



(11)

EP 4 818 592 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
07.10.2026 Bulletin 2026/41

(51) International Patent Classification (IPC):
F24F 11/49^(2018.01)

(21) Application number: **26732114.9**

(52) Cooperative Patent Classification (CPC):
F24F 11/49; F24F 11/88; F25B 49/02; F24F 2110/12

(22) Date of filing: **14.01.2026**

(86) International application number:
PCT/JP2026/000822

(87) International publication number:
WO 2026/168101 (13.08.2026 Gazette 2026/33)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH LA MA MD TN

(72) Inventors:
• **KIMURA Naoto**
Osaka-shi, Osaka 530-0001 (JP)
• **TAKEGAMI Masaaki**
Osaka-shi, Osaka 530-0001 (JP)
• **SHIRASAKI Tetsuya**
Osaka-shi, Osaka 530-0001 (JP)
• **YOKOHARA Kazuma**
Osaka-shi, Osaka 530-0001 (JP)

(30) Priority: **10.02.2025 JP 2025019966**

(71) Applicant: **DAIKIN INDUSTRIES, LTD.**
Osaka-Shi, Osaka 530-0001 (JP)

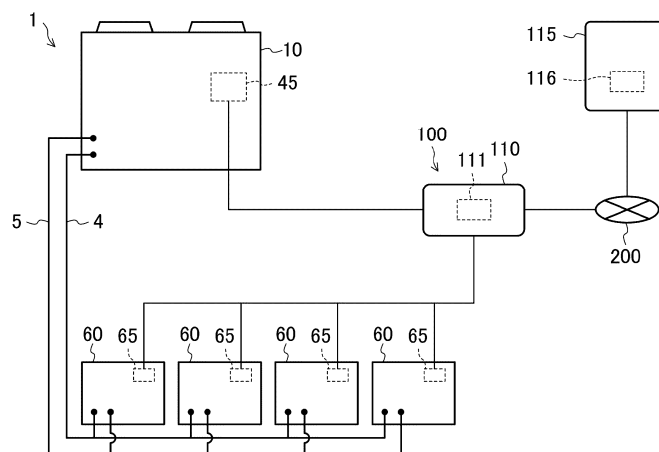
(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) **MANAGEMENT SYSTEM AND MANAGEMENT METHOD FOR REFRIGERATION CYCLE DEVICE**

(57) A management system (100) targets a refrigeration cycle apparatus (1) having an outdoor unit (10) and a cooling unit (60). The management system (100) has a processor (111) and a storage (116). The processor (111) is configured to acquire a physical quantity relating to a refrigerant in a refrigerant circuit at an acquisition time

and calculate an acquisition-time capacity of the outdoor unit (10) based on the physical quantity acquired. The storage (116) is configured to store operating information that is based on an acquisition-time outdoor air temperature and the acquisition-time capacity.

FIG.1



EP 4 818 592 A1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to a management system and a management method for a refrigeration cycle apparatus.

BACKGROUND ART

[0002] Refrigeration cycle apparatuses including a heat-source-side unit and a utilization-side unit have been known. Patent Document 1 discloses a refrigeration cycle apparatus including one outdoor unit (heat-source-side unit) and a plurality of display cases (utilization-side units). The refrigeration cycle apparatus of Patent Document 1 includes a controller that communicates with the outdoor unit and the display cases.

CITATION LIST

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Unexamined Patent Publication No. 2022-43465

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0004] When configuring a refrigeration cycle apparatus, a heat-source-side unit having a cooling capacity adapted to the usage conditions of the refrigeration cycle apparatus is selected. Examples of the usage conditions of the refrigeration cycle apparatus include the number of the utilization-side units, the model of the utilization-side units, and the climate at the installation site of the refrigeration cycle apparatus.

[0005] The actual usage conditions after the installation of the refrigeration cycle apparatus include items that are unknown prior to the installation of the refrigeration cycle apparatus. Thus, when configuring a refrigeration cycle apparatus, a heat-source-side unit having an excessive cooling capacity relative to the expected cooling load is often selected to avoid insufficient cooling capacity of the heat-source-side unit. As a result, the heat-source-side unit of the refrigeration cycle apparatus after installation is considered to operate at a cooling capacity significantly lower than its maximum capacity for most of the year. However, until now, the state of the heat-source-side unit in the refrigeration cycle apparatus after installation has not been accurately determined.

[0006] It is an object of the present disclosure to determine the state of a heat-source-side unit in an installed refrigeration cycle apparatus.

SOLUTION TO THE PROBLEM

[0007] A first aspect of the present disclosure is directed to a management system (100) targeting a refrigeration cycle apparatus (1) having a refrigerant circuit (6) that includes a heat-source-side unit (10) and at least one utilization-side unit (60), the heat-source-side unit (10) including a heat exchanger (13) configured to allow heat exchange between outdoor air and a refrigerant, the management system (100) including: a processor (111) configured to acquire a physical quantity relating to the refrigerant in the refrigerant circuit (6) and calculate an acquisition-time capacity based on the physical quantity acquired, the acquisition-time capacity being a cooling capacity exhibited by the heat-source-side unit (10) at an acquisition time at which the physical quantity is acquired; and a storage (116) configured to store operating information that is based on an acquisition-time outdoor air temperature, which is a temperature of the outdoor air at the acquisition time, and on the acquisition-time capacity calculated by the processor (111).

[0008] According to the first aspect, the processor (111) calculates the acquisition-time capacity of the heat-source-side unit (10) at the acquisition time. The storage (116) stores the operating information. The operating information is information based on the acquisition-time outdoor air temperature and the acquisition-time capacity both at the acquisition time. Thus, the state of the heat-source-side unit (10) of the refrigeration cycle apparatus (1), which is installed and in actual operation, can be determined.

[0009] A second aspect of the present disclosure is an embodiment of the first aspect. In the second aspect, a maximum value of the cooling capacity that can be exhibited by the heat-source-side unit (10) at the acquisition-time outdoor air temperature is an acquisition-time maximum capacity, and the operating information includes a capacity index indicating a relationship between the acquisition-time capacity and the acquisition-time maximum capacity.

[0010] According to the second aspect, the storage (116) stores the operating information including the capacity index.

[0011] A third aspect of the present disclosure is an embodiment of the second aspect. In the third aspect, the capacity index is a ratio of the acquisition-time capacity to the acquisition-time maximum capacity, or a difference between the acquisition-time maximum capacity and the acquisition-time capacity.

[0012] According to the third aspect, the capacity index included in the operating information is the "ratio of the acquisition-time capacity to the acquisition-time maximum capacity" or the "difference between the acquisition-time maximum capacity and the acquisition-time capacity."

[0013] A fourth aspect of the present disclosure is an embodiment of any one of the first to third aspects. In the fourth aspect, the processor (111) acquires the physical

quantity at each of a plurality of the acquisition times and calculates the acquisition-time capacity at each of the plurality of acquisition times, and the operating information is information based on the acquisition-time outdoor air temperature and the acquisition-time capacity at each of the plurality of acquisition times.

[0014] According to the fourth aspect, the processor (111) calculates the acquisition-time capacity at each of the plurality of acquisition times. The storage (116) stores the operating information that is based on the acquisition-time outdoor air temperature and the acquisition-time capacity both at each of the plurality of acquisition times.

[0015] A fifth aspect of the present disclosure is an embodiment of the second or third aspect. In the fifth aspect, the processor (111) acquires the physical quantity at each of a plurality of the acquisition times and calculates the acquisition-time capacity at each of the plurality of acquisition times, and the operating information is a bivariate frequency distribution of the acquisition-time outdoor air temperature and the capacity index at each of the plurality of acquisition times, in which the acquisition-time outdoor air temperature is a first variate and the capacity index is a second variate.

[0016] According to the fifth aspect, the processor (111) calculates the acquisition-time capacity at each of the plurality of acquisition times. The storage (116) stores the bivariate frequency distribution of the acquisition-time outdoor air temperature and the capacity index at each of the plurality of acquisition times as the operating information.

[0017] A sixth aspect of the present disclosure is an embodiment of the fourth or fifth aspect. In the sixth aspect, the processor (111) acquires the physical quantity periodically.

[0018] According to the sixth aspect, the processor (111) acquires the physical quantity relating to the refrigerant in the refrigerant circuit (6) periodically.

[0019] A seventh aspect of the present disclosure is an embodiment of the fourth, fifth, or sixth aspect. In the seventh aspect, the refrigerant circuit (6) of the refrigeration cycle apparatus (1) as a target includes a plurality of utilization-side units (60), each of the plurality of utilization-side units (60) switches between a cooling state in which an object is cooled and an inactive state in which the object is not cooled, and each of the acquisition times is a time at which all the utilization-side units (60) are in the cooling state.

[0020] According to the seventh aspect, the processor (111) acquires the physical quantity relating to the refrigerant in the refrigerant circuit (6) at the acquisition time at which all the utilization-side units (60) are in the cooling state.

[0021] An eighth aspect of the present disclosure is an embodiment of the second, third, or fifth aspect. In the eighth aspect, the storage (116) stores characteristic information indicating a correlation between the temperature of the outdoor air and the cooling capacity of the heat-source-side unit (10), and the processor (111)

calculates the acquisition-time maximum capacity based on the acquisition-time outdoor air temperature and the characteristic information.

[0022] According to the eighth aspect, the processor (111) calculates the acquisition-time maximum capacity based on the characteristic information stored by the storage (116) and the acquisition-time outdoor air temperature.

[0023] A ninth aspect of the present disclosure is an embodiment of any one of the first to eighth aspects. In the ninth aspect, the management system further includes: a control unit (110) configured to communicate with the heat-source-side unit (10) based on a first communication protocol and to communicate with the utilization-side unit (60) based on a second communication protocol, wherein the control unit (110) includes the processor (111), and the processor (111) communicates with the heat-source-side unit (10) to acquire the physical quantity.

[0024] According to the ninth aspect, the management system (100) has the control unit (110). The processor (111) provided in the control unit (110) communicates with the heat-source-side unit (10) to acquire the physical quantity relating to the refrigerant in the refrigerant circuit (6).

[0025] A tenth aspect of the present disclosure is directed to a management method targeting a refrigeration cycle apparatus (1) having a refrigerant circuit (6) that includes a heat-source-side unit (10) and a utilization-side unit (60), the heat-source-side unit (10) including a heat exchanger (13) configured to allow heat exchange between outdoor air and a refrigerant, the method including: a processing step of acquiring a physical quantity relating to the refrigerant in the refrigerant circuit (6) at an acquisition time, and calculating an acquisition-time capacity based on the physical quantity acquired, the acquisition-time capacity being a cooling capacity exhibited by the heat-source-side unit (10) at the acquisition time; and a storage step of storing, in a storage medium, operating information that is based on an acquisition-time outdoor air temperature, which is a temperature of the outdoor air at the acquisition time, and on the acquisition-time capacity calculated in the processing step.

[0026] According to the tenth aspect, in the processing step, the acquisition-time capacity of the heat-source-side unit (10) at the acquisition time is calculated. In the storage step, the operating information is recorded on the storage medium. The operating information is information based on the acquisition-time outdoor air temperature and the acquisition-time capacity both at the acquisition time. Thus, the state of the heat-source-side unit (10) of the refrigeration cycle apparatus (1), which is installed and in actual operation, can be determined.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

[FIG. 1] FIG. 1 is a configuration diagram showing schematic configurations of a management system and a refrigeration cycle apparatus.

[FIG. 2] FIG. 2 is a piping diagram illustrating a configuration of a refrigerant circuit of the refrigeration cycle apparatus.

[FIG. 3] FIG. 3 is a Mollier diagram (pressure-enthalpy diagram) showing a refrigeration cycle performed by the refrigeration cycle apparatus.

[FIG. 4] FIG. 4 is a block diagram showing a configuration of the management system.

[FIG. 5] FIG. 5 is a flowchart illustrating processes performed by the management system.

[FIG. 6] FIG. 6 shows an exemplary bivariate frequency distribution stored as operating information by a storage of the management system.

[FIG. 7] FIG. 7 is a piping diagram illustrating a configuration of a refrigerant circuit of a refrigeration cycle apparatus according to a first variation.

DESCRIPTION OF EMBODIMENTS

[0028] An embodiment will be described.

[0029] As illustrated in FIG. 1, a management system (100) of this embodiment includes a control unit (110) and a storage unit (115). The management system (100) of this embodiment targets a refrigeration cycle apparatus (1).

- Refrigeration Cycle Apparatus -

[0030] The refrigeration cycle apparatus (1) to be managed by the management system (100) of this embodiment will be described with reference to FIG. 1 and FIG. 2.

[0031] The refrigeration cycle apparatus (1) is installed in a store such as a supermarket. The refrigeration cycle apparatus (1) includes one outdoor unit (10) and a plurality of cooling units (60). The number of the cooling units (60) illustrated in FIG. 1 and FIG. 2 is merely an example.

[0032] The outdoor unit (10) is a heat-source-side unit installed outdoors. The cooling units (60) are utilization-side units installed indoors. The cooling units (60) cool air as a target. Examples of the cooling units (60) include a refrigeration display case, a freezing display case, and a unit cooler installed in a refrigerator.

[0033] The refrigeration cycle apparatus (1) includes a refrigerant circuit (6). In the refrigerant circuit (6), the one outdoor unit (10) and the plurality of cooling units (60) are connected through a liquid connection pipe (4) and a gas connection pipe (5). In the refrigerant circuit (6), the plurality of cooling units (60) are connected to each other in parallel.

[0034] The refrigerant circuit (6) is filled with carbon dioxide as a refrigerant. The refrigerant used to fill the refrigerant circuit (6) is not limited to carbon dioxide. The refrigerant circuit (6) may be filled with a fluorocarbon refrigerant.

- Outdoor Unit -

[0035] The outdoor unit (10) includes an outdoor circuit (11), an outdoor controller (45), an outdoor fan (12), and an air-supply fan (17a). The outdoor fan (12) is a fan for supplying outdoor air to an outdoor heat exchanger (13) which will be described later. The air-supply fan (17a) is a fan for supplying outdoor air to an intercooler (17) which will be described later. The outdoor circuit (11) and the outdoor controller (45) will be described later.

<Outdoor Circuit>

[0036] The outdoor circuit (11) includes a low-stage compressor (22), a high-stage compressor (21), the outdoor heat exchanger (13), an outdoor expansion valve (14a), a receiver (15), a subcooling heat exchanger (16), the intercooler (17), a liquid-side shutoff valve (18a), and a gas-side shutoff valve (18b). The outdoor circuit (11) also includes an injection pipe (38), a venting pipe (37), and a low-stage pipe (24b).

[0037] The liquid-side shutoff valve (18a) is disposed at one end of the outdoor circuit (11). The gas-side shutoff valve (18b) is disposed at the other end of the outdoor circuit (11). In the outdoor circuit (11), the low-stage compressor (22), the intercooler (17), the high-stage compressor (21), the outdoor heat exchanger (13), the outdoor expansion valve (14a), the receiver (15), and the subcooling heat exchanger (16) are arranged sequentially from the gas-side shutoff valve (18b) toward the liquid-side shutoff valve (18a).

[0038] The high-stage compressor (21) and the low-stage compressor (22) are rotary compressors each including a compression mechanism that is driven by a motor. The compressors (21, 22) are hermetic scroll compressors, for example. The high-stage compressor (21) and the low-stage compressor (22) are configured as capacity-variable-type compressors each including a compression mechanism of which the rotational speed can be changed.

[0039] The outdoor heat exchanger (13) is a heat exchanger that allows heat exchange between the refrigerant and outdoor air. The outdoor heat exchanger (13) is a fin-and-tube air heat exchanger. The outdoor heat exchanger (13) allows heat exchange between the refrigerant discharged from the high-stage compressor (21) and the outdoor air.

[0040] The outdoor expansion valve (14a) is an electronic expansion valve having a variable opening degree. The receiver (15) is a container member that stores the refrigerant.

[0041] The subcooling heat exchanger (16) is, for example, a plate heat exchanger. The subcooling heat exchanger (16) has a first flow path (16a) and a second flow path (16b). The first flow path (16a) is provided in a pipe connecting the receiver (15) and the liquid-side shutoff valve (18a). The second flow path (16b) is provided in the injection pipe (38). The subcooling heat

exchanger (16) exchanges heat between the refrigerant flowing through the first flow path (16a) and the refrigerant flowing through the second flow path (16b).

[0042] The intercooler (17) is a heat exchanger that allows heat exchange between the refrigerant and outdoor air. The intercooler (17) is a fin-and-tube air heat exchanger. The intercooler (17) allows heat exchange between the refrigerant discharged from the low-stage compressor (22) and the outdoor air.

[0043] One end of the injection pipe (38) is connected to a pipe connecting the first flow path (16a) of the subcooling heat exchanger (16) and the liquid-side shut-off valve (18a). The other end of the injection pipe (38) is connected to a pipe connecting the intercooler (17) and the high-stage compressor (21). As described above, the second flow path (16b) of the subcooling heat exchanger (16) is provided in the injection pipe (38).

[0044] The injection pipe (38) is provided with a decompression valve (40). The decompression valve (40) is disposed upstream of the subcooling heat exchanger (16) in the injection pipe (38). The decompression valve (40) is an electronic expansion valve having a variable opening degree.

[0045] One end of the venting pipe (37) is connected to the top of the receiver (15). The other end of the venting pipe (37) is connected to the downstream of the subcooling heat exchanger (16) in the injection pipe (38). A venting valve (39) is provided with the venting pipe (37). The venting valve (39) is an electronic expansion valve having a variable opening degree.

[0046] The low-stage pipe (24b) is arranged in parallel with the low-stage compressor (22). One end of the low-stage pipe (24b) is connected to a pipe connecting the low-stage compressor (22) and the gas-side shutoff valve (18b). The other end of the low-stage pipe (24b) is connected to a pipe connecting the low-stage compressor (22) and the intercooler (17). The low-stage pipe (24b) is provided with a check valve (CV8). The check valve (CV8) allows refrigerant to flow from one end toward the other end of the low-stage pipe (24b) and shuts off the flow of the refrigerant in the reverse direction.

[0047] A pipe connecting the high-stage compressor (21) and the outdoor heat exchanger (13) is provided with a check valve (CV1). The check valve (CV1) allows refrigerant to flow from the high-stage compressor (21) toward the outdoor heat exchanger (13) and shuts off the flow of the refrigerant in the reverse direction.

<Sensor>

[0048] The outdoor unit (10) includes a plurality of sensors. These sensors include a high-pressure sensor (71), an intermediate-pressure sensor (72), a low-pressure sensor (73), a liquid refrigerant pressure sensor (75), a high-stage suction temperature sensor (77), a low-stage suction temperature sensor (78), a liquid refrigerant temperature sensor (76), and an outdoor air temperature sensor (79).

[0049] The high-pressure sensor (71) is connected to a discharge pipe of the high-stage compressor (21). The high-pressure sensor (71) measures the pressure of the refrigerant discharged by the high-stage compressor (21).

[0050] The intermediate-pressure sensor (72) is connected to the pipe connecting the intercooler (17) and the high-stage compressor (21). The intermediate-pressure sensor (72) measures the pressure of the refrigerant to be sucked into the high-stage compressor (21).

[0051] The low-pressure sensor (73) is connected to a suction pipe of the low-stage compressor (22). The low-pressure sensor (73) measures the pressure of the refrigerant to be sucked into the low-stage compressor (22).

[0052] The liquid refrigerant pressure sensor (75) is connected to a pipe connecting the receiver (15) and the subcooling heat exchanger (16). The liquid refrigerant pressure sensor (75) measures the pressure of a liquid refrigerant that has flowed out of the receiver (15).

[0053] The high-stage suction temperature sensor (77) is attached to a suction pipe of the high-stage compressor (21). The high-stage suction temperature sensor (77) measures the temperature of the refrigerant to be sucked into the high-stage compressor (21).

[0054] The low-stage suction temperature sensor (78) is attached to the suction pipe of the low-stage compressor (22). The low-stage suction temperature sensor (78) measures the temperature of the refrigerant to be sucked into the low-stage compressor (22).

[0055] The liquid refrigerant temperature sensor (76) is attached to the pipe connecting the subcooling heat exchanger (16) and the liquid-side shutoff valve (18a). The liquid refrigerant temperature sensor (76) measures the temperature of the refrigerant that has passed through the first flow path (16a) of the subcooling heat exchanger (16).

[0056] The outdoor air temperature sensor (79) is provided in an air flow path in the outdoor unit (10). The outdoor air temperature sensor (79) measures the temperature of outdoor air before it passes through the outdoor heat exchanger (13).

<Outdoor Controller>

[0057] The outdoor controller (45) includes a microcomputer and a memory device. The memory device is a semiconductor memory. The memory device stores software for operating the microcomputer.

[0058] The outdoor controller (45) receives measurement values of the sensors provided in the outdoor unit (10). The outdoor controller (45) controls the constituent devices, such as the compressors (21, 22), provided in the outdoor unit (10) using the received measurement values of the sensors.

[0059] The outdoor controller (45) is configured to be capable of communicating with external devices. The outdoor controller (45) performs wired communication

with the control unit (110) of the management system (100). The outdoor controller (45) exchanges signals and data with the control unit (110).

- Cooling Unit -

[0060] Each of the cooling units (60) includes a cooling circuit (61), a cooling fan (62), and an internal controller (65). The cooling fan (62) is a fan for supplying inside air to a cooling heat exchanger (64) which will be described later.

<Cooling Circuit>

[0061] The cooling circuit (61) is provided with a cooling expansion valve (63) and the cooling heat exchanger (64) arranged sequentially from the liquid end to the gas end. The cooling expansion valve (63) is an electronic expansion valve having a variable opening degree. The cooling heat exchanger (64) is a fin-and-tube air heat exchanger. The cooling heat exchanger (64) allows heat exchange between inside air and the refrigerant.

[0062] The liquid connection pipe (4) is connected to the liquid end of the cooling circuit (61). The liquid end of the cooling circuit (61) is connected to the liquid-side shutoff valve (18a) of the outdoor circuit (11) through the liquid connection pipe (4). The gas connection pipe (5) is connected to the gas end of the cooling circuit (61). The gas end of the cooling circuit (61) is connected to the gas-side shutoff valve (18b) of the outdoor circuit (11) through the gas connection pipe (5).

<Internal Controller>

[0063] The internal controller (65) includes a microcomputer and a memory device. The memory device is a semiconductor memory. The memory device stores software for operating the microcomputer. The internal controller (65) controls the cooling expansion valve (63) and the cooling fan (62).

[0064] The internal controller (65) is configured to be capable of communicating with external devices. The internal controller (65) performs wired communication with the control unit (110) of the management system (100). The internal controller (65) exchanges signals and data with the control unit (110).

[0065] The internal controller (65) switches the cooling unit (60) between a cooling state and an inactive state such that the internal temperature falls within a target range.

[0066] If the internal temperature is higher than the upper limit of the target range, the internal controller (65) opens the cooling expansion valve (63) and adjusts the opening degree of the cooling expansion valve (63). When the cooling expansion valve (63) is open, the refrigerant passes through the cooling heat exchanger (64), and the inside air is cooled by the cooling heat exchanger (64). Thus, the cooling unit (60) enters a

cooling state.

[0067] If the internal temperature is lower than the lower limit of the target range, the internal controller (65) maintains the cooling expansion valve (63) in a closed state. When the cooling expansion valve (63) is closed, the refrigerant does not pass through the cooling heat exchanger (64), and the inside air is not cooled by the cooling heat exchanger (64). Thus, the cooling unit (60) enters an inactive state.

- Operation of Refrigeration Cycle Apparatus -

[0068] Operation of the refrigeration cycle apparatus (1) will be described. The refrigeration cycle apparatus (1) causes the refrigerant to circulate through the refrigerant circuit (6), thereby performing a refrigeration cycle. In the refrigerant circuit (6), the outdoor heat exchanger (13) of the outdoor unit (10) functions as a radiator, and the cooling heat exchangers (64) of the cooling units (60) function as evaporators.

[0069] The refrigeration cycle performed by the refrigeration cycle apparatus (1) will be described with reference to the Mollier diagram of FIG. 3.

[0070] In the refrigerant circuit (6), the refrigerant in the state at point A is sucked into the low-stage compressor (22). The refrigerant in the state at point A is compressed to the state at point B in the low-stage compressor (22). The refrigerant in the state at point B discharged from the low-stage compressor (22) dissipates heat to outdoor air in the intercooler (17) to be in the state at point C. In the refrigerant circuit (6), the refrigerant in the state at point C and the refrigerant having passed through the injection pipe (38) merge to be in the state at point D. The refrigerant in the state at point D is sucked into the high-stage compressor (21) and is compressed to be in the state at point E.

[0071] The refrigerant in the state at point E flows into the outdoor heat exchanger (13) and dissipates heat to outdoor air to be in the state at point F. The refrigerant in the state at point F is decompressed while passing through the outdoor expansion valve (14a) to be in the state at point G. The refrigerant in the state at point G flows into the receiver (15) and is separated into a saturated liquid refrigerant in the state at point H and a saturated gas refrigerant in the state at point I.

[0072] The refrigerant in the state at point H flows into the first flow path (16a) of the subcooling heat exchanger (16) and dissipates heat to the refrigerant flowing through the second flow path (16b) to be in the state at point J. Part of the refrigerant in the state at point J flows into the injection pipe (38), while the rest of the refrigerant flows into the liquid connection pipe (4). The refrigerant that has flowed into the liquid connection pipe (4) flows into the cooling circuits (61) of the cooling units (60).

[0073] The refrigerant in the state at point J that has flowed into the respective cooling circuits (61) is decompressed while passing through the cooling expansion valve (63) to be in the state at point K. The refrigerant

in the state at point K flows into the cooling heat exchanger (64), and absorbs heat from the inside air and evaporates to be in the state at point A. Each of the cooling units (60) blows the inside air cooled in the cooling heat exchanger (64) into the inside space. The refrigerant in the state at point A flows into the outdoor circuit (11) through the gas connection pipe (5) and is sucked into the low-stage compressor (22).

[0074] The refrigerant in the state at point J that has flowed into the injection pipe (38) is decompressed while passing through the decompression valve (40) to be in the state at point L. The refrigerant in the state at point L flows into the second flow path (16b) of the subcooling heat exchanger (16), and absorbs heat from the refrigerant flowing through the first flow path (16a) and evaporates to be in the state at point M.

[0075] The refrigerant in the state at point I that has flowed from the receiver (15) into the venting pipe (37) is decompressed while passing through the venting valve (39) to be in the state at point N, and then flows into the injection pipe (38). In the injection pipe (38), the refrigerant in the state at point M that has flowed out of the second flow path (16b) of the subcooling heat exchanger (16) and the refrigerant in the state at point N that has flowed in from the venting pipe (37) merge. The refrigerant in the state at point M and the refrigerant in the state at point N that have merged in the injection pipe (38) are sucked into the high-stage compressor (21) together with the refrigerant in the state at point C that has flowed out of the intercooler (17).

- Management System -

[0076] The management system (100) of this embodiment will be described with reference to FIG. 1 and FIG. 4.

[0077] The management system (100) includes the control unit (110) and the storage unit (115). The control unit (110) is installed in a store, such as a supermarket, together with the refrigeration cycle apparatus (1) to be managed by the management system (100). The control unit (110) controls operation of the refrigeration cycle apparatus (1). The storage unit (115) is installed at a location away from the store where the control unit (110) is installed. In the management system (100), the control unit (110) and the storage unit (115) are communicably connected to each other via a telecommunication line (200) such as the Internet.

<Control Unit>

[0078] The control unit (110) performs wired communication with the outdoor controller (45) of the outdoor unit (10). The control unit (110) transmits and receives signals and data to and from the outdoor controller (45) based on a first communication protocol. The control unit (110) also performs wired communication with the internal controllers (65) of the respective cooling units (60). The control unit (110) transmits and receives signals and data to and

from the respective internal controllers (65) based on a second communication protocol different from the first communication protocol. Thus, even if the manufacturer of the outdoor unit (10) differs from the manufacturer of the cooling units (60), the control unit (110) can communicate with both the outdoor unit (10) and the cooling units (60).

[0079] The control unit (110) of the management system (100) of the present embodiment includes a processor (111). The processor (111) is implemented by a microprocessor provided in the control unit (110). The microprocessor functions as the processor (111) by executing an application program.

15 <Storage Unit>

[0080] The storage unit (115) is implemented, for example, by a personal computer, a mainframe computer for use as a server, or a cloud storage. The storage unit (115) includes a storage (116). The storage (116) is implemented by a storage medium. Examples of the storage medium forming the storage (116) include a hard disk drive (HDD) and a solid state drive (SSD).

25 - Processes Performed By Management System -

[0081] The refrigeration cycle apparatus (1) to be managed by the management system (100) of this embodiment operates continuously unless trouble, such as a failure, occurs. While the refrigeration cycle apparatus (1) is in operation, the management system (100) monitors the operating state of the refrigeration cycle apparatus (1) through a management method.

35 <Process Performed By Control Unit>

[0082] The processor (111) of the control unit (110) performs a data generation process. The data generation process is a process for generating data forming operating information which will be described later. The data generation process is a processing step of the management method to be executed by the management system (100).

[0083] The processor (111) performs the data generation process at each of a plurality of acquisition times. The processor (111) of this embodiment periodically performs the data generation process. The processor (111) performs the data generation process, for example, every hour.

[0084] As shown in FIG. 5, the data generation process includes an acquisition process, first to fourth calculation processes, and a transmission process. In the data generation process, the processor (111) performs the acquisition process, the first calculation process, the second calculation process, the third calculation process, the fourth calculation process, and the transmission process in order.

(Acquisition Process)

[0085] The acquisition process will be described. This acquisition process is a processing step of the management method to be executed by the management system (100).

[0086] In the acquisition process, the processor (111) acquires, from the outdoor unit (10), a measurement value P_A of the low-pressure sensor (73), a measurement value T_A of the low-stage suction temperature sensor (78), a measurement value P_J of the liquid refrigerant pressure sensor (75), and a measurement value T_J of the liquid refrigerant temperature sensor (76).

[0087] The measurement value P_A of the low-pressure sensor (73) and the measurement value T_A of the low-stage suction temperature sensor (78) are the pressure and temperature of the refrigerant to be sucked into the low-stage compressor (22) (the refrigerant in the state at point A in FIG. 3). The measurement value P_J of the liquid refrigerant pressure sensor (75) and the measurement value T_J of the liquid refrigerant temperature sensor (76) are the pressure and temperature of the refrigerant to be supplied to the cooling units (60) from the outdoor unit (10) (the refrigerant in the state at point J in FIG. 3). These measurement values P_A , T_A , P_J , and T_J are physical quantities relating to the refrigerant in the refrigerant circuit (6).

[0088] In the acquisition process, the processor (111) also acquires, from the outdoor unit (10), the operation frequency f_L of the low-stage compressor (22) and the measurement value T_O of the outdoor air temperature sensor (79).

[0089] The operation frequency f_L of the low-stage compressor (22) is the frequency of an alternating current to be supplied to a motor of the low-stage compressor (22). The measurement value T_O of the outdoor air temperature sensor (79) is the temperature of outdoor air before it passes through the outdoor heat exchanger (13) of the outdoor unit (10). The acquired measurement value T_O of the outdoor air temperature sensor (79) at each acquisition time is an acquisition-time outdoor air temperature.

(First Calculation Process)

[0090] The first calculation process will be described. The first calculation process is a first calculation step of the management method executed by the management system (100).

[0091] The processor (111) stores physical property data on the refrigerant (carbon dioxide in this embodiment) filling the refrigerant circuit (6) of the refrigeration cycle apparatus (1) in advance. The processor (111) calculates the density ρ_A and the specific enthalpy h_A using: the measurement value P_A of the low-pressure sensor (73) and the measurement value T_A of the low-stage suction temperature sensor (78) both acquired in the acquisition process; and the physical property data

on the refrigerant stored in advance.

[0092] The density ρ_A and the specific enthalpy h_A calculated by the processor (111) are the density and the specific enthalpy of the refrigerant to be sucked into the low-stage compressor (22) (the refrigerant in the state at point A in FIG. 3). The specific enthalpy h_A calculated by the processor (111) is substantially equal to the specific enthalpy of the refrigerant that has flowed out of the cooling heat exchangers (64) of the cooling units (60).

[0093] The processor (111) calculates the specific enthalpy h_J using: the measurement value P_J of the liquid refrigerant pressure sensor (75) and the measurement value T_J of the liquid refrigerant temperature sensor (76) both acquired in the acquisition process; and the physical property data on the refrigerant stored in advance.

[0094] The specific enthalpy h_J calculated by the processor (111) is the specific enthalpy of the refrigerant to be supplied to the cooling units (60) from the outdoor unit (10) (the refrigerant in the state at point J in FIG. 3). The specific enthalpy h_J calculated by the processor (111) is substantially equal to the specific enthalpy h_K of the refrigerant flowing into the cooling heat exchangers (64) of the cooling units (60) ($h_J = h_K$).

(Second Calculation Process)

[0095] The second calculation process will be described. The second calculation process is a second calculation step of the management method executed by the management system (100).

[0096] The processor (111) stores, in advance, the volume V_L of the refrigerant to be sucked by the low-stage compressor (22) per revolution. The processor (111) calculates the rotational speed N_L of the low-stage compressor (22) based on the operation frequency f_L of the low-stage compressor (22) acquired in the acquisition process.

[0097] The processor (111) calculates the mass flow rate G of the refrigerant to be sucked into the low-stage compressor (22) based on the density ρ_A calculated in the first calculation process, the rotational speed N_L calculated in the second calculation process, the volume V_L stored in advance, and the following Formula 1. The mass flow rate G is equal to the sum of the mass flow rates of the refrigerant that has passed through the cooling heat exchangers (64) of the cooling units (60).

$$G = \rho_A \times N_L \times V_L \text{ (Formula 1)}$$

(Third Calculation Process)

[0098] The third calculation process will be described. The third calculation process is a third calculation step of the management method executed by the management system (100).

[0099] The processor (111) stores, in advance, characteristic information on the outdoor unit (10) forming the

refrigeration cycle apparatus (1). The characteristic information on the outdoor unit (10) stored in the processor (111) is information indicating a correlation between the temperature of outdoor air and the cooling capacity of the outdoor unit (10).

[0100] More specifically, the characteristic information on the outdoor unit (10) stored in the processor (111) is information indicating a correlation between a value of the temperature of the outdoor air and the maximum value of the cooling capacity that can be exhibited by the outdoor unit (10) when the temperature of the outdoor air is that value. The characteristic information may be, for example, data in which the temperature of the outdoor air and the maximum value of the cooling capacity are associated with each other, or may be a correlation formula indicating the maximum value of the cooling capacity as a function of the temperature of the outdoor air.

[0101] The processor (111) calculates the acquisition-time maximum capacity $Q_{\max}$ based on the acquisition-time outdoor air temperature acquired in the acquisition process (= the measurement value T_O of the outdoor air temperature sensor (79)) and the characteristic information on the outdoor unit (10) stored in advance. For example, if the characteristic information is the above-mentioned correlation formula, the processor (111) calculates the acquisition-time maximum capacity $Q_{\max}$ by substituting the acquisition-time outdoor air temperature T_O into the correlation formula. The acquisition-time maximum capacity $Q_{\max}$ is the maximum value of the cooling capacity that can be exhibited by the outdoor unit (10) when the temperature of the outdoor air is the acquisition-time outdoor air temperature T_O (in other words, at an acquisition time).

[0102] The processor (111) calculates the cooling capacity Q of the outdoor unit (10) based on the specific enthalpy h_A and the specific enthalpy h_K calculated in the first calculation process, the mass flow rate G calculated in the second calculation process, and the following Formula 2.

$$Q = G(h_A - h_K) \text{ (Formula 2)}$$

[0103] The cooling capacity Q calculated in the third calculation process is the sum of the amounts of heat which the refrigerant has absorbed from the inside air in the cooling heat exchangers (64) of the cooling units (60). The cooling capacity Q is the acquisition-time capacity of the outdoor unit (10). The acquisition-time capacity is the cooling capacity exhibited by the outdoor unit (10) at the acquisition time.

(Fourth Calculation Process)

[0104] The fourth calculation process will be described. The fourth calculation process is a fourth calculation step of the management method executed by the

management system (100).

[0105] The processor (111) calculates the capacity index I_Q based on the acquisition-time capacity Q and the acquisition-time maximum capacity $Q_{\max}$ calculated in the third calculation process and the following Formula 3. The capacity index I_Q calculated by the processor (111) of this embodiment is the ratio of the acquisition-time capacity Q to the acquisition-time maximum capacity $Q_{\max}$.

$$I_Q = Q/Q_{\max} \text{ (Formula 3)}$$

(Transmission Process)

[0106] The transmission process will be described. The transmission process is a transmission step of the management method executed by the management system (100).

[0107] The processor (111) transmits data in which the acquisition-time outdoor air temperature T_O acquired in the acquisition process and the capacity index I_Q calculated in the fourth calculation process are paired, to the storage unit (115).

<Process Performed by Storage Unit>

[0108] The storage unit (115) performs a data accumulation process. The data accumulation process is a process for adding data transmitted by the processor (111) of the control unit (110) to the operating information stored in the storage (116). The data accumulation process is a storage step of the management method executed by the management system (100).

[0109] The operating information stored in the storage (116) is a "bivariate frequency distribution of the acquisition-time outdoor air temperature and the capacity index at respective acquisition times, in which the acquisition-time outdoor air temperature is a first variate and the capacity index is a second variate." The operating information is information based on the acquisition-time outdoor air temperature, the acquisition-time capacity, and the acquisition-time maximum capacity. The operating information includes the capacity index.

[0110] FIG. 6 shows an example of the operating information stored in the storage (116). The operating information stored in the storage (116) is information based on the acquisition-time outdoor air temperature T_O , the acquisition-time capacity Q , and the acquisition-time maximum capacity $Q_{\max}$ at respective acquisition times, and indicates the operating state of the outdoor unit (10) at the acquisition time.

[0111] For example, if the data transmitted by the processor (111) indicates ($T_O = 31^\circ\text{C}$, $I_Q = 72\%$), the storage unit (115) performs a process for incrementing by one the frequency in the dot-marked cell, in the bivariate frequency distribution of FIG. 6 stored by the storage (116) as the data accumulation process.

- Features of Embodiment -

<First Feature>

[0112] In the management system (100) of this embodiment, the processor (111) calculates the acquisition-time capacity of the outdoor unit (10) at each acquisition time. The storage (116) stores the operating information. The operating information stored in the storage (116) of this embodiment is information based on the acquisition-time outdoor air temperature T_O , the acquisition-time capacity Q , and the acquisition-time maximum capacity Q_{max} at each acquisition time. Thus, the state of the outdoor unit (10) of the refrigeration cycle apparatus (1), which is installed and in actual operation, can be determined.

<Second Feature>

[0113] In the management system (100) of this embodiment, the processor (111) calculates the acquisition-time capacity Q at respective acquisition times. In the management system (100) of this embodiment, the capacity index I_Q is the "ratio of the acquisition-time capacity Q to the acquisition-time maximum capacity Q_{max} ," and the storage (116) stores the bivariate frequency distribution (see FIG. 6) of the acquisition-time outdoor air temperature T_O and the capacity index I_Q at respective acquisition times as the operating information.

[0114] If such a bivariate frequency distribution as shown in FIG. 6 is obtained, it is possible to determine the operating state of the outdoor unit (10) of the refrigeration cycle apparatus (1) actually installed in a store or the like. For example, it is assumed that a bivariate frequency distribution as shown in FIG. 6 is obtained as a result of operation of the refrigeration cycle apparatus (1) for one year. In this case, the capacity index I_Q ($= Q/Q_{max}$) exceeded 80% only 28 times in one year (8760 hours). Thus, the cooling capacity of the outdoor unit (10) has a margin of about 20% of the maximum cooling capacity.

[0115] For example, if it is determined that the cooling capacity of the outdoor unit (10) has a margin when an operator of a store plans to add a refrigeration display case, a vendor of the refrigeration cycle apparatus can propose to the store operator that an additional refrigeration display case be connected to the existing outdoor unit (10) without installing a new outdoor unit. Further, when installing a new refrigeration cycle apparatus in the same area, a vendor of the refrigeration cycle apparatus can propose to the store operator the introduction of an outdoor unit having a lower maximum cooling capacity (and therefore a lower cost) than the existing outdoor unit (10). As described above, if such a bivariate frequency distribution as shown in FIG. 6 is obtained as the operating information, it is possible, in businesses involving refrigeration cycle apparatuses, to present customers with new proposals that could not previously be pre-

sented.

- Variations of Embodiment -

[0116] The management system (100) of the foregoing embodiment may be modified as follows. The following variations may be combined or replaced as necessary as long as the functions of the management system (100) are not impaired.

<First Variation>

[0117] As illustrated in FIG. 7, a refrigeration cycle apparatus (1) to be managed by the management system (100) of this embodiment may include both a cooling unit (60) and an air-conditioning unit (50) as utilization-side units. The air-conditioning unit (50) is a unit configured to provide air conditioning for a space where a person is present. In the refrigeration cycle apparatus (1) of this variation, the air-conditioning unit (50) is installed in a store and provides air conditioning for a sales area of the store, for example.

[0118] In the refrigeration cycle apparatus (1) of this variation, a plurality of air-conditioning units (50) are connected to the outdoor unit (10) via a second liquid connection pipe (2) and a second gas connection pipe (3). A first liquid connection pipe (4) and a first gas connection pipe (5) of the refrigeration cycle apparatus (1) of this variation correspond to the liquid connection pipe and the gas connection pipe of the refrigeration cycle apparatus (1) of the first embodiment.

(Outdoor Unit)

[0119] The following description focuses on the differences between the outdoor unit (10) included in the refrigeration cycle apparatus (1) of this variation and the outdoor unit (10) of the first embodiment.

[0120] The outdoor unit (10) of this variation includes a second low-stage compressor (23), a second outdoor expansion valve (14b), a flow path switching mechanism (30), a second liquid-side shutoff valve (19a), and a second gas-side shutoff valve (19b). A first low-stage compressor (22), a first outdoor expansion valve (14a), a first liquid-side shutoff valve (18a), and a first gas-side shutoff valve (18b) of the outdoor unit (10) of this variation correspond to the low-stage compressor, the outdoor expansion valve, the liquid-side shutoff valve, and the gas-side shutoff valve of the outdoor unit (10) of the first embodiment, respectively.

[0121] The outdoor unit (10) of this variation further includes a first outdoor liquid pipe (33), a second outdoor liquid pipe (34), a first outdoor gas pipe (35), a second outdoor gas pipe (36), and a second low-stage pipe (24c). A first low-stage pipe (24b) of the outdoor unit (10) of this variation corresponds to the low-stage pipe of the outdoor unit (10) of the first embodiment.

[0122] The second low-stage compressor (23) is a

hermetic compressor similar to the first low-stage compressor (22). The second outdoor expansion valve (14b) is an electronic expansion valve similar to the first outdoor expansion valve (14a).

[0123] The flow path switching mechanism (30) includes a first switching valve (81) and a second switching valve (82). The first switching valve (81) and the second switching valve (82) are four-way switching valves. Each of the first switching valve (81) and the second switching valve (82) switches between a first state in which a first port communicates with a third port and a second port communicates with a fourth port (indicated by the solid lines in FIG. 7) and a second state in which the first port communicates with the fourth port and the second port communicates with the third port (indicated by the broken lines in FIG. 7). The third port of the first switching valve (81) is closed. The fourth port of the second switching valve (82) is closed.

[0124] The first port of the first switching valve (81) and the first port of the second switching valve (82) are connected to a discharge pipe of the high-stage compressor (21). The third port of the second switching valve (82) is connected to the gas end of the outdoor heat exchanger (13) through a pipe.

[0125] One end of the first outdoor gas pipe (35) is connected to the second gas-side shutoff valve (19b). The other end of the first outdoor gas pipe (35) is connected to the fourth port of the first switching valve (81).

[0126] A first branch end of the second outdoor gas pipe (36) is connected to the second port of the first switching valve (81). A second branch end of the second outdoor gas pipe (36) is connected to the second port of the second switching valve (82). The other end of the second outdoor gas pipe (36) is connected to a suction pipe of the second low-stage compressor (23).

[0127] A second low-pressure sensor (74) is connected to the suction pipe of the second low-stage compressor (23). The second low-pressure sensor (74) measures the pressure of the refrigerant to be sucked into the second low-stage compressor (23). A first low-pressure sensor (73) of the outdoor unit (10) of this variation corresponds to the low-pressure sensor of the outdoor unit (10) of the first embodiment.

[0128] A discharge pipe of the second low-stage compressor (23) is connected to the intercooler (17). A pipe connecting the second low-stage compressor (23) to the intercooler (17) is provided with a check valve (CV3). The check valve (CV3) allows refrigerant to flow from the second low-stage compressor (23) toward the intercooler (17) and shuts off the flow of the refrigerant in the reverse direction.

[0129] A pipe connecting the first low-stage compressor (22) to the intercooler (17) is provided with a check valve (CV2). The check valve (CV2) allows refrigerant to flow from the first low-stage compressor (22) toward the intercooler (17) and shuts off the flow of the refrigerant in the reverse direction.

[0130] The second low-stage pipe (24c) is arranged in

parallel with the second low-stage compressor (23). One end of the second low-stage pipe (24c) is connected to the suction pipe of the second low-stage compressor (23). The other end of the second low-stage pipe (24c) is connected to the discharge pipe of the second low-stage compressor (23). The second low-stage pipe (24c) is provided with a check valve (CV9). The check valve (CV9) allows refrigerant to flow from one end toward the other end of the second low-stage pipe (24c) and shuts off the flow of the refrigerant in the reverse direction.

[0131] The first outdoor liquid pipe (33) includes a first branch pipe (33a), a second branch pipe (33b), and a junction pipe (33c). One end of the first branch pipe (33a) is connected to a pipe connecting the subcooling heat exchanger (16) and the first liquid-side shutoff valve (18a). One end of the second branch pipe (33b) is connected to a pipe connecting the first outdoor expansion valve (14a) and the receiver (15). The other end of each of the first branch pipe (33a) and the second branch pipe (33b) is connected to one end of the junction pipe (33c). The other end of the junction pipe (33c) is connected to the second liquid-side shutoff valve (19a).

[0132] The first branch pipe (33a) of the first outdoor liquid pipe (33) is provided with a check valve (CV6). The check valve (CV6) allows refrigerant to flow from one end toward the other end of the first branch pipe (33a) and shuts off the flow of the refrigerant in the reverse direction. The second branch pipe (33b) of the first outdoor liquid pipe (33) is provided with a check valve (CV7). The check valve (CV7) allows refrigerant to flow from the other end toward one end of the second branch pipe (33b) and shuts off the flow of the refrigerant in the reverse direction. The pipe connecting the first outdoor expansion valve (14a) and the receiver (15) is provided with a check valve (CV4). The check valve (CV4) allows refrigerant to flow from the first outdoor expansion valve (14a) toward the receiver (15) and shuts off the flow of the refrigerant in the reverse direction.

[0133] One end of the second outdoor liquid pipe (34) is connected to the pipe connecting the subcooling heat exchanger (16) and the first liquid-side shutoff valve (18a). The other end of the second outdoor liquid pipe (34) is connected to the pipe connecting the first outdoor expansion valve (14a) and the check valve (CV4). The second outdoor liquid pipe (34) is provided with the second outdoor expansion valve (14b) and a check valve (CV5) arranged sequentially from one end to the other end of the second outdoor liquid pipe (34). The check valve (CV5) allows refrigerant to flow from one end toward the other end of the second outdoor liquid pipe (34) and shuts off the flow of the refrigerant in the reverse direction.

(Air-Conditioning Unit)

[0134] The air-conditioning units (50) each include an indoor circuit (51) and an indoor fan (52). The indoor fan (52) is a fan for supplying indoor air to an indoor heat

exchanger (54) which will be described later.

[0135] The indoor circuit (51) includes an indoor expansion valve (53) and an indoor heat exchanger (54) arranged sequentially from the liquid end to the gas end. The indoor expansion valve (53) is an electronic expansion valve having a variable opening degree. The indoor heat exchanger (54) is a fin-and-tube air heat exchanger. The indoor heat exchanger (54) allows heat exchange between indoor air and the refrigerant.

[0136] The liquid end of the indoor circuit (51) is connected to the second liquid connection pipe (2). The liquid end of the indoor circuit (51) is connected to the second liquid-side shutoff valve (19a) of the outdoor circuit (11) through the second liquid connection pipe (2). The gas end of the indoor circuit (51) is connected to the second gas connection pipe (3). The gas end of the indoor circuit (51) is connected to the second gas-side shutoff valve (19b) of the outdoor circuit (11) through the second gas connection pipe (3).

(Operation of Refrigeration Cycle Apparatus)

[0137] The refrigeration cycle apparatus (1) of this variation selectively performs a cooling operation, a first heating operation, a second heating operation, and a third heating operation.

[0138] In the cooling operation, the first switching valve (81) and the second switching valve (82) are set to the first state, and the first low-stage compressor (22), the second low-stage compressor (23), and the high-stage compressor (21) are activated. In the cooling operation, the outdoor heat exchanger (13) functions as a radiator, and the cooling heat exchangers (64) and the indoor heat exchangers (54) function as evaporators.

[0139] In the first heating operation, the first switching valve (81) is set to the second state; the second switching valve (82) is set to the first state; and the first low-stage compressor (22), the second low-stage compressor (23), and the high-stage compressor (21) are activated. In the first heating operation, the outdoor heat exchanger (13) and the indoor heat exchangers (54) function as radiators, and the cooling heat exchangers (64) function as evaporators.

[0140] In the second heating operation, the first switching valve (81) and the second switching valve (82) are set to the second state; the first low-stage compressor (22) and the high-stage compressor (21) are activated; and the second low-stage compressor (23) is inactive. In the second heating operation, the indoor heat exchangers (54) function as radiators; the cooling heat exchangers (64) function as evaporators; and the outdoor heat exchanger (13) is inactive.

[0141] In the third heating operation, the first switching valve (81) and the second switching valve (82) are set to the second state, and the first low-stage compressor (22), the second low-stage compressor (23), and the high-stage compressor (21) are activated. In the third heating operation, the indoor heat exchangers (54) func-

tion as radiators, and the cooling heat exchangers (64) and the outdoor heat exchanger (13) function as evaporators.

5 <Second Variation>

[0142] In the management system (100) of this embodiment, the time interval at which the processor (111) performs a data generation process does not have to be constant. The time interval at which the processor (111) performs the data generation process may differ, for example, between daytime and nighttime within a day, or between a half-year including a summer period (May to October) and a half-year including a winter period (January to April, and November and December) within a year. The processor (111) may perform the data generation process only in the half-year including a summer period (May to October) within a year.

20 <Third Variation>

[0143] In the management system (100) of the present embodiment, the processor (111) performs, in the data generation process, first to fourth calculation processes and a transmission process each time an acquisition process is performed. However, in the data generation process, the processor (111) does not have to perform the first to fourth calculation processes and the transmission process each time the acquisition process is performed.

[0144] The processor (111) of this variation performs only the acquisition process for, for example, a predetermined period (e.g., one week), and records data (P_A , T_A , P_J , T_J , f_L , T_O) acquired by the acquisition process within the predetermined period in a storage medium such as a memory device. When the predetermined period has elapsed, the processor (111) performs the first to fourth calculation processes using data at each acquisition time obtained by the acquisition processes within the predetermined period, and calculates the capacity index I_Q at each acquisition time within the predetermined period. Then, in the transmission process, the processor (111) transmits data in which the acquisition-time outdoor air temperature T_O and the capacity index I_Q at each acquisition time within the predetermined period are paired, to the storage unit (115).

<Fourth Variation>

[0145] The refrigeration cycle apparatus (1) to be managed by the management system (100) of this embodiment may include an air-conditioning unit (50) instead of the cooling unit (60) as a utilization-side unit. Similarly to the first variation, the air-conditioning unit (50) is a unit configured to provide air conditioning for a space where a person is present. The installation site of the refrigeration cycle apparatus (1) of this variation is not limited to a store, and may be, for example, an office building.

<Fifth Variation>

[0146] In the management system (100) of this embodiment, the capacity index I_Q calculated in the fourth calculation process by the processor (111) of the control unit (110) may be the "difference between the acquisition-time maximum capacity $Q_{\max}$ and the acquisition-time capacity Q " ($I_Q = Q_{\max} - Q$).

<Sixth Variation>

[0147] In the management system (100) of this embodiment, the processor (111) performs the data generation process at all acquisition times. However, the processor (111) may perform the data generation process at some acquisition times. For example, a processor (111) of this variation performs a data generation process only at the acquisition times at which all the cooling units (60) in the refrigeration cycle apparatus (1) are in the cooling state, and does not perform the data generation process at the acquisition times at which some cooling units (60) in the refrigeration cycle apparatus (1) are in the inactive state.

<Seventh Variation>

[0148] In the management system (100) of this embodiment, the storage unit (115) may be provided in a store where the refrigeration cycle apparatus (1) is installed, together with the control unit (110). In this case, the control unit (110) and the storage unit (115) communicate with each other via a local area network (LAN), for example.

[0149] In the management system (100) of this embodiment, the storage unit (115) may be integrated with the control unit (110). In this case, the control unit (110) includes both the processor (111) and the storage (116) and also functions as the storage unit (115).

[0150] While the embodiment and variations thereof have been described above, it will be understood that various changes in form and details may be made without departing from the spirit and scope of the claims. The elements according to the embodiment, the variations thereof, and the other embodiments may be combined and replaced with each other. The ordinal numbers such as "first," "second," . . . in the description and claims are used to distinguish the terms to which these expressions are given, and do not limit the number and order of the terms.

INDUSTRIAL APPLICABILITY

[0151] As described above, the present disclosure is useful for a management system and a management method for a refrigeration cycle apparatus.

DESCRIPTION OF REFERENCE CHARACTERS

[0152]

1	Refrigeration Cycle Apparatus
6	Refrigerant Circuit
10	Outdoor Unit (Heat-Source-Side Unit)
13	Outdoor Heat Exchanger (Heat Exchanger)
5 60	Cooling Unit (Utilization-Side Unit)
100	Management System
111	Processor
116	Storage

10 Claims

1. A management system (100) targeting a refrigeration cycle apparatus (1) having a refrigerant circuit (6) that includes a heat-source-side unit (10) and at least one utilization-side unit (60), the heat-source-side unit (10) including a heat exchanger (13) configured to allow heat exchange between outdoor air and a refrigerant, the management system (100) comprising:

a processor (111) configured to acquire a physical quantity relating to the refrigerant in the refrigerant circuit (6) and calculate an acquisition-time capacity based on the physical quantity acquired, the acquisition-time capacity being a cooling capacity exhibited by the heat-source-side unit (10) at an acquisition time at which the physical quantity is acquired; and
a storage (116) configured to store operating information that is based on an acquisition-time outdoor air temperature, which is a temperature of the outdoor air at the acquisition time, and on the acquisition-time capacity calculated by the processor (111).

2. The management system of claim 1, wherein

a maximum value of the cooling capacity that can be exhibited by the heat-source-side unit (10) at the acquisition-time outdoor air temperature is an acquisition-time maximum capacity, and
the operating information includes a capacity index indicating a relationship between the acquisition-time capacity and the acquisition-time maximum capacity.

3. The management system of claim 2, wherein the capacity index is a ratio of the acquisition-time capacity to the acquisition-time maximum capacity, or a difference between the acquisition-time maximum capacity and the acquisition-time capacity.

4. The management system of any one of claims 1 to 3, wherein

the processor (111) acquires the physical quantity at each of a plurality of the acquisition times

and calculates the acquisition-time capacity at each of the plurality of acquisition times, and the operating information is information based on the acquisition-time outdoor air temperature and the acquisition-time capacity at each of the plurality of acquisition times.

5. The management system of claim 2 or 3, wherein

the processor (111) acquires the physical quantity at each of a plurality of the acquisition times and calculates the acquisition-time capacity at each of the plurality of acquisition times, and the operating information is a bivariate frequency distribution of the acquisition-time outdoor air temperature and the capacity index at each of the plurality of acquisition times, in which the acquisition-time outdoor air temperature is a first variate and the capacity index is a second variate.

6. The management system of claim 4 or 5, wherein the processor (111) acquires the physical quantity periodically.

7. The management system of claim 4, 5, or 6, wherein

the refrigerant circuit (6) of the refrigeration cycle apparatus (1) as a target includes a plurality of utilization-side units (60), each of the plurality of utilization-side units (60) switches between a cooling state in which an object is cooled and an inactive state in which the object is not cooled, and each of the acquisition times is a time at which all the utilization-side units (60) are in the cooling state.

8. The management system of claim 2, 3, or 5, wherein

the storage (116) stores characteristic information indicating a correlation between the temperature of the outdoor air and the cooling capacity of the heat-source-side unit (10), and the processor (111) calculates the acquisition-time maximum capacity based on the acquisition-time outdoor air temperature and the characteristic information.

9. The management system of any one of claims 1 to 8 further comprising:

a control unit (110) configured to communicate with the heat-source-side unit (10) based on a first communication protocol and to communicate with the utilization-side unit (60) based on a second communication protocol, wherein the control unit (110) includes the processor

(111), and

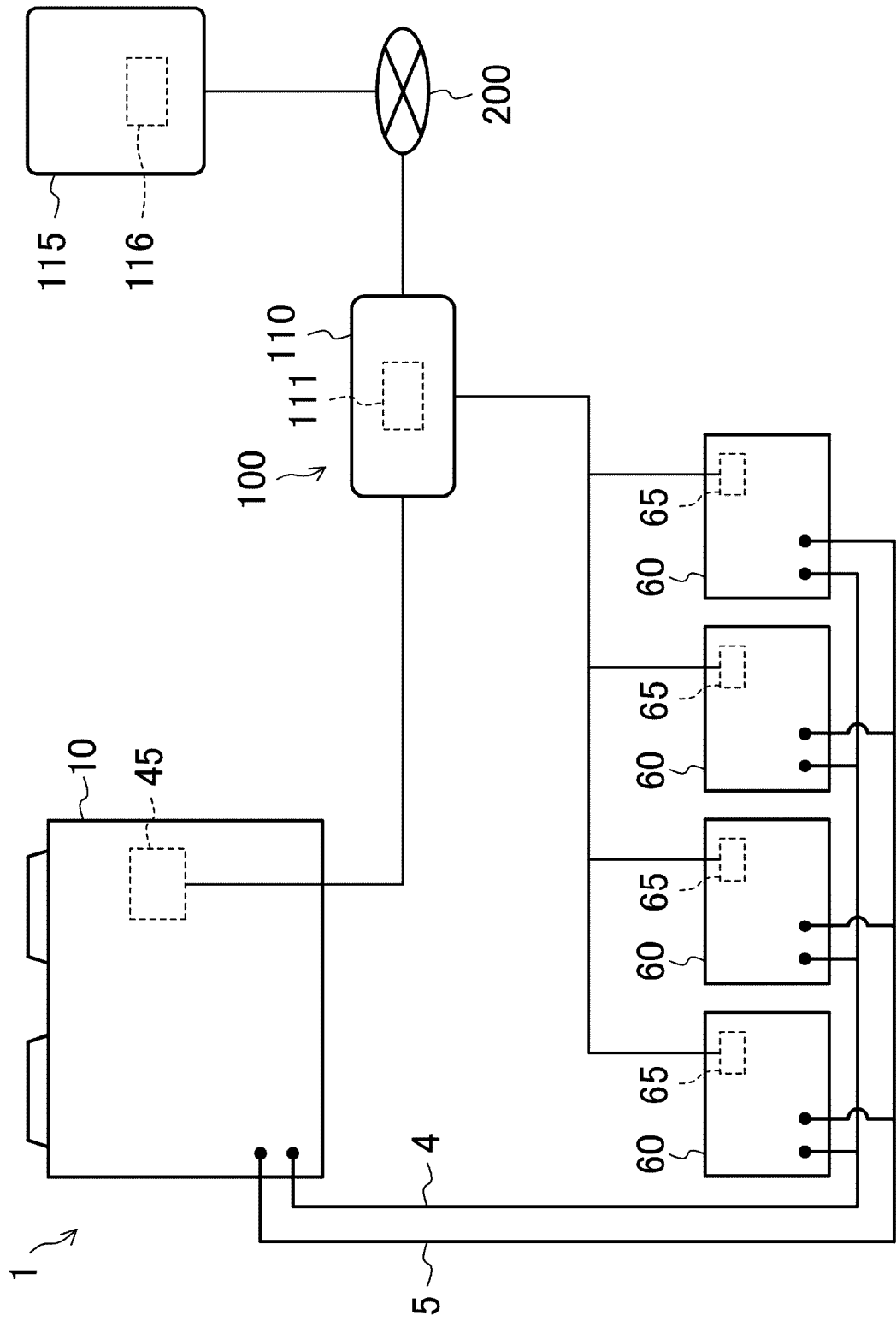
the processor (111) communicates with the heat-source-side unit (10) to acquire the physical quantity.

10. A management method targeting a refrigeration cycle apparatus (1) having a refrigerant circuit (6) that includes a heat-source-side unit (10) and a utilization-side unit (60), the heat-source-side unit (10) including a heat exchanger (13) configured to allow heat exchange between outdoor air and a refrigerant, the method comprising:

a processing step of acquiring a physical quantity relating to the refrigerant in the refrigerant circuit (6) at an acquisition time, and calculating an acquisition-time capacity based on the physical quantity acquired, the acquisition-time capacity being a cooling capacity exhibited by the heat-source-side unit (10) at the acquisition time; and

a storage step of storing, in a storage medium, operating information that is based on an acquisition-time outdoor air temperature, which is a temperature of the outdoor air at the acquisition time, and on the acquisition-time capacity calculated in the processing step.

FIG. 1



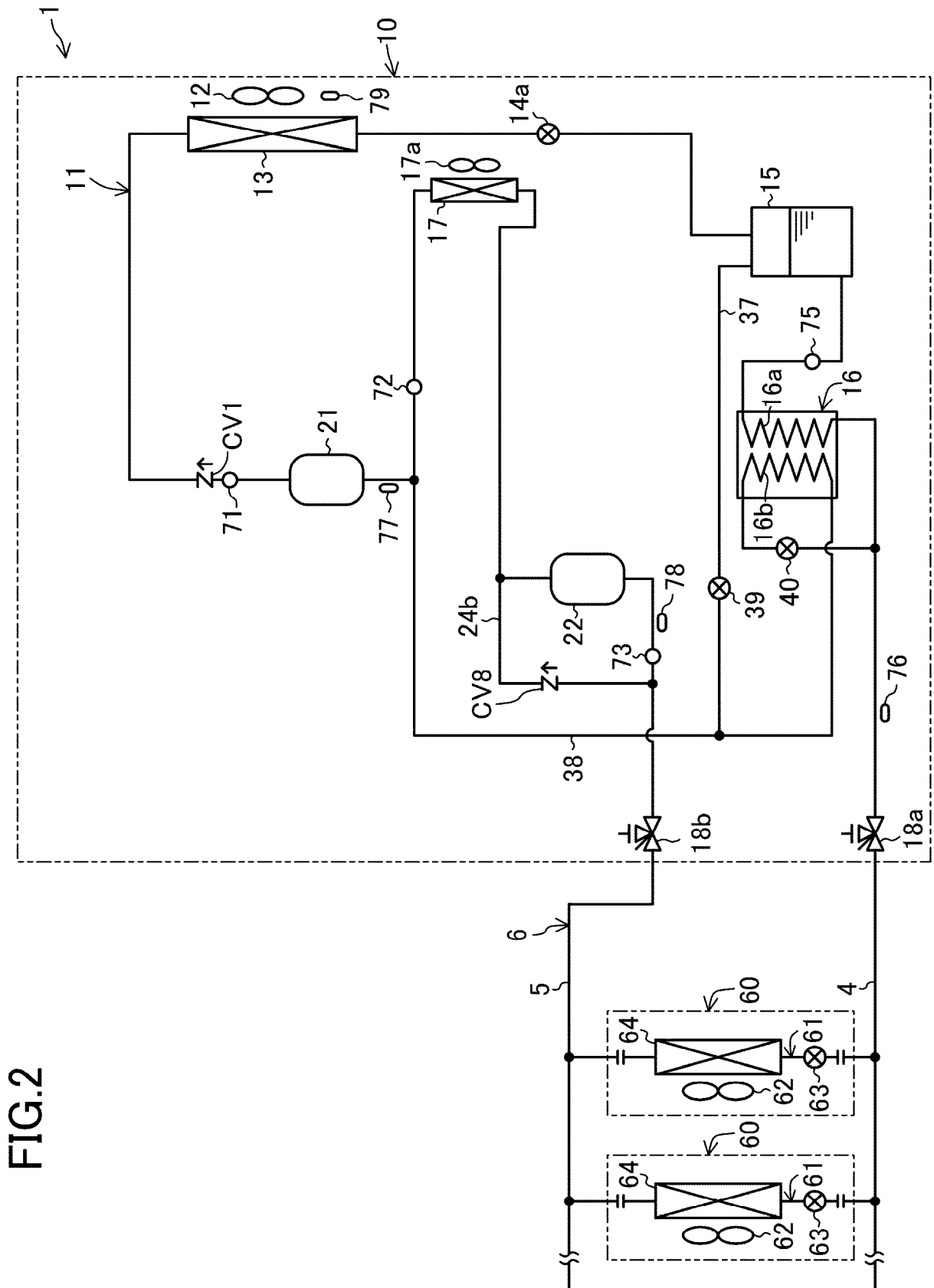


FIG.4

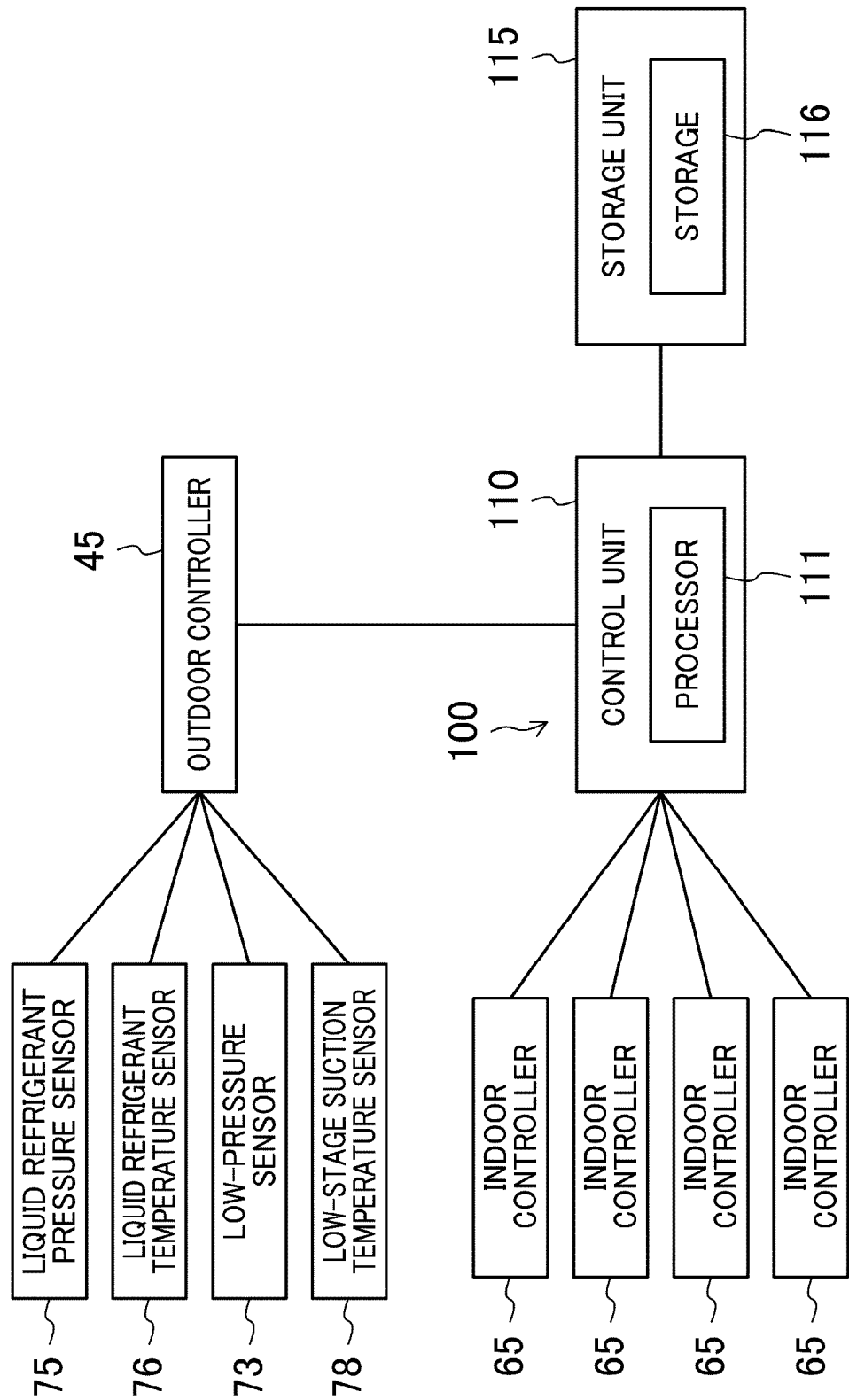


FIG.5

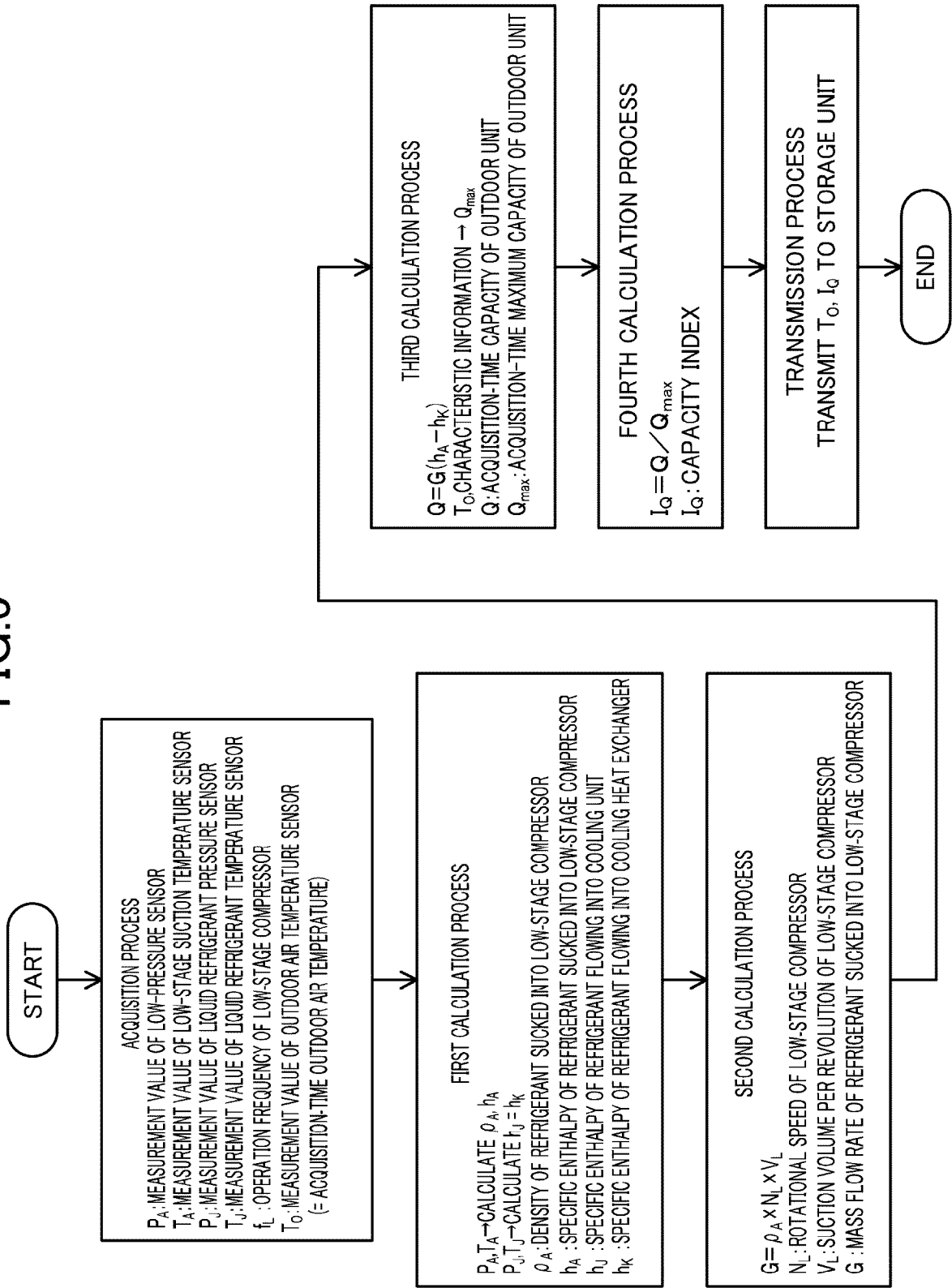
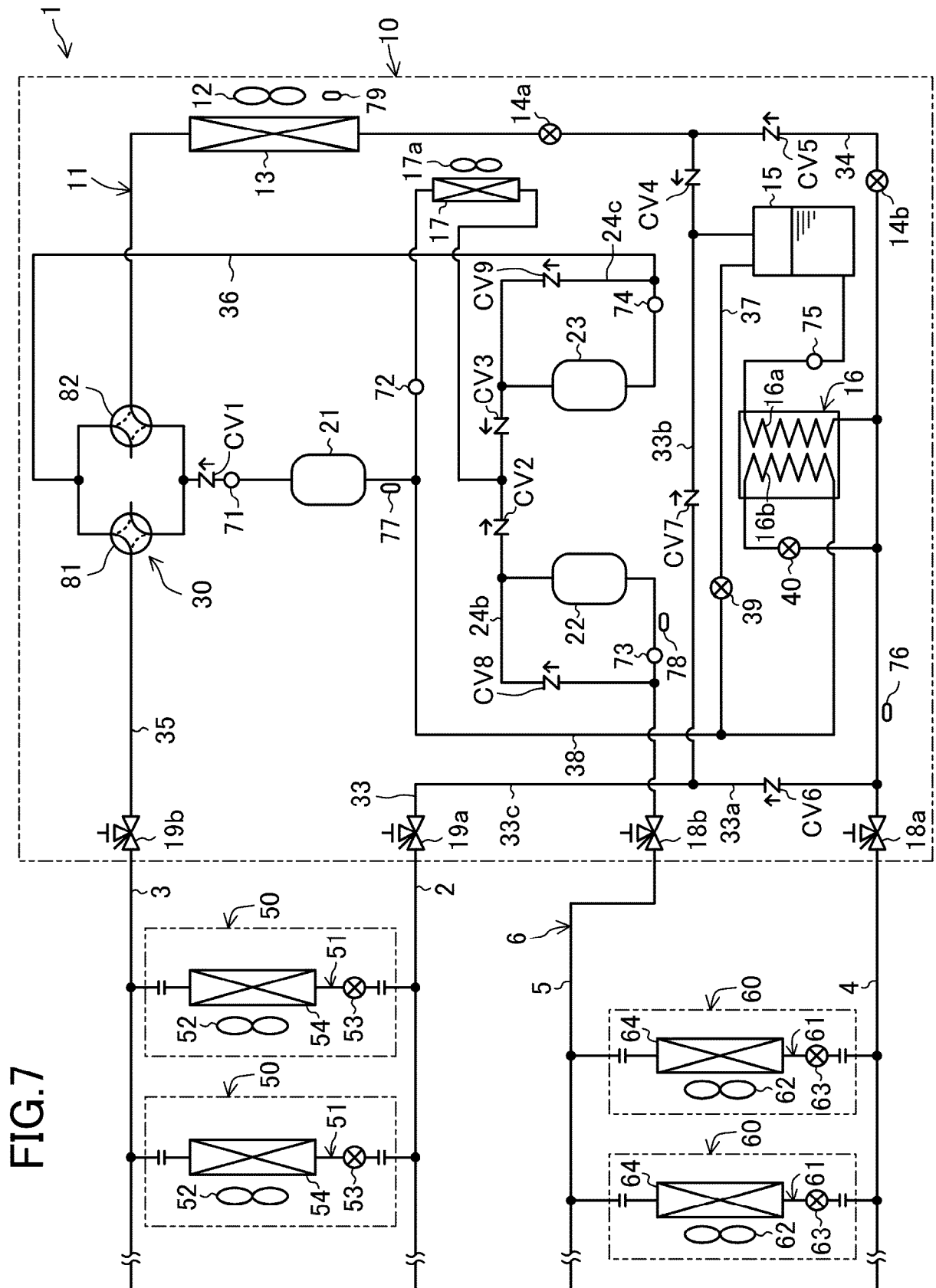


FIG.6

	$I_Q < 50$	$50 \leq I_Q < 60$	$60 \leq I_Q < 70$	$70 \leq I_Q < 80$	$80 \leq I_Q < 90$	$90 \leq I_Q \leq 100$
$T_O < 25.0$	4565	862	146	121	0	0
$25.0 \leq T_O < 27.5$	205	240	203	119	0	0
$27.5 \leq T_O < 30.0$	17	290	203	145	2	0
$30.0 \leq T_O < 32.5$	8	26	382	128	4	0
$32.5 \leq T_O < 35.0$	2	7	289	135	5	0
$35.0 \leq T_O < 37.5$	0	4	239	81	5	0
$37.5 \leq T_O < 40.0$	0	0	16	197	6	0
$40.0 \leq T_O$	0	0	38	64	6	0



TRANSLATION

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2026/000822

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/49(2018.01)i; **F24F 11/88**(2018.01)i; **F25B 49/02**(2006.01)i; **F24F 110/12**(2018.01)n

FI: F24F11/49; F24F11/88; F25B49/02 A; F24F110:12

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)

F24F11/49; F24F11/88; F25B49/02; F24F110/12

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

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	WO 2019/234824 A1 (MITSUBISHI ELECTRIC CORPORATION) 12 December 2019 (2019-12-12) entire text, all drawings	1-10
A	JP 2022-186161 A (MITSUBISHI ELECTRIC CORPORATION) 15 December 2022 (2022-12-15) entire text, all drawings	1-10
A	JP 2008-281255 A (TAKASAGO THERMAL ENGINEERING CO., LTD.) 20 November 2008 (2008-11-20) entire text, all drawings	1-10
A	JP 2006-183953 A (TOKYO ELECTRIC POWER CO., INC.) 13 July 2006 (2006-07-13) entire text, all drawings	1-10

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

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

24 February 2026

Date of mailing of the international search report

10 March 2026

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
Japan

Authorized officer

Telephone No.

TRANSLATION

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2026/000822

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO	2019/234824	A1	12 December 2019	TW 202004095 A	
JP	2022-186161	A	15 December 2022	(Family: none)	
JP	2008-281255	A	20 November 2008	(Family: none)	
JP	2006-183953	A	13 July 2006	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2022043465 A [0003]