and reduced in pressure by the heat source-side pressure reducing device 4 provided to the first heat source-side refrigerant pipe 10 to turn into intermediate-pressure liquid refrigerant or two-phase refrigerant, and flows into the heat source-side unit 100 via the first extension refrigerant pipe 300.

[0043] The intermediate-pressure liquid refrigerant or the two-phase refrigerant flowing into the heat source-side unit 100 flows into the first load-side pressure reducing device 5a and the second load-side pressure reducing device 5b. The intermediate-pressure liquid refrigerant or the two-phase refrigerant flowing into the first load-side pressure reducing device 5a and the second load-side pressure reducing device 5b is further expanded and reduced in pressure to turn into low-temperature and low-pressure two-phase refrigerant. The low-temperature and low-pressure two-phase refrigerant flows into the first load-side heat exchanger 6a and the second load-side heat exchanger 6b, absorbs heat from a high-temperature medium such as the indoor air, and evaporates into high-quality two-phase refrigerant or low-temperature and low-pressure gas refrigerant. The high-quality two-phase refrigerant or the low-temperature and low-pressure gas refrigerant flowing from the first load-side heat exchanger 6a and the second load-side heat exchanger 6b flows into the accumulator 8 via the second extension refrigerant pipe 400, the second heat source-side refrigerant pipe 12, the refrigerant flow switching device 7, and the third heat source-side refrigerant pipe 14. A liquid-phase component of the high-quality two-phase refrigerant or the low-temperature and low-pressure gas refrigerant is removed by the accumulator 8, and thereafter the refrigerant is sucked into the compressor 2. The refrigerant sucked into the compressor 2 is compressed into high-temperature and high-pressure gas refrigerant and discharged from the compressor 2. The high-temperature and high-pressure gas refrigerant discharged from the compressor 2 flows into the heat source-side heat exchanger 3 via the fourth heat source-side refrigerant pipe 16, the refrigerant flow switching device 7, and the fifth heat source-side refrigerant pipe 18. The above-described cycle is repeated during the cooling operation of the air-conditioning apparatus 1.

[0044] During the heating operation, passages inside the refrigerant flow switching device 7 are switched from passages indicated by the solid lines to passages indicated by the broken lines, as illustrated in Fig. 1. With this configuration, the high-temperature and high-pressure gas refrigerant flows into the first load-side heat exchanger 6a and the second load-side heat exchanger 6b, and transfers heat to a low-temperature medium such as the indoor air to turn into high-pressure liquid refrigerant. Thereby, the indoor air is heated by the heat transfer action of the refrigerant.

[0045] Control processing of the controller 500 of the air-conditioning apparatus 1 according to Embodiment 1 is now described.

[0046] The controller 500 of the air-conditioning apparatus 1 according to Embodiment 1 is configured such that, during the cooling operation, when the outside air temperature of the outdoor air supplied to the heat source-side heat exchanger 3 exceeds a reference outside air temperature, and when the total load capacity Q of at least one load-side unit (first load-side unit 200a and/or second load-side unit 200b) is reduced over time, the controller 500 adjusts the opening degree of the heat source-side pressure reducing device 4 in accordance with a reduction amount of the total load capacity Q.

[0047] Fig. 2 is a flowchart for illustrating an example of the control processing performed by the controller 500 of the air-conditioning apparatus 1 according to Embodiment 1 during the cooling operation. The control processing of Fig. 2 may constantly be performed during the cooling operation, or may be performed as necessary when a fluctuation of an outside air temperature T is detected, for example.

[0048] At Step S11, the controller 500 determines whether or not the outside air temperature T detected by the first temperature sensor 30 is higher than a reference outside air temperature T0. The reference outside air temperature T0 is set to 52 degrees Celsius, for example, as a boundary value between a high outside air temperature environment and a normal outside air temperature environment. In this case, the normal temperature environment refers to an outside air temperature environment in which the fluctuation of the total load capacity Q does not cause the pressure of the refrigerant flowing through an existing pipe to exceed a pressure-withstanding reference value. When the outside air temperature T is equal to or lower than the reference outside air temperature T0, the control processing is completed, and the normal cooling operation continues.

[0049] When the outside air temperature T exceeds the reference outside air temperature T0, at Step S12, the controller 500 measures a current load capacity $Q1_{now}$ of the first load-side unit 200a and a current load capacity $Q2_{now}$ of the second load-side unit 200b, and calculates a current total load capacity Q_{now} with equation (2) given below.

$$Q_{now} = Q1_{now} + Q2_{now} \cdots (2)$$

[0050] Then, at Step S13, the controller 500 determines whether or not the current total load capacity Q_{now} is less than an immediately preceding total load capacity Q_{last} stored in the storage unit of the controller 500. When the current total load capacity Q_{now} is equal to or greater than the immediately preceding total load capacity Q_{last}, the control processing is completed, and the normal cooling operation continues.

[0051] When the current total load capacity Q_{now} is less than the immediately preceding total load capacity Q_{last}, at Step S14, the controller 500 calculates an opening degree adjustment value ΔD of the heat source-side pressure reducing device 4. The opening degree adjustment value ΔD is calculated from equation (3) given below with a correction coefficient K.

$$\Delta D = K \times (Q_{last} - Q_{now}) \cdots (3)$$

[0052] In this case, the correction coefficient K is a constant calculated and determined based on the correlation between the reduction amount of the total load capacity Q, the reduction amount of the pressure P detected by the first pressure sensor 40, and the actually measured value of the opening degree adjustment value ΔD for cancelling the fluctuation of the pressure P, for example.

[0053] Then, at Step S15, the controller 500 controls an opening degree D of the heat source-side pressure reducing device 4 to open the heat source-side pressure reducing device 4 by the opening degree adjustment value ΔD, and the control processing is completed.

[0054] Effects of the present invention provided by Embodiment 1 are now described.

[0055] As described above, the air-conditioning apparatus 1 according to Embodiment 1 includes the refrigeration cycle, the heat source-side unit 100, the at least one load-side unit, and the controller 500. The refrigeration cycle includes the compressor 2, the heat source-side heat exchanger 3, the pressure reducing device (heat source-side pressure reducing device 4), and the load-side heat exchanger (first load-side heat exchanger 6a and/or the second load-side heat exchanger 6b) connected via the refrigerant pipes (for example, first heat source-side refrigerant pipe 10 and first extension refrigerant pipe 300) to allow the refrigerant to circulate through the refrigeration cycle to perform at least the cooling operation with the heat source-side heat exchanger 3 functioning as the radiator and the load-side heat exchanger (first load-side heat exchanger 6a and/or second load-side heat exchanger 6b) functioning as the evaporator.

The heat source-side unit 100 houses the compressor 2, the heat source-side heat exchanger 3, and the pressure reducing device (heat source-side pressure reducing device 4). The at least one load-side unit (first load-side unit 200a and/or second load-side unit 200b) houses the load-side heat exchanger (first load-side heat exchanger 6a and/or second load-side heat exchanger 6b), and is connected to the heat source-side unit 100 via the existing refrigerant pipes (first extension refrigerant pipe 300 and second extension refrigerant pipe 400). The controller 500 controls the refrigeration cycle. During the cooling operation, when the outside air temperature of the outdoor air supplied to the heat source-side heat exchanger 3 exceeds the reference outside air temperature, and when the total load capacity of the at least one load-side unit (first load-side unit 200a and/or second load-side unit 200b) is reduced over time, the controller 500 adjusts the opening degree of the pressure reducing device (heat source-side pressure reducing device 4) in accordance with the reduction amount of the total load capacity.

[0056] Further, the operation control device (controller 500) according to Embodiment 1 controls the air-conditioning apparatus 1 including the refrigeration cycle in which the compressor 2, the heat source-side heat exchanger 3, and the pressure reducing device (heat source-side pressure reducing device 4), which are housed in the heat source-side unit 100, and the load-side heat exchanger (first load-side heat exchanger 6a and/or second load-side heat exchanger 6b), which is housed in the at least one load-side unit (first load-side unit 200a and/or second load-side unit 200b) connected to the heat source-side unit 100 via the existing refrigerant pipes (first extension refrigerant pipe 300 and second extension refrigerant pipe 400), are connected via the refrigerant pipes (for example, first heat source-side refrigerant pipe 10 and first extension refrigerant pipe 300) to allow the refrigerant to circulate through the refrigeration cycle to perform at least the cooling operation with the heat source-side heat exchanger 3 functioning as the radiator, and the load-side heat exchanger (first load-side heat exchanger 6a and/or second load-side heat exchanger 6b) functioning as the evaporator. During the cooling operation, when the outside air temperature of the outdoor air supplied to the heat source-side heat exchanger 3 exceeds the reference outside air temperature, and when the total load capacity of the at least one load-side unit (first load-side unit 200a and/or second load-side unit 200b) is reduced over time, the operation control device (controller 500) adjusts the opening degree of the pressure reducing device (heat source-side pressure reducing device 4) in accordance with the reduction amount of the total load capacity.

[0057] Hitherto, there has been known a refrigerating and air-conditioning apparatus including an outdoor unit and an indoor unit connected by a gas pipe and a liquid pipe. The outdoor unit includes a compressor, a four-way valve, an outdoor heat exchanger, an outdoor unit-side expansion device, and an accumulator, and the indoor unit includes an indoor-side expansion device and an indoor heat exchanger. Further, the related-art refrigerating and air-conditioning apparatus includes a model in which only the outdoor unit and the indoor unit are updated in the update of the refrigerating and air-conditioning apparatus, with the existing gas pipe and liquid pipe continuing to be used, that is, with the existing pipes (gas pipe and liquid pipe) being cleaned and reused (existing pipe reusing model).

[0058] In the refrigerating and air-conditioning apparatus to be updated, the gas pipe and the liquid pipe may have a pressure resistant design according to refrigerant characteristics of refrigerant having a low design pressure, such as R22 or R407C. Further, the updated refrigerating and air-conditioning apparatus may use refrigerant such as R410A having a design pressure higher than that of R22 or R407C. Therefore, the refrigerating and air-conditioning apparatus reusing the existing pipes has a configuration capable of performing control to prevent the pressure of the refrigerant flowing into the existing pipes from exceeding the respective pressure-withstanding reference values of the gas pipe and the liquid pipe in the outdoor unit and the indoor unit.

[0059] For example, the refrigerating and air-conditioning apparatus reusing the existing pipes may have a pressure sensor installed to an outdoor unit liquid line to detect the pressure (intermediate pressure) of the refrigerant flowing into the corresponding existing pipe. The refrigerating and air-conditioning apparatus using the pressure sensor adjusts the frequency of the compressor and the opening degree of the outdoor unit-side expansion device installed to the outdoor unit liquid line, to thereby control the pressure of the refrigerant detected by the pressure sensor so as to have a target value (target intermediate-pressure).

[0060] In recent years, due to the progression of global warming or urban heat island phenomenon, temperature in environments installed with the outdoor unit of the refrigerating and air-conditioning apparatus is liable to increase. Further, when outdoor units are installed in a concentrated manner, air inlets and air outlets of the outdoor units may be blocked. Accordingly, there occurs a short circuit causing hindrance to heat transfer from the outdoor units, thereby increasing the temperature of the air sucked by the outdoor units. Therefore, the outdoor unit of the refrigerating and air-conditioning apparatus is required to have a configuration capable of increasing the range of temperature of the outside air (outdoor air) usable by the outdoor unit (increasing allowable upper limit value of outside air temperature, for example).

[0061] During the cooling operation in the high outside air temperature environment, however, the pressure of the high-pressure-side and the pressure of the refrigerant flowing into an existing pipe increase, thereby increasing the frequency of pressure anomaly occurring in the refrigerating and air-conditioning apparatus. Meanwhile, when the load capacity of the indoor unit is reduced during the cooling operation, the timing of reduction in frequency of the compressor delays behind the timing of reduction in load capacity of the indoor unit, thereby increasing the pressure of the refrigerant flowing into the existing pipe. Therefore, the reduction in load capacity of the indoor unit during the cooling operation in the high outside air temperature environment raises a problem of an increased possibility that the pressure of the refrigerant flowing into the existing pipe may exceed the pressure-withstanding reference value.

[0062] For example, it is assumed that the refrigerating and air-conditioning apparatus includes five indoor units connected together, and that the five indoor units have the same load capacity. In this case, it is assumed that the total load capacity is 100% when all of the five indoor units are operating. During the cooling operation in the high outside air temperature environment, when the five indoor units are all operating and then four thereof are stopped, the total load capacity of the indoor units is reduced to 20%. Further, when the five indoor units are all operating and then four thereof are stopped, the respective electronic expansion valves of the four stopped indoor units are closed. When a refrigerant circulation amount of 100% is obtained under a state in which the five indoor units are all operating, in a case in which four of the indoor units are stopped, the frequency of the compressor needs to be reduced to reduce the refrigerant circulation amount to 20% to maintain the pressure of the refrigerant flowing into the existing pipe. With the delay of the timing of reduction in frequency of the compressor behind the timing of reduction in load capacity of the indoor unit, however, the pressure of the refrigerant flowing into the existing pipe temporarily increases and exceeds the pressure-withstanding reference value of the existing pipe, resulting in pressure anomaly.

[0063] In contrast, with the configuration of Embodiment 1, it is possible to control the opening degree of the heat source-side pressure reducing device 4 at the timing of detection of the reduction in load capacity. That is, with the configuration of Embodiment 1, it is possible to adjust the opening degree of the heat source-side pressure reducing device 4 in accordance with the reduction in total load capacity of the at least one load-side unit. Therefore, with the configuration of Embodiment 1, it is possible to prevent the reduction in load capacity from increasing the pressure of the refrigerant flowing through the existing pipe during the cooling operation in the high outside air temperature environment, and to control the pressure of the refrigerant flowing through the existing pipe to have a value equal to or lower than a pressure-withstanding reference value P0 (29 kg/cm^2, for example). Accordingly, with the configuration of Embodiment 1, it is possible to provide the reliable air-conditioning apparatus 1 and the reliable controller 500 (operation control device), which are capable of reducing the frequency of abnormal stop of the air-conditioning apparatus 1 due to pressure anomaly.

Embodiment 2

[0064] In Embodiment 2 of the present invention, a description is given of an example of processing of controlling the solenoid valve 25 performed by the controller 500 according to Embodiment 1 described above. Fig. 3 is a flowchart for illustrating an example of the control processing performed by the controller 500 of the air-conditioning apparatus 1 according to Embodiment 2 during the cooling operation.

[0065] In the air-conditioning apparatus 1 of Embodiment 2, the controller 500 is configured to open the solenoid valve 25 for a certain time during the cooling operation when the pressure of the refrigerant flowing through the first heat source-side refrigerant pipe 10 on the refrigerant outflow port side of the heat source-side pressure reducing device 4 exceeds the pressure-withstanding reference value of the first extension refrigerant pipe 300, which is an existing pipe.

[0066] At Step S21, the controller 500 determines whether or not the pressure P of the refrigerant flowing through the first heat source-side refrigerant pipe 10 on the refrigerant outflow port side of the heat source-side pressure reducing device 4, which is detected by the first pressure sensor 40, exceeds the pressure-withstanding reference value P0 of the first extension refrigerant pipe 300. The pressure-withstanding reference value P0 is set to 29 kg/cm^2, for example.

[0067] When the pressure P exceeds the pressure-withstanding reference value P0, the controller 500 opens the solenoid valve 25 at Step S22.

[0068] Then, at Step S23, the controller 500 counts a time M during which the solenoid valve 25 is open, and determines whether or not a certain time M0 has elapsed. When the certain time M0 has not elapsed, the controller 500 maintains the open state of the solenoid valve 25.

[0069] In this case, for example, the certain time M0 may represent a time from when operating frequency of the compressor 2 is reduced by the controller 500 to control a pressure P at the pressure withstanding reference value P0 until when the operating frequency of the compressor 2 is stabilized. For example, the certain time M0 may be set to 60 seconds.

[0070] After the lapse of the certain time M0, the controller 500 closes the solenoid valve 25 at Step S24, and completes the control processing.

[0071] As described above, in the air-conditioning apparatus 1 according to Embodiment 2, the heat source-side unit 100 further includes the accumulator 8 arranged on the suction pipe side of the compressor 2, the bypass refrigerant pipe 20 serving as a bypass between the refrigerant pipe (first heat source-side refrigerant pipe 10) on the refrigerant outflow port side of the pressure reducing device (heat source-side pressure reducing device 4) and the refrigerant pipe (third heat source-side refrigerant pipe 14) connected to the refrigerant inflow port side of the accumulator 8, and the solenoid valve 25 provided to the bypass refrigerant pipe 20. During the cooling operation, when the pressure of the refrigerant flowing through the refrigerant pipe (first heat source-side refrigerant pipe 10) on the refrigerant outflow port side of the pressure reducing device (heat source-side pressure reducing device 4) exceeds the pressure-withstanding reference value of the existing refrigerant pipe (first extension refrigerant pipe 300), the controller 500 opens the solenoid valve 25 for a certain time.

[0072] Further, the operation control device (controller 500) according to Embodiment 2 controls the air-conditioning apparatus 1 including the heat source-side unit 100 further housing the accumulator 8 arranged on the suction pipe side of the compressor 2, the bypass refrigerant pipe 20 serving as a bypass between the refrigerant pipe (first heat source-side refrigerant pipe 10) on the refrigerant outflow port side of the pressure reducing device (heat source-side pressure reducing device 4) and the refrigerant pipe (third heat source-side refrigerant pipe 14) connected to the refrigerant inflow port side of the accumulator 8, and the solenoid valve 25 provided to the bypass refrigerant pipe 20. During the cooling operation, when the pressure of the refrigerant flowing through the refrigerant pipe (first heat source-side refrigerant pipe 10) on the refrigerant outflow port side of the pressure reducing device (heat source-side pressure reducing device 4) exceeds the pressure-withstanding reference value of the existing refrigerant pipe (first extension refrigerant pipe 300), the operation control device (controller 500) opens the solenoid valve 25 for a certain time.

[0073] With the configuration of Embodiment 2, it is possible to promptly reduce the pressure of the refrigerant flowing through the first extension refrigerant pipe 300 by opening the solenoid valve 25. Therefore, it is possible to provide the further reliable air-conditioning apparatus 1 and the further reliable controller 500 (operation control device).

Other Embodiments

[0074] The present invention is not limited to Embodiments 1 and 2 described above, and a variety of modifications can be made thereto. For example, Embodiments 1 and 2 described above are not limited to the air-conditioning apparatus 1, and may also be applied to apparatus such as a hot water supply system.

[0075] Further, Embodiments 1 and 2 described above may be used in combination. Reference Signs List

[0076] 1 air-conditioning apparatus 2 compressor 3 heat source-side heat exchanger 4 heat source-side pressure reducing device 5a first load-side pressure reducing device 5b second load-side pressure reducing device 6a first load-side heat exchanger 6b second load-side heat exchanger 7 refrigerant flow switching device 8 accumulator 9a first extension refrigerant pipe connecting valve 9b second extension refrigerant pipe connecting valve 10 first heat source-side refrigerant pipe 12 second heat source-side refrigerant pipe 14 third heat source-side refrigerant pipe 16 fourth heat source-side refrigerant pipe 18 fifth heat source-side refrigerant pipe 20 bypass refrigerant pipe 25 solenoid valve 30 first temperature sensor 35a second temperature sensor 35b third temperature sensor 40 first pressure sensor 45 second pressure sensor 50 first control unit 55a second control unit 55b third control unit 58 communication line 100 heat source-side unit 200a first load-side unit 200b second load-side unit 300 first extension refrigerant pipe 400 second extension refrigerant pipe 500 controller

Claims

1. An air-conditioning apparatus comprising:

   a refrigeration cycle including a compressor, a heat source-side heat exchanger, a pressure reducing device, and a load-side heat exchanger connected via refrigerant pipes to allow refrigerant to circulate through the refrigeration cycle to perform at least a cooling operation with the heat source-side heat exchanger serving as a radiator and the load-side heat exchanger serving as an evaporator;
   a heat source-side unit housing the compressor, the heat source-side heat exchanger, and the pressure reducing device;
   at least one load-side unit housing the load-side heat exchanger, and connected to the heat source-side unit via existing refrigerant pipes; and
   a controller configured to control the refrigeration cycle,
   wherein, during the cooling operation, when an outside air temperature of outdoor air supplied to the heat source-side heat exchanger exceeds a reference outside air temperature, and when a total load capacity of the at least one load-side unit is reduced over time, the controller adjusts an opening degree of the pressure reducing device in accordance with a reduction amount of the total load capacity.

2. The air-conditioning apparatus of claim 1, wherein the heat source-side unit further comprises

   an accumulator arranged on a suction pipe side of the compressor,
   a bypass refrigerant pipe serving as a bypass between a refrigerant pipe on a refrigerant outflow port side of the pressure reducing device and a refrigerant pipe connected to a refrigerant inflow port side of the accumulator, and
   a solenoid valve provided to the bypass refrigerant pipe, and

   wherein, during the cooling operation, when a pressure of the refrigerant flowing through the refrigerant pipe on the refrigerant outflow port side of the pressure reducing device exceeds a pressure-withstanding reference value of a corresponding one of the existing refrigerant pipes, the controller opens the solenoid valve for a certain time.

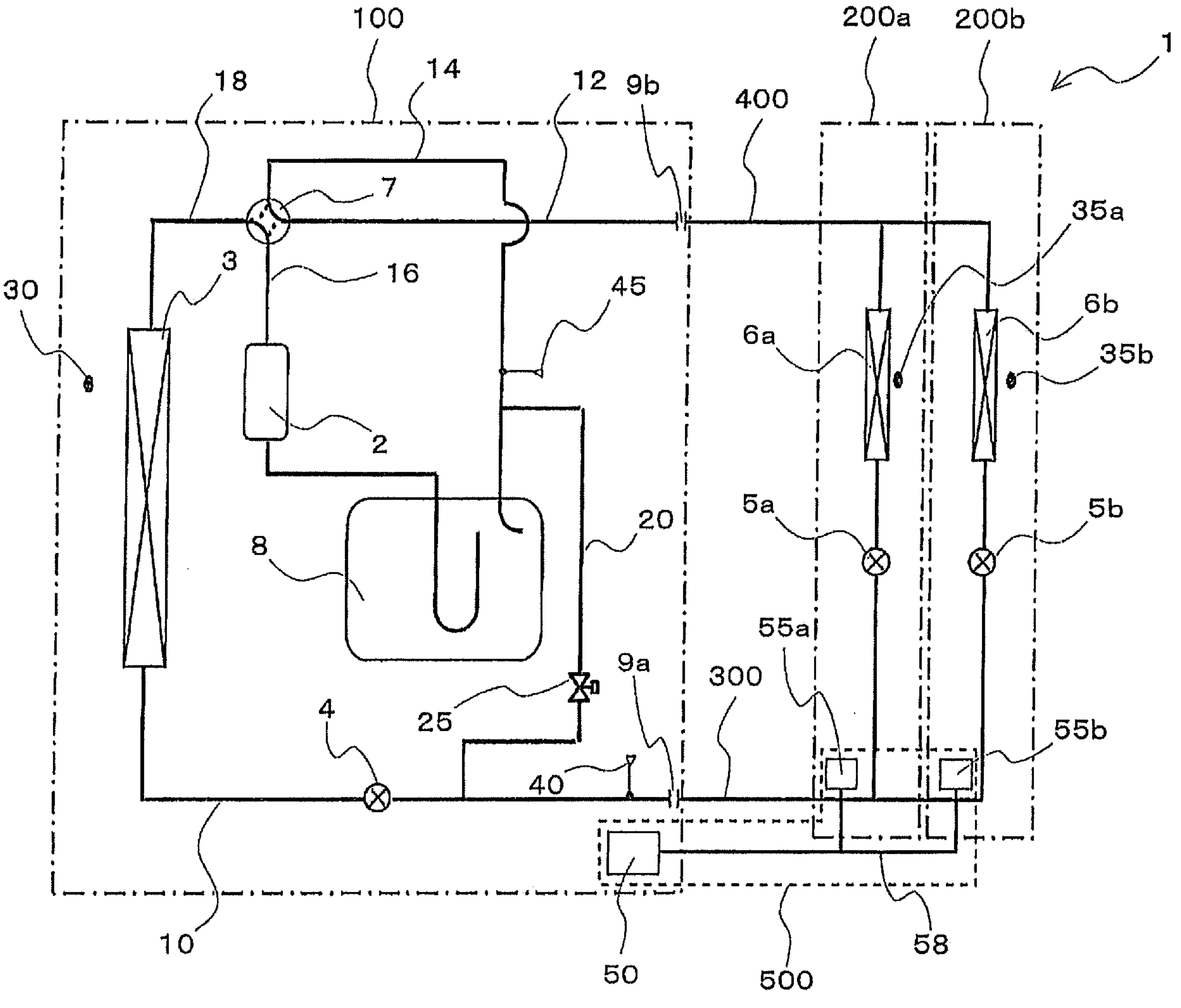
3. An operation control device, which is configured to control an air-conditioning apparatus comprising a refrigeration cycle including a compressor, a heat source-side heat exchanger, a pressure reducing device, and a load-side heat exchanger connected via refrigerant pipes to allow refrigerant to circulate through the refrigeration cycle to perform at least a cooling operation with the heat source-side heat exchanger serving as a radiator and the load-side heat exchanger serving as an evaporator, the compressor, the heat source-side heat exchanger, and the pressure reducing device being housed in a heat source-side unit, the load-side heat exchanger being housed in at least one load-side unit connected to the heat source-side unit via existing refrigerant pipes,
wherein, during the cooling operation, when an outside air temperature of outdoor air supplied to the heat source-side heat exchanger exceeds a reference outside air temperature, and when a total load capacity of the at least one load-side unit is reduced over time, the operation control device adjusts an opening degree of the pressure reducing device in accordance with a reduction amount of the total load capacity.

4. The operation control device of claim 3,
wherein the operation control device is further configured to control the air-conditioning apparatus including the heat source-side unit further housing

an accumulator arranged on a suction pipe side of the compressor,
a bypass refrigerant pipe serving as a bypass between a refrigerant pipe on a refrigerant outflow port side of the pressure reducing device and a refrigerant pipe connected to a refrigerant inflow port of the accumulator, and
a solenoid valve provided to the bypass refrigerant pipe, and

wherein, during the cooling operation, when a pressure of the refrigerant flowing through the refrigerant pipe on the refrigerant outflow port side of the pressure reducing device exceeds a pressure-withstanding reference value of a corresponding one of the existing refrigerant pipes, the operation control device opens the solenoid valve for a certain time.

FIG. 1



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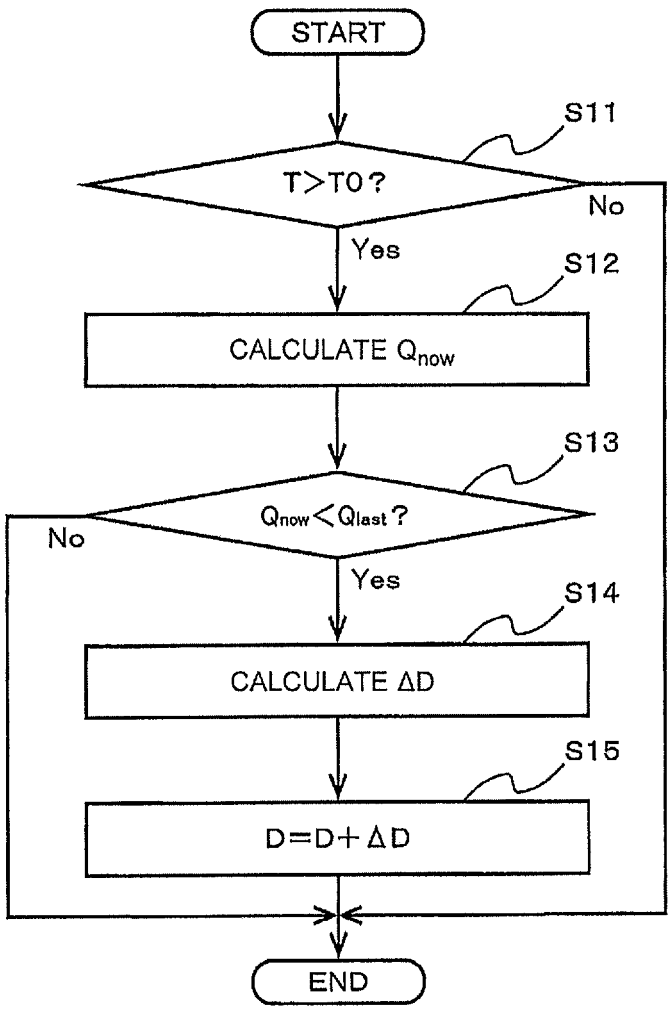
10
50
500
58

FIG. 2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S12
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S13
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S14
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S15
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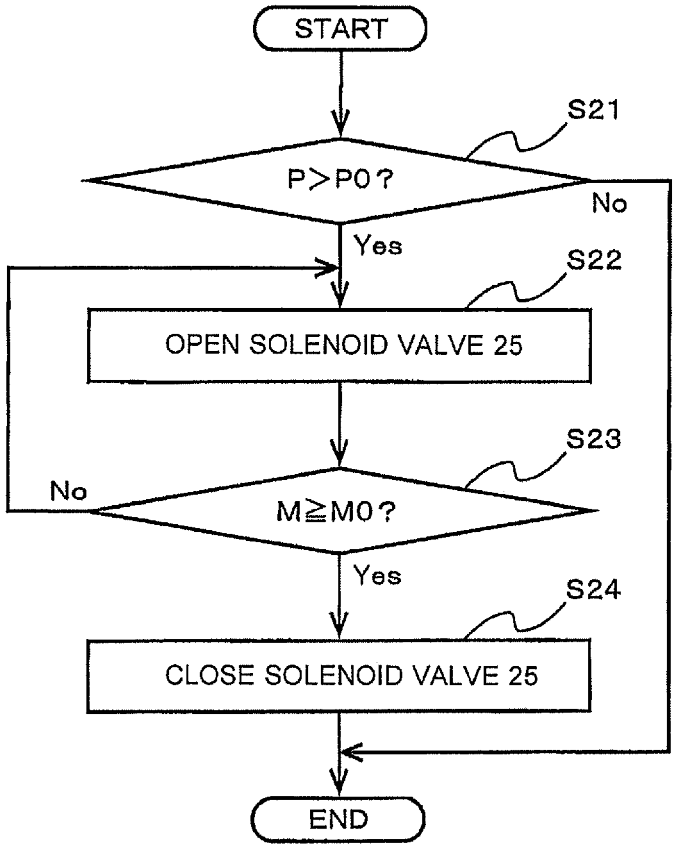
FIG. 3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S23
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M≧M0？
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S24
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END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/065730

A. CLASSIFICATION OF SUBJECT MATTER
F24F11/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24F11/02

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	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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.
A	JP 2005-147541 A (Matsushita Electric Industrial Co., Ltd.), 09 June 2005 (09.06.2005), entire text; all drawings (Family: none)	1-4
A	JP 2002-162126 A (Toshiba Carrier Corp.), 07 June 2002 (07.06.2002), entire text; all drawings (Family: none)	1-4
A	JP 2005-140431 A (Hitachi Home & Life Solution, Inc.), 02 June 2005 (02.06.2005), claim 3 (Family: none)	1-4

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 August 2015 (17.08.15)	25 August 2015 (25.08.15)

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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