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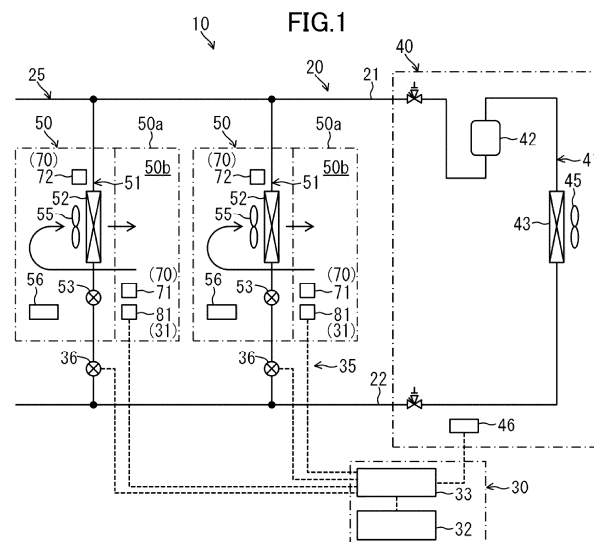
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(54) CONTROL SYSTEM AND REFRIGERATION SYSTEM

(57) A control unit (33) outputs control information for controlling cooling operation of each of a plurality of cooling units (50) so that among the plurality of cooling units (50), a cooling unit (50) with a high degree of priority performs the cooling operation preferentially on the basis of priority information indicative of a degree of priority of

each of the plurality of cooling units (50), first information that can be used to derive a cooling capacity required of each of the plurality of cooling units (50), and second information that can be used to derive a capacity which the heat source unit (40) can actually demonstrate.



Description

Technical Field

5 **[0001]** The present disclosure relates to a control system and a refrigeration system.

Background Art

10 **[0002]** Patent Literature 1 discloses a refrigeration apparatus including a refrigerator unit and a plurality of showcases. The refrigerator unit includes a first compressor, a first radiator, and a refrigerator controller. Each of the showcases includes an expansion valve, an evaporator, and a showcase controller. The first compressor, the first radiator, the expansion valve, and the evaporator constitute a first refrigeration cycle circuit that cools the showcase.

15 **[0003]** The showcase controller controls an opening degree of the expansion valve in accordance with a difference between a refrigerant temperature on an outlet side of the evaporator and a refrigerant temperature on an inlet side of the evaporator. This cools an inside of the showcase to a predetermined temperature. On the other hand, the refrigerator controller stops operation of the first compressor when a pressure on a low-pressure side of the first refrigeration cycle circuit becomes less than a predetermined value.

Citation List

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Patent Literature

[0004] PTL 1: Japanese Unexamined Patent Application Publication No. 2013-011423

25 Summary of Invention

Technical Problem

30 **[0005]** In the refrigeration apparatus of Patent Literature 1, the refrigerator controller controls the refrigerator unit independently without considering a "cooling capacity required of each of the plurality of showcases". If a capacity which the refrigerator unit can actually demonstrate decreases, cooling capacities of the plurality of showcases uniformly decrease. It is therefore impossible to control cooling operation of each of the plurality of showcases so that a specific showcase that should be cooled can preferentially perform the cooling operation.

35 Solution to Problem

[0006] A first aspect of the present disclosure relates to a control system applied to a refrigeration apparatus (20) including a refrigerant circuit (25) that includes a heat source unit (40) including a compression element (42) and a radiator (43) and a plurality of cooling units (50) each including an evaporator (52) and performing or stopping cooling operation depending on a difference between a temperature of a target to be cooled and a set temperature, the refrigeration apparatus (20) performing a refrigeration cycle by circulating a refrigerant through the refrigerant circuit (25), the control system including: a control unit (33) configured to control the refrigeration apparatus (20), in which the control unit (33) outputs control information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), a cooling unit (50) with a high degree of priority performs the cooling operation preferentially over a cooling unit (50) with a low degree of priority on the basis of priority information indicative of a degree of priority of each of the plurality of cooling units (50), first information that is usable for deriving a cooling capacity required of each of the plurality of cooling units (50), and second information that is usable for deriving a capacity which the heat source unit (40) is capable of actually demonstrating.

50 **[0007]** In the first aspect, the cooling capacity required of each of the plurality of cooling units (50) can be derived on the basis of the first information. Furthermore, the capacity which the heat source unit (40) can actually demonstrate can be derived on the basis of the second information. The "control information for controlling the cooling operation of each of the plurality of cooling units (50) can be output so that among the plurality of cooling units (50), a cooling unit (50) with a high degree of priority can perform the cooling operation preferentially over a cooling unit (50) with a low degree of priority" can be output in consideration of the "cooling capacity required of each of the plurality of cooling units (50)" and the "capacity which the heat source unit (40) can actually demonstrate". This, for example, allows the cooling unit that requires cooling to operate preferentially even in a case where the capacity of the heat source unit (40) is insufficient.

55 **[0008]** In the control system according to the first aspect, a second aspect of the present disclosure is a control system in which each of the plurality of cooling units (50) includes a showcase (50a) and cools air in the showcase (50a) in the cooling

operation, and the degree of priority of each of the plurality of cooling units (50) is set in accordance with a type of article stored in the showcase (50a) of the cooling unit (50).

[0009] In the second aspect, the degree of priority of each of the cooling units (50) can be properly set in accordance with the type of article stored in the showcase (50a) of the cooling unit (50). This makes it possible to properly perform processing based on the degree of priority of the cooling unit (50).

[0010] In the control system according to the first or second aspect, a third aspect of the present disclosure is a control system in which the control unit (33) outputs the control information in a case where a capacity according to a sum of cooling capacities required of the plurality of cooling units (50) is higher than the capacity which the heat source unit (40) is capable of actually demonstrating.

[0011] In the third aspect, in a case where the capacity which the heat source unit (40) can actually demonstrate is insufficient, the cooling operation of each of the plurality of cooling units (50) can be controlled on the basis of the control information so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority can perform the cooling operation preferentially over the cooling unit (50) with a low degree of priority. This makes it easy to secure a cooling capacity of the cooling unit (50) with a high degree of priority among the plurality of cooling units (50) even in a case where the capacity of the heat source unit (40) is insufficient.

[0012] In the control system according to the third aspect, a fourth aspect of the present disclosure is a control system in which the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority.

[0013] In the fourth aspect, the cooling operation of each of the plurality of cooling units (50) can be controlled on the basis of the control information so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority. This makes it easy to secure a cooling capacity of the cooling unit (50) with a high degree of priority among the plurality of cooling units (50) even in a case where the capacity of the heat source unit (40) is insufficient.

[0014] In the control system according to the third or fourth aspect, a fifth aspect of the present disclosure is a control system in which the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority secures a cooling capacity preferentially over the cooling unit (50) with a low degree of priority.

[0015] In the fifth aspect, the cooling operation of each of the plurality of cooling units (50) can be controlled on the basis of the control information so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority can secure a cooling capacity preferentially over the cooling unit (50) with a low degree of priority. This makes it easy to secure a cooling capacity of the cooling unit (50) with a high degree of priority among the plurality of cooling units (50) even in a case where the capacity of the heat source unit (40) is insufficient.

[0016] In the control system according to any one of the third to fifth aspects, a sixth aspect of the present disclosure is a control system in which the first information includes information concerning a representative cooling capacity, which is a representative value of the cooling capacity of each of the plurality of cooling units (50), and the sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the representative cooling capacities of the plurality of cooling units (50).

[0017] In the sixth aspect, the insufficiency of the capacity of the heat source unit (40) can be properly determined on the basis of the sum of the representative cooling capacities of the plurality of cooling units (50). This makes it possible to properly perform processing for outputting the control information.

[0018] In the control system according to any one of the third to fifth aspects, a seventh aspect of the present disclosure is a control system in which the control unit (33) outputs the control information on the basis of the priority information, the first information, the second information, and third information indicative of the temperature of the target to be cooled and the set temperature in each of the plurality of cooling units (50), the first information includes information that is usable for deriving a predicted cooling capacity, which is a predicted value of the cooling capacity required of each of the plurality of cooling units (50), and the sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the predicted cooling capacities of the plurality of cooling units (50).

[0019] In the seventh aspect, the insufficiency of the capacity of the heat source unit (40) can be properly determined on the basis of the sum of the predicted cooling capacities of the plurality of cooling units (50). This makes it possible to properly perform processing for outputting the control information.

[0020] In the control system according to any one of the first to seventh aspects, an eighth aspect of the present disclosure is a control system in which the degree of priority includes a first degree of priority and a second degree of priority lower than the first degree of priority, the first degree of priority is a degree of priority set for a cooling unit (50) that is prohibited from forcibly stopping the cooling operation among the plurality of cooling units (50), and the second degree of priority is a degree of priority set for the cooling unit (50) that is permitted to forcibly stop the cooling operation among the plurality of cooling units (50).

[0021] In the eighth aspect, the plurality of cooling units (50) can be classified into a cooling unit (50) that is permitted to

forcibly stop the cooling operation in a case where the capacity of the heat source unit (40) is insufficient and a cooling unit (50) that does not stop the cooling operation even in a case where the capacity of the heat source unit (40) is insufficient. This makes it possible to smoothly select a "cooling unit (50) that forcibly stops the cooling operation" from among the plurality of cooling units (50) in a case where the capacity of the heat source unit (40) is insufficient.

[0022] A ninth aspect of the present disclosure relates to a refrigeration system including the control system according to any one of the first to eighth aspects; the refrigeration apparatus (20); and an adjustment portion (35) that is capable of adjusting a flow rate of the refrigerant flowing through each of the plurality of cooling units (50), in which the adjustment portion (35) operates on the basis of the control information.

[0023] In the ninth aspect, control based on the degree of priority of each cooling unit (50) (control of the cooling operation of each cooling unit (50)) can be performed by causing the adjustment portion (35) that is capable of adjusting the flow rate of the refrigerant for each cooling unit (50) to operate on the basis of the control information.

Brief Description of Drawings

[0024]

[Fig. 1] Fig. 1 is a pipe system diagram illustrating a configuration of a refrigeration system according to an embodiment.

[Fig. 2] Fig. 2 is a block diagram illustrating connection of portions in the refrigeration system according to the embodiment.

[Fig. 3] Fig. 3 is a schematic view illustrating a configuration of a cooling unit.

[Fig. 4] Fig. 4 illustrates a relationship between a type of article stored in the cooling unit and a degree of priority.

[Fig. 5] Fig. 5 is a flowchart illustrating first heat source processing of a control system.

[Fig. 6] Fig. 6 is a flowchart illustrating first use processing of the control system.

[Fig. 7] Fig. 7 is a flowchart illustrating cooling capacity control of the control system.

[Fig. 8] Fig. 8 is a flowchart illustrating second heat source processing of the control system.

[Fig. 9] Fig. 9 is a flowchart illustrating second use processing of the control system.

[Fig. 10] Fig. 10 is a pipe system diagram illustrating a configuration of a refrigeration system according to a modification of the embodiment.

[Fig. 11] Fig. 11 is a block diagram illustrating connection of portions in the refrigeration system according to the modification of the embodiment.

Description of Embodiments

[0025] An embodiment is described in detail below with reference to the drawings. Note that identical or corresponding portions in the drawings are given identical reference signs, and repeated description thereof is omitted.

(Embodiment)

[0026] Fig. 1 illustrates a configuration of a refrigeration system (10) according to the embodiment. The refrigeration system (10) includes a refrigeration apparatus (20), a control system (30) applied to the refrigeration apparatus (20), and an adjustment portion (35).

[Refrigeration Apparatus]

[0027] The refrigeration apparatus (20) includes a heat source unit (40) and a plurality of cooling units (50). The plurality of cooling units (50) have similar configurations. Each of the cooling units (50) constitutes refrigeration equipment such as a showcase, a refrigerator, or a freezer, and cools an inside of the refrigeration equipment. For example, the heat source unit (40) is installed outdoors. The cooling units (50) are installed indoors.

[0028] The heat source unit (40) includes a heat source circuit (41), a heat source fan (45), and a heat source control unit (46). The heat source circuit (41) includes a compression element (42) and a heat source heat exchanger (43). Each of the plurality of cooling units (50) includes a utilization circuit (51), a utilization fan (55), and a utilization control unit (56). The utilization circuit (51) includes a utilization heat exchanger (52) and a utilization expansion valve (53).

[0029] The heat source circuit (41) of the heat source unit (40) and the utilization circuit (51) of each of the plurality of cooling units (50) are connected by a gas communication pipe (21) and a liquid communication pipe (22). In this example, the utilization circuit (51) of each of the plurality of cooling units (50) is connected in parallel with the heat source circuit (41) of the heat source unit (40). Specifically, the gas communication pipe (21) is connected to a gas end of the heat source circuit (41), the liquid communication pipe (22) is connected to a liquid end of the heat source circuit (41), a gas end of the

utilization circuit (51) is connected to the gas communication pipe (21), and a liquid end of the utilization circuit (51) is connected to the liquid communication pipe (22).

[0030] As described above, the heat source circuit (41) of the heat source unit (40) and the utilization circuit (51) of each of the plurality of cooling units (50) are connected to constitute a refrigerant circuit (25). The refrigerant circuit (25) includes the heat source unit (40) and the plurality of cooling units (50). The refrigerant circuit (25) is filled with a refrigerant. For example, the refrigerant may be a natural refrigerant such as carbon dioxide or may be another kind of refrigerant. The refrigeration apparatus (20) performs a refrigeration cycle by circulating the refrigerant through the refrigerant circuit (25).

<Compression Element>

[0031] The compression element (42) takes the refrigerant in and compresses and discharges the refrigerant thus taken in. An inlet of the compression element (42) is connected to one end of the gas communication pipe (21) through a refrigerant pipe.

[0032] In this example, the compression element (42) is constituted by a single compressor. An inlet of the compression element (42) is an intake port of the compressor, and an outlet of the compression element (42) is a discharge port of the compressor. For example, the compressor that constitutes the compression element (42) is a rotary compressor that includes an electric motor and a compression mechanism that is driven to rotate by the electric motor. The compressor that constitutes the compression element (42) is a variable capacity compressor whose number of revolutions (operating frequency) is adjustable.

<Heat Source Fan>

[0033] The heat source fan (45) is disposed close to the heat source heat exchanger (43) and transports heat source air to the heat source heat exchanger (43). The heat source air is, for example, outdoor air.

<Heat Source Heat Exchanger>

[0034] The heat source heat exchanger (43) causes the refrigerant flowing through the heat source heat exchanger (43) and the heat source air transported to the heat source heat exchanger (43) to exchange heat with each other. The heat source heat exchanger (43) is, for example, a fin-and-tube heat exchanger. A gas end of the heat source heat exchanger (43) is connected to the outlet of the compression element (42) through a refrigerant pipe. A liquid end of the heat source heat exchanger (43) is connected to one end of the liquid communication pipe (22) through a refrigerant pipe. In this example, the heat source heat exchanger (43) functions as a radiator.

<Heat Source Sensor>

[0035] The heat source unit (40) is provided with a heat source sensor (60) that detects various kinds of physical quantities in each portion of the heat source unit (40). For example, the heat source sensor (60) includes various kinds of sensors such as a pressure sensor and a temperature sensor. Examples of the physical quantities detected by the heat source sensor (60) include a pressure and a temperature on a high-pressure side (a high-pressure refrigerant) of the refrigerant circuit (25), a pressure and a temperature on a low-pressure side (a low-pressure refrigerant) of the refrigerant circuit (25), a pressure and a temperature of the refrigerant of the heat source heat exchanger (43), and a temperature of air taken into the heat source unit (40). The heat source sensor (60) transmits a detection signal indicative of a detection result to the heat source control unit (46).

<Heat Source Control Unit>

[0036] The heat source control unit (46) is connected to each portion of the heat source unit (40) by a signal line. In this example, portions such as the compression element (42), the heat source fan (45), and the heat source sensor (60) are connected to the heat source control unit (46), as illustrated in Fig. 2. The heat source control unit (46) receives a signal transmitted from an outside of the heat source unit (40). The heat source control unit (46) controls each portion of the heat source unit (40) on the basis of the detection signal of the heat source sensor (60) and the signal transmitted from the outside of the heat source unit (40). Operation of the heat source unit (40) is thus controlled.

[0037] For example, the heat source control unit (46) includes a processor and a memory that is electrically connected to the processor and in which a program causing the processor to operate and information are stored. When the processor executes the program, various functions of the heat source control unit (46) are realized.

<Utilization Fan>

[0038] The utilization fan (55) is disposed close to the utilization heat exchanger (52) and transports utilization air to the utilization heat exchanger (52). The utilization air is, for example, interior air.

<Utilization Heat Exchanger>

[0039] The utilization heat exchanger (52) causes the refrigerant flowing through the utilization heat exchanger (52) and the utilization air transported to the utilization heat exchanger (52) to exchange heat with each other. The utilization heat exchanger (52) is, for example, a fin-and-tube heat exchanger. A liquid end of the utilization heat exchanger (52) is connected to the liquid communication pipe (22) through a refrigerant pipe. A gas end of the utilization heat exchanger (52) is connected to the gas communication pipe (21) through a refrigerant pipe. In this example, the utilization heat exchanger (52) functions as an evaporator.

<Utilization Expansion Valve>

[0040] The utilization expansion valve (53) is provided in a refrigerant pipe between the liquid end of the utilization heat exchanger (52) and the liquid communication pipe (22). An opening degree of the utilization expansion valve (53) is adjustable. The utilization expansion valve (53) is, for example, an electric valve.

<Utilization Sensor>

[0041] Each of the cooling units (50) is provided with a utilization sensor (70) for detecting various kinds of physical quantities in each portion of the cooling unit (50). For example, the utilization sensor (70) includes various kinds of sensors such as a pressure sensor and a temperature sensor. Examples of the physical quantities detected by the utilization sensor (70) include a pressure and a temperature on a high-pressure side (a high-pressure refrigerant) of the refrigerant circuit (25), a pressure and a temperature on a low-pressure side (a low-pressure refrigerant) of the refrigerant circuit (25), a pressure and a temperature of the refrigerant of the utilization heat exchanger (52), and a temperature of air taken into the cooling unit (50). The utilization sensor (70) transmits a detection signal indicative of a detection result to the utilization control unit (56). Operation of the cooling unit (50) is thus controlled.

[0042] In this example, the utilization sensor (70) includes an interior temperature sensor (71) and a superheating degree sensor (72). The interior temperature sensor (71) detects a temperature of interior air to be cooled by the cooling unit (50). The superheating degree sensor (72) detects a degree of superheating of the refrigerant at a refrigerant outlet of the utilization heat exchanger (52). For example, the superheating degree sensor (72) includes an inlet temperature sensor that detects a temperature of the refrigerant at a refrigerant inlet of the utilization heat exchanger (52) and an outlet temperature sensor that detects a temperature of the refrigerant at the refrigerant outlet of the utilization heat exchanger (52). A difference between the temperature of the refrigerant detected by the inlet temperature sensor and the temperature of the refrigerant detected by the outlet temperature sensor corresponds to a degree of superheating of the refrigerant at the refrigerant outlet of the utilization heat exchanger (52).

<Utilization Control Unit>

[0043] The utilization control unit (56) is connected to each portion of the cooling unit (50) by a signal line. As illustrated in Fig. 2, portions such as the utilization expansion valve (53), the utilization fan (55), and the utilization sensor (70) are connected to the utilization control unit (56). The utilization control unit (56) receives a signal transmitted from the outside of the cooling unit (50). The utilization control unit (56) controls each portion of the cooling unit (50) on the basis of the detection signal of the utilization sensor (70) and the signal transmitted from the outside of the cooling unit (50).

[0044] For example, the utilization control unit (56) includes a processor and a memory that is electrically connected to the processor and in which a program causing the processor to operate and information are stored. When the processor executes the program, various functions of the utilization control unit (56) are realized.

[Structure of Cooling Unit]

[0045] Fig. 3 illustrates a structure of the cooling unit (50). In this example, the cooling unit (50) includes a showcase (50a). The cooling unit (50) cools air (interior air) in the showcase (50a) in cooling operation.

[0046] In the showcase (50a), an interior space (50b) and an air passage (50c) are provided. The interior space (50b) is a space whose one face (front face in this example) is an open face. In this example, a plurality of shelves for displaying articles stored in the interior space (50b) are provided in the interior space (50b).

[0047] The air passage (50c) has an intake port (50d) and a blow-out port (50e) that are opened to the interior space (50b). The intake port (50d) and the blow-out port (50e) are provided in the showcase (50a) along a peripheral edge portion of the open face of the interior space (50b). In this example, the intake port (50d) is provided in a lower portion of the showcase (50a), and the blow-out port (50e) is provided in an upper portion of the showcase (50a).

[0048] The utilization fan (55) and the utilization heat exchanger (52) are disposed in the air passage (50c). The utilization fan (55) forms a flow of air traveling from the intake port (50d) to the blow-out port (50e) by passing the utilization fan (55) and the utilization heat exchanger (52) in the air passage (50c). The air sucked from the interior space (50b) into the air passage (50c) through the intake port (50d) is thus cooled in the utilization heat exchanger (52), which is an evaporator, and is blown from the air passage (50c) into the interior space (50b) through the blow-out port (50e). On the open face of the interior space (50b), an air curtain is formed by the flow of air from the blow-out port (50e) toward the intake port (50d).

[0049] The interior temperature sensor (71) and a temperature sensor (81), which will be described later, are disposed close to the intake port (50d) and detect, as an "interior air temperature", a temperature of air sucked from the interior space (50b) into the air passage (50c) through the intake port (50d).

[Operation of Refrigeration Apparatus]

[0050] Next, operation of the refrigeration apparatus (20) is described with reference to Fig. 1.

[0051] In the heat source unit (40), the compression element (42) and the heat source fan (45) are driven. The heat source control unit (46) controls the compression element (42) and the heat source fan (45).

[0052] Each of the plurality of cooling units (50) performs or stops cooling operation depending on a difference between a temperature of a target to be cooled and a set temperature. The cooling operation is operation for cooling the interior of the cooling unit (50). In this example, the temperature of the target to be cooled is the temperature of the interior air inside the cooling unit (50). The set temperature is a preset target temperature of the interior air.

[0053] Specifically, in the cooling unit (50), in a case where the interior temperature detected by the interior temperature sensor (71) is higher than the set temperature, the utilization control unit (56) controls driving of the utilization fan (55) and adjusts the opening degree of the utilization expansion valve (53) so that the cooling operation is performed. In the cooling unit (50) that is performing the cooling operation, the utilization control unit (56) adjusts the opening degree of the utilization expansion valve (53) so that the degree of superheating detected by the superheating degree sensor (72) becomes a preset target degree of superheating. In a case where the interior temperature detected by the interior temperature sensor (71) is not higher than the set temperature, the utilization control unit (56) stops the utilization fan (55) and fully closes the utilization expansion valve (53) so that the cooling operation stops.

[Flow of Refrigerant in Operation of Refrigeration Apparatus]

[0054] In the heat source unit (40), the refrigerant discharged from the compression element (42) releases heat in the heat source heat exchanger (43), which is a radiator. The refrigerant that has flowed out from the heat source heat exchanger (43) flows into the liquid communication pipe (22). The refrigerant that has flowed into the liquid communication pipe (22) flows into the cooling unit (50) that is performing the cooling operation among the plurality of cooling units (50).

[0055] In the cooling unit (50) that is performing the cooling operation, the refrigerant that has flowed from the liquid communication pipe (22) into the cooling unit (50) is decompressed in the utilization expansion valve (53) and then evaporates in the utilization heat exchanger (52), which is an evaporator. The interior air is thus cooled. The refrigerant that has flowed out from the utilization heat exchanger (52) flows into the heat source unit (40) through the gas communication pipe (21).

[0056] In the heat source unit (40), the refrigerant that has flowed from the gas communication pipe (21) into the heat source unit (40) is taken into the compression element (42) and is compressed in the compression element (42).

[Adjustment Portion]

[0057] The adjustment portion (35) is configured to be capable of adjusting a flow rate of the refrigerant flowing through each of the plurality of cooling units (50). In this example, the adjustment portion (35) includes a plurality of adjustment valves (36) that correspond to the plurality of cooling units (50).

[0058] The plurality of adjustment valves (36) have similar configurations. Each of the adjustment valves (36) is connected between the liquid communication pipe (22) and a refrigerant inlet of the cooling unit (50) (specifically, the liquid end of the utilization circuit (51)). In this example, each of the adjustment valves (36) is an electric valve whose opening degree is adjustable. By adjusting the opening degree of the adjustment valve (36), the flow rate of the refrigerant flowing through the cooling unit (50) is adjusted, and as a result, a cooling capacity demonstrated by the cooling unit (50) can be adjusted. By fully closing the adjustment valve (36), the flow of the refrigerant in the cooling unit (50) is stopped, and as a result, the cooling operation of the cooling unit (50) can be forcibly stopped.

[Control System]

[0059] The control system (30) controls the refrigeration system (10). In this example, the control system (30) includes an information acquisition unit (31), a storage unit (32), and a control unit (33).

<Information Acquisition Unit>

[0060] The information acquisition unit (31) acquires information concerning the refrigeration system (10). The information acquired by the information acquisition unit (31) is transmitted to the control unit (33). For example, the information acquisition unit (31) includes various kinds of sensors such as a pressure sensor and a temperature sensor, a receiving unit that receives information and data, and an operation unit that receives user's input of information and data.

[0061] The information concerning the refrigeration system (10) includes information concerning the heat source unit (40) and information concerning each of the plurality of cooling units (50). The information concerning the heat source unit (40) includes "information that can be used to derive a capacity which the heat source unit (40) can actually demonstrate".

The information concerning each of the plurality of cooling units (50) includes at least part of "information indicative of a degree of priority of each of the plurality of cooling units (50)", "information that can be used to derive a cooling capacity required of each of the plurality of cooling units (50)", and "information indicative of a temperature of a target to be cooled and a set temperature in each of the plurality of cooling units (50)".

[0062] In the following description, the information indicative of the degree of priority of each of the plurality of cooling units (50) is referred to as "priority information". The information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50) is referred to as "first information". The information that can be used to derive the capacity which the heat source unit (40) can actually demonstrate is referred to as "second information". The information indicative of the temperature of the target to be cooled and the set temperature in each of the plurality of cooling units (50) is referred to as "third information".

[0063] In this example, the information acquisition unit (31) includes the plurality of temperature sensors (81) that correspond to the plurality of cooling units (50). The plurality of temperature sensors (81) have similar configurations. Each of the temperature sensors (81) detects an interior temperature of a corresponding one of the cooling units (50). The plurality of temperature sensors (81) included in the information acquisition unit (31) detect the "temperature of the target to be cooled in each of the plurality of cooling units (50)", which is a part of the third information. The temperature sensors (81) transmit a detection signal indicative of a detection result to the control unit (33).

<Storage Unit>

[0064] The storage unit (32) stores therein various kinds of information and data concerning the refrigeration system (10). Specifically, the storage unit (32) stores therein information concerning the heat source unit (40), information concerning each of the plurality of cooling units (50), information used for control in the refrigeration system (10), data concerning an operating state of the refrigeration apparatus (20), and the like.

[0065] In this example, the "information concerning each of the plurality of cooling units (50)" stored in the storage unit (32) includes the priority information, the first information, and the "set temperature in each of the plurality of cooling units (50)", which is a remaining part of the third information. The "information concerning the heat source unit (40)" stored in the storage unit (32) includes the second information.

[0066] Note that the information and data stored in the storage unit (32) may be information and data input by a user, may be information and data automatically collected by the control unit (33), or may be new information and data (e.g., information and data obtained by machine learning) generated on the basis of the information and data automatically collected by the control unit (33).

<Control Unit>

[0067] The control unit (33) controls the refrigeration apparatus (20). In this example, the control unit (33) is connected to each portion of the refrigeration system (10) by a signal line. As illustrated in Fig. 2, the control unit (33) is connected to portions such as the information acquisition unit (31) (the plurality of temperature sensors (81) in this example), the storage unit (32), the heat source control unit (46), and the adjustment portion (35) (the plurality of adjustment valves (36) in this example). The control unit (33) receives a signal (not illustrated) transmitted from the outside of the refrigeration system (10). The control unit (33) controls the refrigeration system (10) including the refrigeration apparatus (20) on the basis of information obtained by each portion of the refrigeration system (10) and the signal transmitted from the outside of the refrigeration system (10).

[0068] For example, the control unit (33) includes a processor and a memory that is electrically connected to the processor and in which a program causing the processor to operate and information are stored. When the processor

executes the program, various functions of the control unit (33) are realized.

[Processing Performed by Control Unit]

[0069] The control unit (33) outputs information indicative of a capacity required of the heat source unit (40) on the basis of the first information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50) and the third information indicative of the temperature of the target to be cooled and the set temperature in each of the plurality of cooling units (50). Hereinafter, the information indicative of the capacity required of the heat source unit (40) is referred to as "fourth information".

[0070] The control unit (33) outputs the fourth information to the heat source control unit (46) of the heat source unit (40). The heat source control unit (46) controls operation of the heat source unit (40) by controlling each portion (specifically, the compression element (42)) of the heat source unit (40) on the basis of the "capacity required of the heat source unit (40)" indicated by the fourth information. In this example, as the capacity required of the heat source unit (40) becomes higher, the number of revolutions of the compressor that constitutes the compression element (42) becomes larger. In this way, the heat source unit (40) operates on the basis of the fourth information (the information indicative of the capacity required of the heat source unit (40)).

[0071] In this example, the first information includes information concerning a "representative cooling capacity", which is a representative value of the cooling capacity of each of the plurality of cooling units (50). The capacity required of the heat source unit (40) is a capacity according to a sum of the representative cooling capacities of the cooling units (50) that are performing the cooling operation among the plurality of cooling units (50). The control unit (33) outputs the fourth information indicative of the "capacity required of the heat source unit (40)" according to the sum of the representative cooling capacities of the cooling units (50) that are performing the cooling operation among the plurality of cooling units (50) on the basis of the first information and the third information.

[0072] Hereinafter, the processing concerning the representative cooling capacity (processing of outputting the fourth information) is referred to as "first heat source processing". The representative cooling capacity is described in detail later.

[0073] In this example, the first information includes information that can be used to derive a "predicted cooling capacity", which is a predicted value of the cooling capacity required of each of the plurality of cooling units (50). The capacity required of the heat source unit (40) is a capacity according to a sum of the predicted cooling capacities of the plurality of cooling units (50). The control unit (33) outputs the fourth information indicative of the "capacity required of the heat source unit (40)" according to the sum of the predicted cooling capacities of the plurality of cooling units (50) on the basis of the first information and the third information.

[0074] Hereinafter, the processing concerning the predicted cooling capacity (processing of outputting the fourth information) is referred to as "second heat source processing". The predicted cooling capacity is described in detail later. For example, the control unit (33) selectively performs the first heat source processing or the second heat source processing in accordance with an instruction from the outside of the refrigeration system (10).

[0075] Furthermore, the control unit (33) outputs control information for controlling the cooling operation of each of the plurality of cooling units (50) on the basis of the priority information indicative of the degree of priority of each of the plurality of cooling units (50), the first information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50), and the second information that can be used to derive the capacity which the heat source unit (40) can actually demonstrate. Note that the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), a cooling unit (50) with a high degree of priority can perform the cooling operation preferentially over a cooling unit (50) with a low degree of priority.

[0076] The control unit (33) outputs the control information to the adjustment portion (35). The adjustment portion (35) operates on the basis of the control information. Specifically, the control unit (33) controls the plurality of adjustment valves (36) included in the adjustment portion (35) by outputting an opening degree adjustment signal according to the control information to the plurality of adjustment valve (36). Control of the adjustment valves (36) will be described in detail later.

[0077] In this example, the control unit (33) outputs the control information in a case where the capacity according to the sum of cooling capacities required of the plurality of cooling units (50) is higher than the capacity which the heat source unit (40) can actually demonstrate.

[0078] Note that in this example, the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority. Furthermore, the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority can secure a cooling capacity preferentially over the cooling unit (50) with a low degree of priority.

[0079] In this example, the first information includes information concerning the "representative cooling capacity", which is a representative value of the cooling capacity of each of the plurality of cooling units (50). The sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the representative cooling capacities of the plurality of

cooling units (50). The control unit (33) outputs the control information in a case where a capacity according to the sum of the representative cooling capacities of the plurality of cooling units (50) is higher than the capacity which the heat source unit (40) can actually demonstrate.

[0080] Hereinafter, the processing concerning the representative cooling capacity (processing of outputting the control information) is referred to as "first use processing".

[0081] In this example, the first information includes information that can be used to derive the "predicted cooling capacity", which is a predicted value of the cooling capacity required of each of the plurality of cooling units (50). The sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the predicted cooling capacities of the plurality of cooling units (50). The control unit (33) outputs the control information in a case where the capacity according to the sum of the predicted cooling capacities of the plurality of cooling units (50) is higher than the capacity which the heat source unit (40) can actually demonstrate.

[0082] Hereinafter, the processing concerning the predicted cooling capacity (processing of outputting the control information) is referred to as "second use processing". For example, the control unit (33) selectively performs the first use processing or the second use processing in accordance with an instruction from the outside of the refrigeration system (10).

[Degree of Priority]

[0083] Next, the degree of priority of each of the plurality of cooling units (50) is described with reference to Fig. 4. The degree of priority of each of the cooling units (50) is set in accordance with a degree of necessity of cooling in the cooling unit (50). As the degree of necessity of cooling in the cooling unit (50) becomes higher, the degree of priority set for the cooling unit (50) becomes higher.

[0084] In this example, the degree of priority of each of the plurality of cooling units (50) is set in accordance with a type of article stored in the showcase (50a) of the cooling unit (50). Specifically, for each type of article assumed to be stored in the showcase (50a) of the cooling unit (50), a degree of priority set for the cooling unit (50) that stores the type of article is determined in advance. As the degree of necessity of cooling of a stored article becomes higher, a degree of priority set for the cooling unit (50) that stores the article becomes higher.

[0085] Examples of the type of stored article include frozen foods, fresh meat, fresh fish, fruits and vegetables, and soft drinks. For example, the degree of necessity of cooling increases in the order of frozen foods, fresh meat (or fresh fish), fruits and vegetables, and soft drinks.

[0086] In the example of Fig. 4, the degree of priority gradually decreases from "1" toward "4". A degree of priority "1" is set for the cooling unit (50) that stores "frozen foods". A degree of priority "2" is set for the cooling unit (50) that stores "fresh meat". A degree of priority "3" is set for the cooling unit (50) that stores "fruits and vegetables". A degree of priority "4" is set for the cooling unit (50) that stores "soft drinks".

[0087] In this example, the degree of priority includes a first degree of priority and a second degree of priority lower than the first degree of priority. The first degree of priority is a degree of priority set for the cooling unit (50) that is prohibited from forcibly stopping the cooling operation among the plurality of cooling units (50). The second degree of priority is a degree of priority set for the cooling unit (50) that is permitted to forcibly stop the cooling operation among the plurality of cooling units (50).

[0088] In the example of Fig. 4, the degree of priority (the degree of priority "1") set for the cooling unit (50) that stores "frozen foods" and the degree of priority (the degree of priority "2") set for the cooling unit (50) that stores "fresh meat" are the first degree of priority. The cooling unit (50) that stores "frozen foods" and the cooling unit (50) that stores "fresh meat" are cooling units (50) that are prohibited from forcibly stopping the cooling operation.

[0089] In the example of Fig. 4, the degree of priority (the degree of priority "3") set for the cooling unit (50) that stores "fruits and vegetables" and the degree of priority (the degree of priority "4") set for the cooling unit (50) that stores "soft drinks" are the second degree of priority. The cooling unit (50) that stores "fruits and vegetables" and the cooling unit (50) that stores "soft drinks" are cooling units (50) that are permitted to forcibly stop the cooling operation.

[Setting of Degree of Priority]

[0090] In this example, when a type of article stored in a cooling unit (50) is designated, the control unit (33) automatically sets a degree of priority of the cooling unit (50) to a "degree of priority according to the designated type of article" in response to the designation. Then, the control unit (33) registers a setting result of the degree of priority of the cooling unit (50) (which degree of priority is set for each cooling unit (50)) in the priority information stored in the storage unit (32).

[0091] For example, the storage unit (32) stores therein an information table (correspondence information) indicative of a correspondence between a "type of article stored in the cooling unit (50)" and a "degree of priority set for the cooling unit (50)". When an operation (e.g., a button operation) for designating a type of article stored in the cooling unit (50) is input to an operation unit (not illustrated) by a user, the control unit (33) detects a degree of priority corresponding to the type of

article designated by the operation from the information table stored in the storage unit (32). Then, the control unit (33) sets the degree of priority of the cooling unit (50) for which the type of stored article has been designated by the operation to the "degree of priority detected from the information table".

5 [Capacity of Heat Source Unit]

[0092] Next, the capacity of the heat source unit (40) is described. In a case where the heat source unit (40) has no abnormality and the heat source unit (40) is normally operating, the capacity which the heat source unit (40) can actually demonstrate is a predetermined maximum capacity (e.g., rated capacity) of the heat source unit (40). However, in a case
10 where an abnormality occurs in the heat source unit (40), the capacity which the heat source unit (40) can actually demonstrate is lower than the predetermined maximum capacity of the heat source unit (40).

[0093] Examples of the abnormality of the heat source unit (40) (a state where the heat source unit (40) cannot actually demonstrate the predetermined maximum capacity) include an abnormality that occurs due to a factor outside the heat source unit (40) such as an abnormality of an operating condition of the refrigeration apparatus (20) and an abnormality
15 that occurs due to a factor inside the heat source unit (40) such as malfunction of a constituent element of the heat source unit (40).

[0094] Examples of the abnormality that occurs due to a factor outside the heat source unit (40) include a state where operation (specifically, the number of revolutions of the compressor) of the compression element (42) of the heat source unit (40) is restricted because a pressure on a high-pressure side (high-pressure refrigerant) of the refrigerant circuit (25) is
20 higher than a predetermined pressure. Examples of the abnormality that occurs due to a factor inside the heat source unit (40) include a state where one or more of the plurality of compressors that constitute the compression element (42) become abnormal (e.g., fail).

[0095] The heat source control unit (46) derives the capacity which the heat source unit (40) can actually demonstrate on the basis of an operating state of the heat source unit (40) such as presence or absence of an abnormality of the heat source unit (40). The heat source control unit (46) transmits information indicative of the capacity which the heat source unit
25 (40) can actually demonstrate to the control unit (33). The control unit (33) causes the "information indicative of the capacity which the heat source unit (40) can actually demonstrate" transmitted from the heat source control unit (46) to be stored in the storage unit (32).

[0096] Alternatively, the heat source control unit (46) transmits information indicative of the operating state of the heat source unit (40) to the control unit (33). The control unit (33) derives the capacity which the heat source unit (40) can actually demonstrate on the basis of the "information indicative of the operating state of the heat source unit (40)"
30 transmitted from the heat source control unit (46). Then, the control unit (33) causes information indicative of the capacity which the heat source unit (40) can actually demonstrate to be stored in the storage unit (32).

[0097] The "information indicative of the capacity which the heat source unit (40) can actually demonstrate" and the
35 "information indicative of the operating state of the heat source unit (40)" are examples of the information that can be used to derive the capacity which the heat source unit (40) can actually demonstrate.

[Cooling Capacity of Cooling Unit]

[0098] Next, the cooling capacity required of the cooling unit (50) is described. Hereinafter, the cooling capacity required of the cooling unit (50) is referred to as a "cooling capacity of the cooling unit (50)".

<First Cooling Capacity>

[0099] The cooling capacity of the cooling unit (50) includes a "cooling capacity required to cool a target to be cooled in the cooling unit (50)". Hereinafter, the cooling capacity required to cool the target to be cooled in the cooling unit (50) is referred to as a "first cooling capacity".

[0100] The first cooling capacity is a capacity according to a product of a "heat capacity of the cooling unit (50)" and a "difference between the temperature of the target to be cooled and the set temperature in the cooling unit (50)".
50 Specifically, as the product becomes larger, the first cooling capacity becomes higher. Note that the heat capacity of the cooling unit (50) is an amount of heat needed to change the temperature of the target to be cooled by a unit temperature (1°C). The difference between the temperature of the target to be cooled and the set temperature is accurately a temperature difference obtained by subtracting the set temperature from the temperature of the target to be cooled.

[0101] For example, in a case where the cooling unit (50) is a "cooling unit (50) that cools air in the showcase (50a)", the heat capacity of the cooling unit (50) changes in accordance with a product of an "amount of article stored in the showcase (50a)" and "specific heat of the article stored in the showcase (50a)". Specifically, as the product becomes larger, the heat capacity of the cooling unit (50) becomes larger. The "amount of article stored in the showcase (50a)" can be expressed by
55 a product of a "cooling storage volume of the showcase (50a) (specifically, a volume of the interior space (50b))" and a

"storage occupancy rate of the article stored in the showcase (50a) (specifically, a ratio of a volume of the stored article to the volume of the interior space (50b))".

[0102] In view of the above, the first cooling capacity (Q1) can be expressed by the following equation 1. In the equation 1, "V" is the cooling storage volume of the showcase (50a). "r1" is the storage occupancy rate of the article stored in the showcase (50a). "c" is the specific heat of the article stored in the showcase (50a). "T1" is an interior temperature of the showcase (50a) (the temperature of the target to be cooled in the cooling unit (50)). "T0" is the set temperature.

[Math. 1]

$$Q1 = V \times r1 \times c \times (T1 - T0) \quad \dots (1)$$

[0103] Note that the heat capacity of the cooling unit (50) is an example of static information that can be used to derive the cooling capacity of the cooling unit (50) (information that does not change in accordance with the operating state of the cooling unit (50)). Specifically, the specific heat of the article stored in the showcase (50a), the cooling storage volume of the showcase (50a), the amount of article stored in the showcase (50a), and the storage occupancy rate of the article stored in the showcase (50a) are examples of the static information that can be used to derive the cooling capacity of the cooling unit (50).

[0104] The "difference between the temperature of the target to be cooled and the set temperature in the cooling unit (50)" is information that can be derived from the third information indicative of the temperature of the target to be cooled and the set temperature in the cooling unit (50) and is dynamic information that can be used to derive the cooling capacity of the cooling unit (50) (information that changes in accordance with the operating state of the cooling unit (50)).

[0105] The specific heat (c) of the article stored in the showcase (50a) can be estimated from the type of stored article. Examples of the type of stored article include frozen foods, fresh meat, fresh fish, fruits and vegetables, and soft drinks. The type of article stored in the showcase (50a) can be estimated from the set temperature in the showcase (50a). For example, in a case where the set temperature in the showcase (50a) is "0°C", it can be estimated that the type of article stored in the showcase (50a) is "fresh meat" or "fresh fish", and it can be estimated that the specific heat (c) of the stored article is specific heat according to "fresh meat" or "fresh fish".

[0106] Note that the type of article stored in the showcase (50a) and the set temperature in the showcase (50a) are examples of the static information that can be used to derive the cooling capacity of the cooling unit (50) (information that does not change in accordance with the operating state of the cooling unit (50)).

[0107] For example, desired information to be derived may be derived from the above information by using an information table indicative of a correspondence between the above information (e.g., the type of stored article, the set temperature) and the desired information (e.g., the specific heat (c), the heat capacity, the cooling capacity).

<Second Cooling Capacity>

[0108] The cooling capacity of the cooling unit (50) may include a "cooling capacity required for heat absorption of the cooling unit (50)" in addition to the first cooling capacity. Hereinafter, the cooling capacity required for heat absorption of the cooling unit (50) is referred to as a "second cooling capacity".

[0109] The second cooling capacity is a capacity according to a product of the "cooling storage volume of the showcase (50a)", a "heat absorption rate of the cooling unit (50)", and a "difference between an ambient temperature and the temperature of the target to be cooled in the cooling unit (50)". Specifically, as the product becomes larger, the second cooling capacity becomes higher. The heat absorption rate of the cooling unit (50) depends on a structure of the cooling unit (50) (ease with which cold air escapes). The more easily cold air escapes from the cooling unit (50), the higher the heat absorption rate of the cooling unit (50). The difference between the ambient temperature and the temperature of the target to be cooled is accurately a temperature difference obtained by subtracting the temperature of the target to be cooled from the ambient temperature.

[0110] For example, in a case where the cooling unit (50) is a "cooling unit (50) that cools air in the showcase (50a)", the heat absorption rate (ease with which cold air escapes) of the cooling unit (50) depends on the type of showcase (50a).

[0111] In a case where the type of showcase (50a) is a "hermetically sealed type such as a refrigerator", the heat absorption rate of the cooling unit (50) is relatively low. In a case where the type of showcase (50a) is a "glass door equipped type", the heat absorption rate of the cooling unit (50) is higher than that in the case of the "hermetically sealed type". In a case where the type of showcase (50a) is an "opened type without a door", the heat absorption rate of the cooling unit (50) is relatively high.

[0112] In a case where the cooling unit (50) is a "cooling unit (50) that cools air in the showcase (50a)", the ambient temperature of the cooling unit (50) is a "temperature of air in a facility where the showcase (50a) is installed", and the temperature of the target to be cooled by the cooling unit (50) is the "interior temperature of the showcase (50a)".

[0113] In view of the above, the second cooling capacity (Q2) is expressed by the following equation 2. The cooling

capacity (Q) of the cooling unit (50) including the first cooling capacity (Q1) and the second cooling capacity (Q2) is expressed by the following equation (3). In the equation 2 and the equation 3, "r2" is the heat absorption rate of the cooling unit (50). "T2" is a temperature of air in the facility where the showcase (50a) is installed (the ambient temperature of the cooling unit (50)).

[Math. 2]

$$Q2 = V \times r2 \times (T2 - T1) \quad \dots (2)$$

$$Q = Q1 + Q2 = V \times r1 \times c \times (T1 - T0) + V \times r2 \times (T2 - T1) \quad \dots (3)$$

[0114] Note that the cooling storage volume of the cooling unit (50) and the heat absorption rate of the cooling unit (50) are examples of the static information that can be used to derive the cooling capacity of the cooling unit (50) (information that does not change in accordance with the operating state of the cooling unit (50)). The difference between the ambient temperature and the temperature of the target to be cooled in the cooling unit (50) is an example of the dynamic information that can be used to derive the cooling capacity of the cooling unit (50) (information that changes in accordance with the operating state of the cooling unit (50)).

[0115] For example, desired information to be derived may be derived from the above information by using an information table indicative of a correspondence between the above information (e.g., the type of the showcase (50a)) and the desired information (e.g., the heat absorption rate, the cooling capacity).

[Representative Cooling Capacity]

[0116] Next, the representative cooling capacity is described. The representative cooling capacity is a representative value of the cooling capacity of the cooling unit (50). The representative cooling capacity is a static cooling capacity that does not change in accordance with the operating state of the cooling unit (50) (specifically, a difference between the temperature of the target to be cooled and the set temperature).

[0117] The representative cooling capacity is set to a cooling capacity which the cooling unit (50) demonstrates in a case where the cooling unit (50) is in a predetermined operating state. For example, the representative cooling capacity is set to a maximum cooling capacity (rated cooling capacity) which the cooling unit (50) can demonstrate in a case where the cooling unit (50) is in a predetermined operating state.

[0118] For example, the representative cooling capacity may be set to a capacity according to a "first representative cooling capacity", which is a representative value of the first cooling capacity of the cooling unit (50) (the cooling capacity required to cool the target to be cooled). The first representative cooling capacity is a capacity according to a "representative heat capacity", which is a representative value of the heat capacity of the cooling unit (50). Specifically, the first representative cooling capacity may be set to a capacity according to a product of the "representative heat capacity of the cooling unit (50)" and a "representative value (e.g., an assumed maximum value) of the difference between the temperature of the target to be cooled and the set temperature in the cooling unit (50)".

[0119] Note that the representative heat capacity may be set to a heat capacity according to a product of a "representative value (e.g., an assumed maximum value) of the amount of article stored in the showcase (50a)" and a "representative value of the specific heat (c) of the article stored in the showcase (50a)". The first representative cooling capacity and the representative heat capacity are information that changes in accordance with the amount and specific heat of the article stored in the showcase (50a).

[0120] The representative value of the specific heat (c) of the article stored in the showcase (50a) may be set to specific heat of an article that is determined in advance to be stored in the showcase (50a). The representative value of the amount of article stored in the showcase (50a) may be set to a value according to a product of the "cooling storage volume (V) of the showcase (50a)" and a "representative value (e.g., an assumed maximum value) of the storage occupancy rate (r1) of the article stored in the showcase (50a)".

[0121] The representative cooling capacity may be set to a capacity according to the "first representative cooling capacity" and a "second representative cooling capacity", which is a representative value of the second cooling capacity of the cooling unit (50) (the cooling capacity required for heat absorption of the cooling unit (50)). Specifically, the second representative cooling capacity may be set to a capacity according to a product of the "cooling storage volume (V) of the showcase (50a)", the "heat absorption rate of the showcase (50a)", and a "representative value (e.g., an assumed maximum value) of the difference between the ambient temperature and the temperature of the target to be cooled in the cooling unit (50)". The second representative cooling capacity is information that changes in accordance with the structure of the showcase (50a).

[First Heat Source Processing]

[0122] Next, first heat source processing performed by the control unit (33) is described with reference to Fig. 5. During operation of the refrigeration system (10), the control unit (33) repeatedly performs the processing illustrated in Fig. 5.

<Step (S11)>

[0123] The control unit (33) acquires the first information (the information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50)). In this example, the control unit (33) acquires the first information stored in the storage unit (32). Note that the first information in the first heat source processing includes information concerning the representative cooling capacity of each of the plurality of cooling units (50). Specifically, the first information includes the "representative cooling capacity (e.g., rated cooling capacity)" of each of the plurality of cooling units (50).

<Step (S12)>

[0124] The control unit (33) acquires the third information (the information indicative of the temperature of the target to be cooled and the set temperature in each of the plurality of cooling units (50)). In this example, the control unit (33) acquires the "temperature of the target to be cooled (the interior temperature of the showcase (50a)) in each of the plurality of cooling units (50)", which is a part of the third information obtained by the plurality of temperature sensors (81), and the "set temperature (a target value of the interior temperature) of each of the plurality of cooling units (50)", which is a remaining part of the third information stored in the storage unit (32).

<Step (S13)>

[0125] The control unit (33) determines whether or not a "cooling unit (50) that is performing the cooling operation" is included in the plurality of cooling units (50) on the basis of the third information acquired in step (S12). For example, the control unit (33) determines whether or not there is a cooling unit (50) in which the "temperature of the target to be cooled (the interior temperature of the showcase (50a))" acquired in step (S12) is higher than the "set temperature (the target value of the interior temperature)". In a case where there is a cooling unit (50) that is performing the cooling operation, a process in step (S14) is performed. Otherwise, a process in step (S16) is performed.

<Step (S14)>

[0126] In a case where there is/are cooling unit(s) (50) that is/are performing the cooling operation, the control unit (33) derives the capacity required of the heat source unit (40) on the basis of the representative cooling capacity of each "cooling unit (50) that is performing the cooling operation" among the plurality of cooling units (50).

[0127] In this example, the control unit (33) derives a sum of the representative cooling capacities of the cooling units (50) that are performing the cooling operation among the "representative cooling capacities of the plurality of cooling units (50)" acquired in step (S11) and determines the derived sum of the representative cooling capacities as the "capacity required of the heat source unit (40)".

<Step (S15)>

[0128] Next, the control unit (33) outputs the information (the fourth information) indicative of the "capacity required of the heat source unit (40)" derived in step (S14) to the heat source unit (40). The heat source unit (40) thus operates so that the "capacity required of the heat source unit (40)" derived in step (S14) is demonstrated. Specifically, the heat source control unit (46) controls each portion (specifically, the compression element (42)) of the heat source unit (40) so that the "capacity required of the heat source unit (40)" indicated by the fourth information is demonstrated.

<Step (S16)>

[0129] On the other hand, in a case where there is no cooling unit (50) that is performing the cooling operation in step (S13), the control unit (33) outputs information indicative of stoppage of the heat source unit (40) (e.g., an information signal instructing stoppage) to the heat source unit (40). The heat source unit (40) thus stops. Specifically, the heat source control unit (46) stops each portion (specifically, the compression element (42) and the heat source fan (45)) of the heat source unit (40) in response to the "information indicative of stoppage of the heat source unit (40)" output from the control unit (33).

[First Use Processing]

[0130] Next, the first use processing performed by the control unit (33) is described with reference to Fig. 6. During operation of the refrigeration system (10), the control unit (33) repeatedly performs the processing illustrated in Fig. 6.

<Step (S21)>

[0131] The control unit (33) acquires the first information (the information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50)). In this example, the control unit (33) acquires the first information stored in the storage unit (32). Note that the first information in the first use processing includes information concerning the representative cooling capacity of each of the plurality of cooling units (50). Specifically, the first information includes the "representative cooling capacity (e.g., rated cooling capacity)" of each of the plurality of cooling units (50).

<Step (S22)>

[0132] The control unit (33) acquires the second information (the information that can be used to derive the capacity which the heat source unit (40) can actually demonstrate). In this example, the control unit (33) acquires the second information stored in the storage unit (32).

<Step (S23)>

[0133] The control unit (33) derives a sum of the representative cooling capacities of the plurality of cooling units (50) on the basis of the "representative cooling capacity of each of the plurality of cooling units (50)" acquired in step (S21).

<Step (S24)>

[0134] The control unit (33) derives the capacity which the heat source unit (40) can actually demonstrate on the basis of the second information acquired in step (S22).

<Step (S25)>

[0135] Next, the control unit (33) determines whether or not the actual capacity of the heat source unit (40) (the capacity which the heat source unit (40) can actually demonstrate) is insufficient on the basis of the "sum of the representative cooling capacities of the plurality of cooling units (50)" derived in step (S23) and the "capacity which the heat source unit (40) can actually demonstrate" derived in step (S24). In a case where the actual capacity of the heat source unit (40) is insufficient, a process in step (S26) is performed. Otherwise, the processing ends.

[0136] For example, the control unit (33) determines that the actual capacity of the heat source unit (40) is insufficient in a case where the "sum of the representative cooling capacities of the plurality of cooling units (50)" is higher than the "capacity which the heat source unit (40) can actually demonstrate".

<Step (S26)>

[0137] The control unit (33) performs cooling capacity control. In the cooling capacity control, the control unit (33) outputs control information. In this example, the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority and the cooling unit (50) with a high degree of priority can secure a cooling capacity preferentially over the cooling unit (50) with a low degree of priority.

[0138] Specifically, the control information includes stoppage information indicative of a cooling unit (50) whose cooling operation is to be stopped among the plurality of cooling units (50) and secured rate information indicating a secured rate of a cooling capacity in a cooling unit (50) that performs the cooling operation among the plurality of cooling units (50).

[0139] The adjustment portion (35) operates on the basis of the control information output from the control unit (33). In this way, the cooling operation of each of the plurality of cooling units (50) is controlled so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority and the cooling unit (50) with a high degree of priority can secure a cooling capacity preferentially over the cooling unit (50) with a low degree of priority.

[0140] Specifically, the control unit (33) outputs a control signal according to the stoppage information (a control signal for fully closing the adjustment valve (36)) to the adjustment valve (36) that corresponds to the cooling unit (50) indicated by

the stoppage information (the cooling unit (50) whose cooling operation is to be stopped). As a result, the refrigerant ceases to flow into the cooling unit (50) indicated by the stoppage information, and the cooling operation of this cooling unit (50) stops.

[0141] Furthermore, the control unit (33) outputs a control signal according to the secured rate information (a control signal for adjusting the opening degree of the adjustment valve (36)) to the adjustment valve (36) corresponding to the cooling unit (50) indicated by the secured rate information (the cooling unit (50) that performs the cooling operation). Specifically, the control unit (33) outputs the control signal to the adjustment valve (36) so that the opening degree of the adjustment valve (36) corresponding to the cooling unit (50) becomes larger as the "secured rate of cooling capacity in the cooling unit (50)" indicated by the secured rate information becomes higher. This adjusts a flow rate of the refrigerant flowing through the cooling unit (50) indicated by the secured rate information, thereby adjusting the cooling capacity of the cooling unit (50). For example, in a case where the secured rate of the cooling capacity in the cooling unit (50) is "100%", the adjustment valve (36) corresponding to the cooling unit (50) is fully opened.

[Cooling Capacity Control]

[0142] Next, the cooling capacity control (the process in step (S26) illustrated in Fig. 6) performed by the control unit (33) is described with reference to Fig. 7.

<Step (S31)>

[0143] The control unit (33) determines whether or not the cooling unit(s) (50) that is/are performing the cooling operation among the plurality of cooling units (50) include(s) a "cooling unit (50) that is permitted to forcibly stop the cooling operation". In a case where there is a cooling unit (50) that is permitted to stop the cooling operation, a process in step (S32) is performed. Otherwise, a process in step (S35) is performed.

[0144] In this example, the control unit (33) detects a degree of priority of each of the cooling units (50) that are performing the cooling operation from the priority information stored in the storage unit (32). The control unit (33) determines that there is a cooling unit (50) that is permitted to stop the cooling operation in a case where the cooling units (50) that are performing the cooling operation include a "cooling unit (50) for which the second degree of priority is set".

<Step (S32)>

[0145] The control unit (33) determines, as a "cooling unit (50) to be stopped", one of such cooling units (50) that are permitted to forcibly stop the cooling operation among the cooling units (50) that are performing the cooling operation. In the case of the degrees of priority illustrated in Fig. 4, the control unit (33) determines the cooling unit (No. 4) that stores "soft drinks" as the "cooling unit (50) to be stopped".

<Step (S33)>

[0146] Next, the control unit (33) determines whether or not the insufficiency of the capacity of the heat source unit (40) is overcome by stopping the cooling operation of the cooling unit (50) to be stopped. In a case where the insufficiency of the capacity of the heat source unit (40) is overcome, the processing proceeds to step (S34). Otherwise, the process in step (S31) is performed.

<Step (S34)>

[0147] Next, the control unit (33) outputs, to the adjustment portion (35), control information including stoppage information for stopping the cooling unit (50) determined as the "cooling unit (50) to be stopped" in step (S32).

<Step (S35)>

[0148] On the other hand, in a case where the cooling units (50) that are performing the cooling operation do not include a "cooling unit (50) that is permitted to forcibly stop the cooling operation", the control unit (33) derives a "secured rate of the cooling capacity" in each of the cooling units (50) that are not permitted to stop the cooling operation so that the "capacity which the heat source unit (40) can actually demonstrate" is distributed to each of the cooling units (50) that are not permitted to stop the cooling operation at a ratio according to the degrees of priority set for the cooling units (50) that are not permitted to stop the cooling operation. Note that as the degree of priority of the cooling unit (50) becomes higher, the secured rate of the cooling capacity in the cooling unit (50) becomes higher, and a capacity of the heat source unit (40) allocated to the cooling unit (50) becomes higher.

[0149] <Step (S36)>

[0150] Next, the control unit (33) outputs, to the adjustment portion (35), control information including stoppage information for stopping the cooling unit (50) determined as the "cooling unit (50) to be stopped" in step (S32) and secured rate information indicative of the "secured rate of the cooling capacity in each of the cooling units (50) that are not permitted to stop the cooling operation" derived in step (S35).

[0151] In the case of the degrees of priority illustrated in Fig. 4, the control information includes, for example, stoppage information for stopping the cooling unit (No.3) that stores "fruits and vegetables" and the cooling unit (No.4) that stores "soft drinks" and secured rate information indicative of a secured rate of each of the cooling capacity of the cooling unit (No.1) that stores "frozen foods" and the cooling unit (No.2) that stores "fresh meat". The secured rate information includes, for example, information indicating that the secured rate of the cooling capacity in the cooling unit (No.1) that stores "frozen foods" is "100%" and information indicating that the secured rate of the cooling capacity in the cooling unit (No.2) that stores "fresh meat" is "50%".

[Predicted Cooling Capacity]

[0152] Next, the predicted cooling capacity is described. The predicted cooling capacity is a predicted value of the cooling capacity of the cooling unit (50). The predicted cooling capacity is a dynamic cooling capacity that changes in accordance with an operating state (specifically, a difference between the temperature of the target to be cooled and the set temperature) of the cooling unit (50).

[0153] For example, the predicted cooling capacity may be set to a capacity according to a "first predicted cooling capacity", which is a predicted value of the first cooling capacity.

[0154] The first predicted cooling capacity is a capacity according to a product of the "representative heat capacity", which is a representative value of the heat capacity of the cooling unit (50), and the "difference between the temperature of the target to be cooled and the set temperature (actual temperature difference) in the cooling unit (50)". For example, the first predicted cooling capacity may be set to the first cooling capacity (Q1) obtained by substituting the "actual temperature difference ($T1 - T0$)" into the equation 1 into which the "cooling storage volume (V)", the "storage occupancy rate (r1)", and the "specific heat (c)" according to the representative heat capacity of the cooling unit (50) have been already substituted.

[0155] Alternatively, the first predicted cooling capacity may be a capacity according to a product of a "predicted heat capacity", which is a predicted value of the heat capacity of the cooling unit (50), and the "difference between the temperature of the target to be cooled and the set temperature (actual temperature difference) in the cooling unit (50)".

[0156] The predicted heat capacity may be set to a heat capacity according to a product of an "actual value of an amount of article stored in the showcase (50a)" and a "representative value (e.g., an assumed maximum value) or an actual value of the specific heat (c) of the article stored in the showcase (50a)". The predicted heat capacity may be set to a heat capacity according to a product of a "representative value (e.g., an assumed maximum value) or an actual value of the amount of article stored in the showcase (50a)" and an "actual value of the specific heat (c) of the article stored in the showcase (50a)". The first predicted cooling capacity is a capacity according to at least one of the amount and specific heat of the article stored in the showcase (50a).

[0157] For example, the first predicted cooling capacity may be set to the first cooling capacity (Q1) obtained by substituting the "actual storage occupancy rate (r1)", the "actual specific heat (c)", and the "actual temperature difference ($T1 - T0$)" into the equation 1 into which the "cooling storage volume (V)" according to the structure of the cooling unit (50) has been already substituted.

[0158] The predicted cooling capacity may be set to a capacity according to the "first predicted cooling capacity" and a "second predicted cooling capacity", which is a predicted value of the second cooling capacity of the cooling unit (50) (the cooling capacity required for heat absorption of the cooling unit (50)). Specifically, the second predicted cooling capacity may be set to a capacity according to a product of the "cooling storage volume (V) of the showcase (50a)", the "heat absorption rate of the showcase (50a)", and the "difference between the ambient temperature and the temperature of the target to be cooled (actual temperature difference) in the cooling unit (50)". For example, the second predicted cooling capacity may be set to the second cooling capacity (Q2) obtained by substituting the "actual temperature difference ($T2 - T1$)" into the equation 2 into which the "cooling storage volume (V)" and the "heat absorption rate (r2)" according to the structure of the showcase (50a) have been already substituted.

[Second Heat Source Processing]

[0159] Next, the second heat source processing performed by the control unit (33) is described with reference to Fig. 8. During operation of the refrigeration system (10), the control unit (33) repeatedly performs the processing illustrated in Fig. 8. In the second heat source processing, step (S41) and steps (S44 and S45) described below are performed instead of step (S11) and step (S14) in the first heat source processing. Note that the remaining steps (S42, S43, S46, and S47) of the second heat source processing are similar to the steps (S12, S13, S15, and S16) of the first heat source processing,

respectively, and therefore description thereof is omitted.

<Step (S41)>

[0160] The control unit (33) acquires the first information (the information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50)). In this example, the control unit (33) acquires the first information stored in the storage unit (32). The first information in the second heat source processing includes information that can be used to derive the predicted cooling capacity of each of the plurality of cooling units (50). For example, the first information includes the "representative heat capacity" of each of the plurality of cooling units (50). Next, a process in step (S42) is performed.

<Step (S44)>

[0161] In a case where there is/are cooling unit(s) (50) that is/are performing the cooling operation in step (S43), the control unit (33) derives the predicted cooling capacity of each of the plurality of cooling units (50) on the basis of the first information acquired in step (S41) and the third information acquired in step (S42).

[0162] For example, the control unit (33) determines, for each of the plurality of cooling units (50), a product of the "representative heat capacity" and the "difference between the temperature of the target to be cooled and the set temperature (actual temperature difference)" of the cooling unit (50) as the predicted cooling capacity of the cooling unit (50).

<Step (S45)>

[0163] Next, the control unit (33) derives the capacity required of the heat source unit (40) on the basis of the "predicted cooling capacity of each of the plurality of cooling units (50)" derived in step (S44). Next, a process in step (S46) is performed.

[0164] For example, the control unit (33) derives a sum of the "predicted cooling capacities of the plurality of cooling units (50)" derived in step (S44) and determines the sum of the predicted cooling capacities as the "capacity required of the heat source unit (40)".

[Second Use Processing]

[0165] Next, the second use processing performed by the control unit (33) is described with reference to Fig. 9. During operation of the refrigeration system (10), the control unit (33) repeatedly performs the processing illustrated in Fig. 9. In the second use processing, step (S51), step (S53), and step (S55) described below are performed instead of step (S21), step (S23), and step (S25) in the first use processing. Note that the remaining steps (S52, S54, and S56) of the second use processing are similar to the steps (S22, S24, and S26) of the first use processing, respectively, and therefore description thereof is omitted.

<Step (S51)>

[0166] The control unit (33) acquires the first information (the information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50)) and the third information (the information indicative of the temperature of the target to be cooled and the set temperature in each of the plurality of cooling units (50)). Note that the first information in the second use processing includes information that can be used to derive the predicted cooling capacity of each of the plurality of cooling units (50). For example, the first information includes the "representative heat capacity" of each of the plurality of cooling units (50). Next, a process in step (S52) is performed.

[0167] In this example, the control unit (33) acquires the first information stored in the storage unit (32). The control unit (33) acquires the "temperature of the target to be cooled (the interior temperature of the showcase (50a)) in each of the plurality of cooling units (50)", which is a part of the third information obtained by the plurality of temperature sensors (81), and the "set temperature (the target value of the interior temperature) of each of the plurality of cooling units (50)", which is a remaining part of the third information stored in the storage unit (32).

<Step (S53)>

[0168] The control unit (33) derives the predicted cooling capacity of each of the plurality of cooling units (50) on the basis of the first information acquired in step (S51) and the third information acquired in step (S51). Next, a process in step (S54) is performed.

[0169] For example, the control unit (33) determines, for each of the plurality of cooling units (50), a product of the "representative heat capacity" and the "difference between the temperature of the target to be cooled and the set temperature (actual temperature difference)" of the cooling unit (50) as the predicted cooling capacity of the cooling unit (50).

<Step (S55)>

[0170] The control unit (33) determines whether or not the actual capacity of the heat source unit (40) (the capacity which the heat source unit (40) can actually demonstrate) is insufficient on the basis of the "sum of predicted cooling capacities of the plurality of cooling units (50)" derived in step (S53) and the "capacity which the heat source unit (40) can actually demonstrate" derived in step (S54). In a case where the actual capacity of the heat source unit (40) is insufficient, a process in step (S56) is performed. Otherwise, the processing ends.

[0171] For example, the control unit (33) determines that the actual capacity of the heat source unit (40) is insufficient in a case where the "sum of the predicted cooling capacities of the plurality of cooling units (50)" is higher than the "capacity which the heat source unit (40) can actually demonstrate".

[Effects of Embodiment]

[0172] As described above, in the refrigeration system (10) according to the embodiment, the control unit (33) outputs control information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), a cooling unit (50) with a high degree of priority can perform the cooling operation preferentially over a cooling unit (50) with a low degree of priority on the basis of the priority information indicative of a degree of priority of each of the plurality of cooling units (50), the first information that can be used to derive the cooling capacity required of each of the plurality of cooling units (50), and the second information that can be used to derive the capacity which the heat source unit (40) can actually demonstrate.

[0173] According to the above configuration, the cooling capacity required of each of the plurality of cooling units (50) can be derived on the basis of the first information. Furthermore, the capacity which the heat source unit (40) can actually demonstrate can be derived on the basis of the second information. The "control information for controlling the cooling operation of each of the plurality of cooling units (50) can be output so that among the plurality of cooling units (50), a cooling unit (50) with a high degree of priority can perform the cooling operation preferentially over a cooling unit (50) with a low degree of priority" can be output in consideration of the "cooling capacity required of each of the plurality of cooling units (50)" and the "capacity which the heat source unit (40) can actually demonstrate".

[0174] Note that in a conventional refrigeration apparatus (e.g., the refrigeration apparatus of Patent Literature 1), in a case where the "capacity which the heat source unit (40) can actually demonstrate" is lower than the "cooling capacities required of the plurality of cooling units (50)", the capacities of the plurality of cooling units (50) uniformly decrease, and therefore a cooling unit in which frozen foods, fresh foods, or the like are stored and that should be cooled preferentially cannot preferentially be cooled. On the other hand, in the refrigeration system (10) according to the embodiment, according to the above configuration, even in a case where the capacity of the heat source unit (40) is insufficient, a cooling unit that should be cooled can perform operation preferentially.

[0175] In the refrigeration system (10) according to the embodiment, the degree of priority of each of the plurality of cooling units (50) is set in accordance with a type of article stored in the showcase (50a) of the cooling unit (50).

[0176] According to the above configuration, the degree of priority of each of the cooling units (50) can be properly set in accordance with the type of article stored in the showcase (50a) of the cooling unit (50). This makes it possible to properly perform processing based on the degree of priority of the cooling unit (50).

[0177] In the refrigeration system (10) according to the embodiment, the control unit (33) outputs the control information in a case where the capacity according to the sum of cooling capacities required of the plurality of cooling units (50) is higher than the capacity which the heat source unit (40) can actually demonstrate.

[0178] According to the above configuration, in a case where the capacity which the heat source unit (40) can actually demonstrate is insufficient, the cooling operation of each of the plurality of cooling units (50) can be controlled on the basis of the control information so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority can perform the cooling operation preferentially over the cooling unit (50) with a low degree of priority. This makes it easy to secure a cooling capacity of the cooling unit (50) with a high degree of priority among the plurality of cooling units (50) even in a case where the capacity of the heat source unit (40) is insufficient.

[0179] In the refrigeration system (10) according to the embodiment, the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority.

[0180] According to the above configuration, the cooling operation of each of the plurality of cooling units (50) can be

controlled on the basis of the control information so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority. This makes it easy to secure a cooling capacity of the cooling unit (50) with a high degree of priority among the plurality of cooling units (50) even in a case where the capacity of the heat source unit (40) is insufficient.

[0181] In the refrigeration system (10) according to the embodiment, the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority can secure a cooling capacity preferentially over the cooling unit (50) with a low degree of priority.

[0182] According to the above configuration, the cooling operation of each of the plurality of cooling units (50) can be controlled on the basis of the control information so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority can secure a cooling capacity preferentially over the cooling unit (50) with a low degree of priority. This makes it easy to secure a cooling capacity of the cooling unit (50) with a high degree of priority among the plurality of cooling units (50) even in a case where the capacity of the heat source unit (40) is insufficient.

[0183] In the refrigeration system (10) according to the embodiment, the first information includes information concerning a representative cooling capacity, which is a representative value of the cooling capacity of each of the plurality of cooling units (50). The sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the representative cooling capacities of the plurality of cooling units (50).

[0184] According to the above configuration, the insufficiency of the capacity of the heat source unit (40) can be properly determined on the basis of the sum of the representative cooling capacities of the plurality of cooling units (50). This makes it possible to properly perform processing for outputting the control information.

[0185] In the refrigeration system (10) according to the embodiment, the control unit (33) outputs the control information on the basis of the priority information, the first information, the second information, and third information indicative of the temperature of the target to be cooled and the set temperature in each of the plurality of cooling units (50). The first information includes information that can be used to derive a predicted cooling capacity, which is a predicted value of the cooling capacity required of each of the plurality of cooling units (50). The sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the predicted cooling capacities of the plurality of cooling units (50).

[0186] According to the above configuration, the insufficiency of the capacity of the heat source unit (40) can be properly determined on the basis of the sum of the predicted cooling capacities of the plurality of cooling units (50). This makes it possible to properly perform processing for outputting the control information.

[0187] In the refrigeration system (10) according to the embodiment, the degree of priority includes a first degree of priority and a second degree of priority lower than the first degree of priority. The first degree of priority is a degree of priority set for a cooling unit (50) that is prohibited from forcibly stopping the cooling operation among the plurality of cooling units (50). The second degree of priority is a degree of priority set for the cooling unit (50) that is permitted to forcibly stop the cooling operation among the plurality of cooling units (50).

[0188] According to the above configuration, the plurality of cooling units (50) can be classified into a cooling unit (50) that is permitted to forcibly stop the cooling operation in a case where the capacity of the heat source unit (40) is insufficient and a cooling unit (50) that does not stop the cooling operation even in a case where the capacity of the heat source unit (40) is insufficient. This makes it possible to smoothly select a "cooling unit (50) that forcibly stops the cooling operation" from among the plurality of cooling units (50) in a case where the capacity of the heat source unit (40) is insufficient.

[0189] In the refrigeration system (10) according to the embodiment, the adjustment portion (35) operates on the basis of the control information.

[0190] According to the above configuration, control based on the degree of priority of each cooling unit (50) (control of the cooling operation of each cooling unit (50)) can be performed by causing the adjustment portion (35) that is capable of adjusting the flow rate of the refrigerant for each cooling unit (50) (in this example, the adjustment valve (36) provided for each cooling unit (50)) to operate on the basis of the control information. This makes it possible to control the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority can perform the cooling operation preferentially over the cooling unit (50) with a low degree of priority in consideration of the "cooling capacity required of each of the plurality of cooling units (50)" and the "capacity which the heat source unit (40) can actually demonstrate".

(Modification of Embodiment)

[0191] Fig. 10 illustrates a configuration of a refrigeration system (10) according to a modification of the embodiment. The refrigeration system (10) according to the modification of the embodiment is different from the refrigeration system (10) according to the embodiment in connection between the control unit (33) and the utilization control unit (56). In the refrigeration system (10) according to the modification of the embodiment, the information acquisition unit (31) illustrated in Figs. 1 and 2 is omitted. Except for this, the configuration and processing of the refrigeration system (10) according to the modification of the embodiment are similar to those of the refrigeration system (10) according to the embodiment.

[0192] As illustrated in Fig. 11, in the modification of the embodiment, the control unit (33) is connected to the utilization control unit (56) included in each of the plurality of cooling units (50) by a signal line, and can communicate with the utilization control unit (56) included in each of the plurality of cooling units (50). The control unit (33) acquires "information concerning the cooling unit (50)" from the utilization control unit (56) included in each of the plurality of cooling units (50). In this example, the utilization control unit (56) included in each of the plurality of cooling units (50) functions as the information acquisition unit (31).

[0193] The "information concerning the cooling unit (50)" obtained from the utilization control unit (56) includes information obtained by the utilization sensor (70), the set temperature in the cooling unit (50), and the like. The information obtained by the utilization sensor (70) includes the interior temperature obtained by the interior temperature sensor (71), and the like.

[0194] The refrigeration system (10) according to the modification of the embodiment can obtain effects similar to those of the refrigeration system (10) according to the embodiment.

[0195] Note that in the refrigeration system (10) according to the modification of the embodiment, in a case where the control unit (33) can adjust the opening degree of the utilization expansion valve (53) by controlling the utilization control unit (56), the adjustment valve (36) illustrated in Fig. 10 may be omitted. In this case, the utilization expansion valve (53) also functions as the adjustment valve (36).

(Other Embodiments)

[0196] In the above description, the following configuration or setting may be adopted.

[0197] The control unit (33) may be configured to perform only the first heat source processing or may be configured to perform only the second heat source processing. Similarly, the control unit (33) may be configured to perform only the first use processing or may be configured to perform only the second use processing.

[0198] The heat source control unit (46) may control operation of the heat source unit (40) (specifically, the number of revolutions of the compressor that constitutes the compression element (42)) on the basis of a pressure on the low-pressure side (low-pressure refrigerant) of the refrigerant circuit (25) instead of the fourth information output from the control unit (33) (information indicative of the capacity required of the heat source unit (40)).

[0199] Each of the adjustment valves (36) may be an electromagnetic valve that is switchable between opened and closed states. The plurality of cooling units (50) may include a cooling unit (50) for which a corresponding adjustment valve (36) is not provided. For example, the adjustment valve (36) corresponding to the cooling unit (50) that preferentially stops the cooling operation in a case where the capacity of the heat source unit (40) is insufficient may be the electromagnetic valve. No corresponding adjustment valve (36) may be provided for the cooling unit (50) given the highest priority in securing a cooling capacity.

[0200] The refrigeration apparatus (20) may include one or more air-conditioning units (not illustrated) that cool a room in addition to the plurality of cooling units (50) that cool the interior of the refrigeration equipment. Furthermore, the refrigeration apparatus (20) may include another constituent element such as a receiver that separates the stored refrigerant into a gas refrigerant and a liquid refrigerant.

[0201] The compression element (42) may include a plurality of compressors. The plurality of compressors may be connected in series or may be connected in parallel.

[0202] The control unit (33) may include a single processor or may include a plurality of processors. The plurality of processors may be collectively provided inside a single housing or may be provided in different housings. The same applies to the heat source control unit (46) and the utilization control unit (56). The storage unit (32) may include a single memory or may include a plurality of memories.

[0203] The expressions such as "first", "second", and "third" described above are used to distinguish words given these expressions and do not limit the number and order of the words.

[0204] Although the embodiments and modifications have been described above, it will be understood that various changes in form and detail may be made without departing from the spirit and scope of the claims. Furthermore, the elements pertaining to the above embodiment, modifications, and other embodiments may be appropriately combined or substituted.

Industrial Applicability

[0205] As described above, the present disclosure is useful as a control system and a refrigeration system.

Reference Signs List

[0206]

10	refrigeration system
20	refrigeration apparatus
25	refrigerant circuit
30	control system
5	31 information acquisition unit
	32 storage unit
	33 control unit
	35 adjustment portion
	40 heat source unit
10	41 heat source circuit
	42 compression element
	43 heat source heat exchanger (radiator)
	45 heat source fan
	46 heat source control unit
15	50 cooling unit
	51 utilization circuit
	52 utilization heat exchanger (evaporator)
	53 utilization expansion valve
	55 utilization fan
20	56 utilization control unit
	50a showcase
	60 heat source sensor
	70 utilization sensor

25 Claims

1. A control system applied to a refrigeration apparatus (20) including a refrigerant circuit (25) that includes a heat source unit (40) including a compression element (42) and a radiator (43) and a plurality of cooling units (50) each including an evaporator (52) and performing or stopping cooling operation depending on a difference between a temperature of a target to be cooled and a set temperature, the refrigeration apparatus (20) performing a refrigeration cycle by circulating a refrigerant through the refrigerant circuit (25), the control system comprising:

30 a control unit (33) configured to control the refrigeration apparatus (20), wherein the control unit (33) outputs control information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), a cooling unit (50) with a high degree of priority performs the cooling operation preferentially over a cooling unit (50) with a low degree of priority on a basis of priority information indicative of a degree of priority of each of the plurality of cooling units (50), first information that is usable for deriving a cooling capacity required of each of the plurality of cooling units (50), and second information that is usable for deriving a capacity which the heat source unit (40) is capable of actually demonstrating.
2. The control system according to claim 1, wherein

45 each of the plurality of cooling units (50) includes a showcase (50a) and cools air in the showcase (50a) in the cooling operation, and the degree of priority of each of the plurality of cooling units (50) is set in accordance with a type of article stored in the showcase (50a) of the cooling unit (50).
3. The control system according to claim 1 or 2, wherein

50 the control unit (33) outputs the control information in a case where a capacity according to a sum of cooling capacities required of the plurality of cooling units (50) is higher than the capacity which the heat source unit (40) is capable of actually demonstrating.
4. The control system according to claim 3, wherein

55 the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so that among the plurality of cooling units (50), the cooling unit (50) with a low degree of priority stops the cooling operation preferentially over the cooling unit (50) with a high degree of priority.

5. The control system according to claim 3 or 4, wherein
the control information is information for controlling the cooling operation of each of the plurality of cooling units (50) so
that among the plurality of cooling units (50), the cooling unit (50) with a high degree of priority secures a cooling
capacity preferentially over the cooling unit (50) with a low degree of priority.

5
6. The control system according to any one of claims 3 to 5, wherein
the first information includes information concerning a representative cooling capacity, which is a representative
value of the cooling capacity of each of the plurality of cooling units (50), and
10 the sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the representative cooling
capacities of the plurality of cooling units (50).

7. The control system according to any one of claims 3 to 5, wherein
15 the control unit (33) outputs the control information on a basis of the priority information, the first information, the
second information, and third information indicative of the temperature of the target to be cooled and the set
temperature in each of the plurality of cooling units (50),
the first information includes information that is usable for deriving a predicted cooling capacity, which is a
predicted value of the cooling capacity required of each of the plurality of cooling units (50), and
20 the sum of the cooling capacities required of the plurality of cooling units (50) is a sum of the predicted cooling
capacities of the plurality of cooling units (50).

8. The control system according to any one of claims 1 to 7, wherein
25 the degree of priority includes a first degree of priority and a second degree of priority lower than the first degree of
priority,
the first degree of priority is a degree of priority set for a cooling unit (50) that is prohibited from forcibly stopping the
cooling operation among the plurality of cooling units (50), and
the second degree of priority is a degree of priority set for the cooling unit (50) that is permitted to forcibly stop the
30 cooling operation among the plurality of cooling units (50).

9. A refrigeration system comprising:
the control system according to any one of claims 1 to 8;
35 the refrigeration apparatus (20); and
an adjustment portion (35) that is capable of adjusting a flow rate of the refrigerant flowing through each of the
plurality of cooling units (50), wherein
the adjustment portion (35) operates on a basis of the control information.

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FIG.1

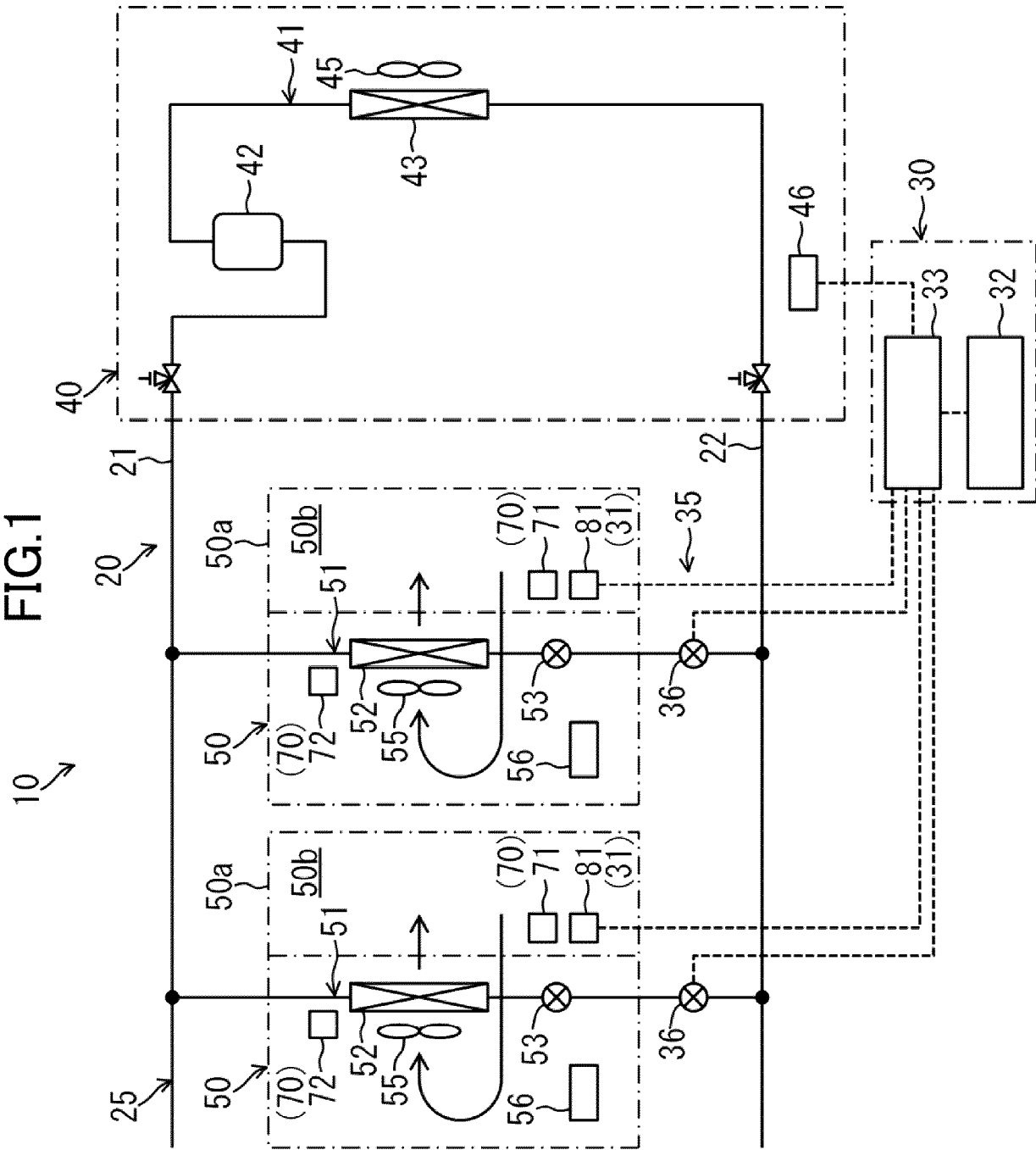


FIG.2

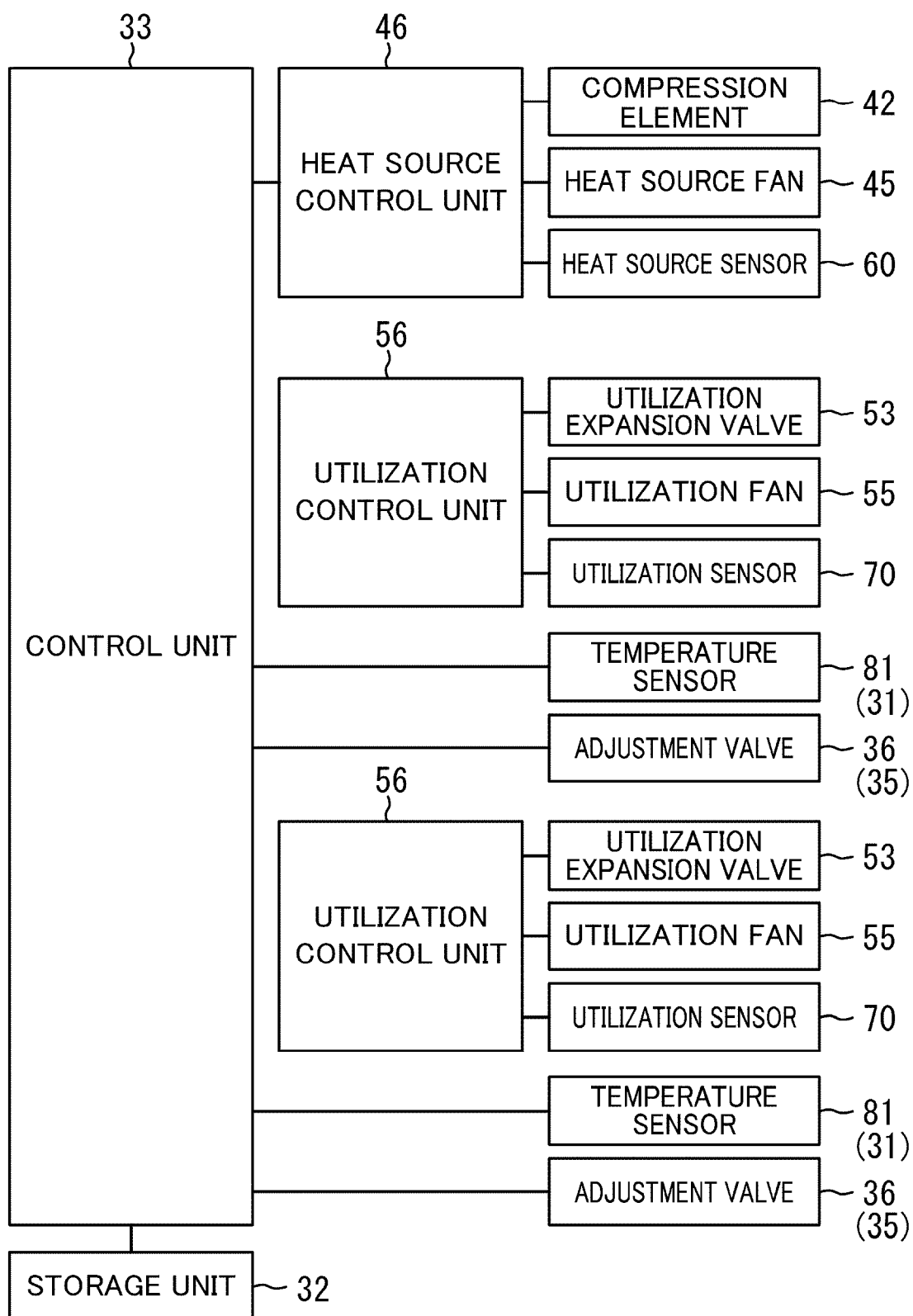


FIG.3

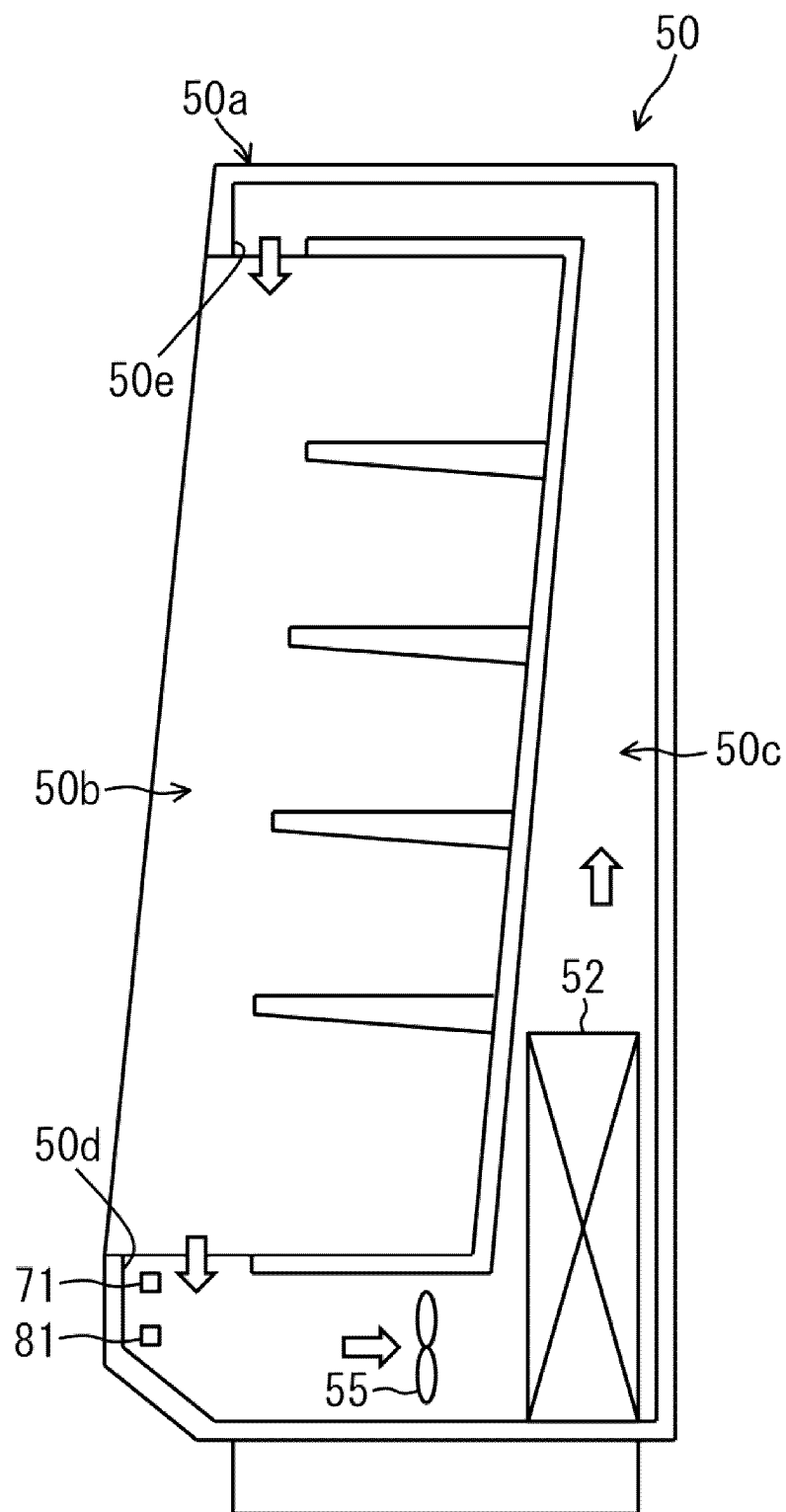


FIG.4

COOLING UNIT	TYPE OF STORED ARTICLE	DEGREE OF PRIORITY
No.1	FROZEN FOODS	1 (FIRST DEGREE OF PRIORITY)
No.2	FRESH MEAT	2 (FIRST DEGREE OF PRIORITY)
No.3	FRUITS AND VEGETABLES	3 (SECOND DEGREE OF PRIORITY)
No.4	SOFT DRINKS	4 (SECOND DEGREE OF PRIORITY)

FIG.5

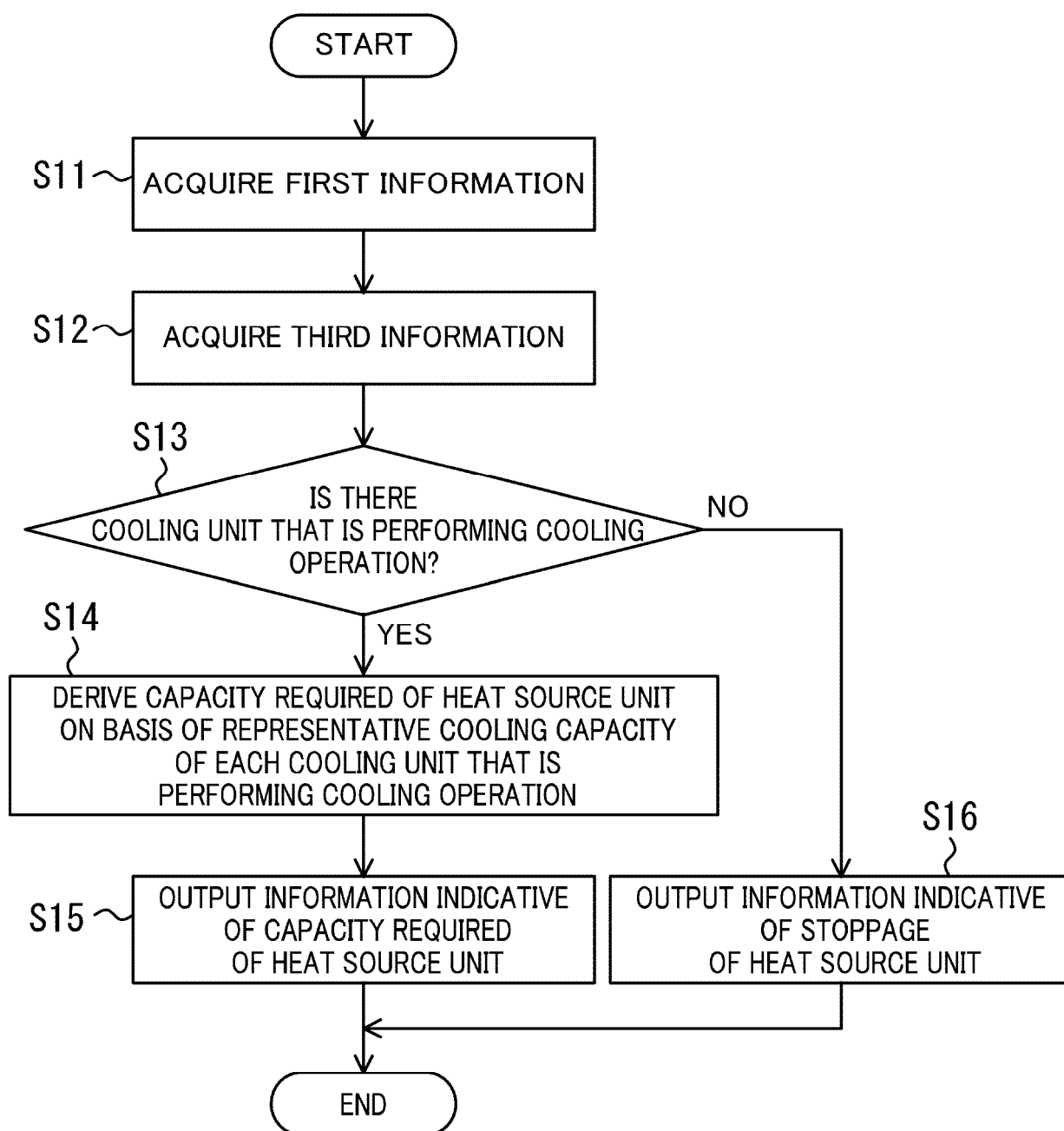


FIG.6

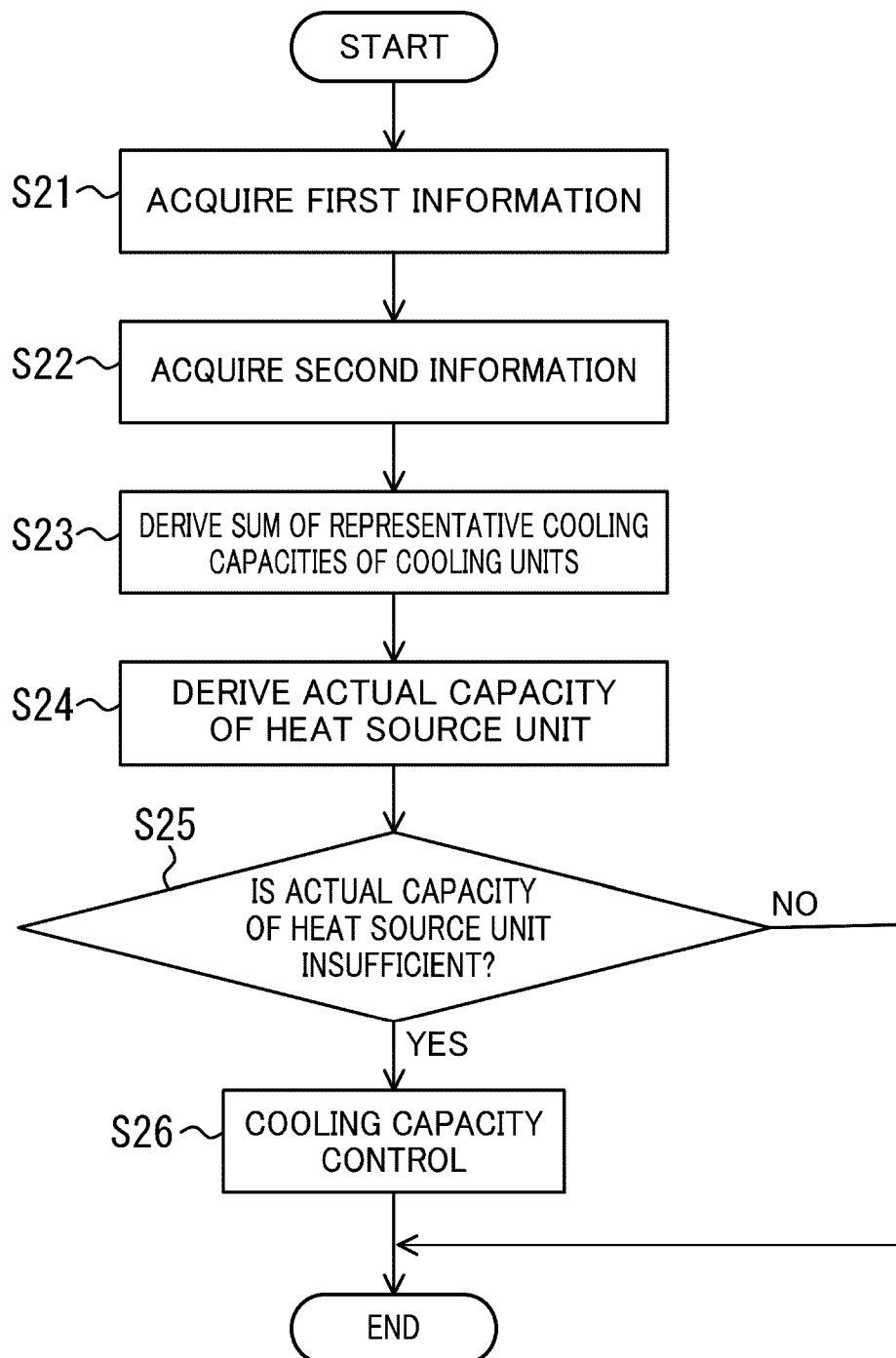


FIG.7

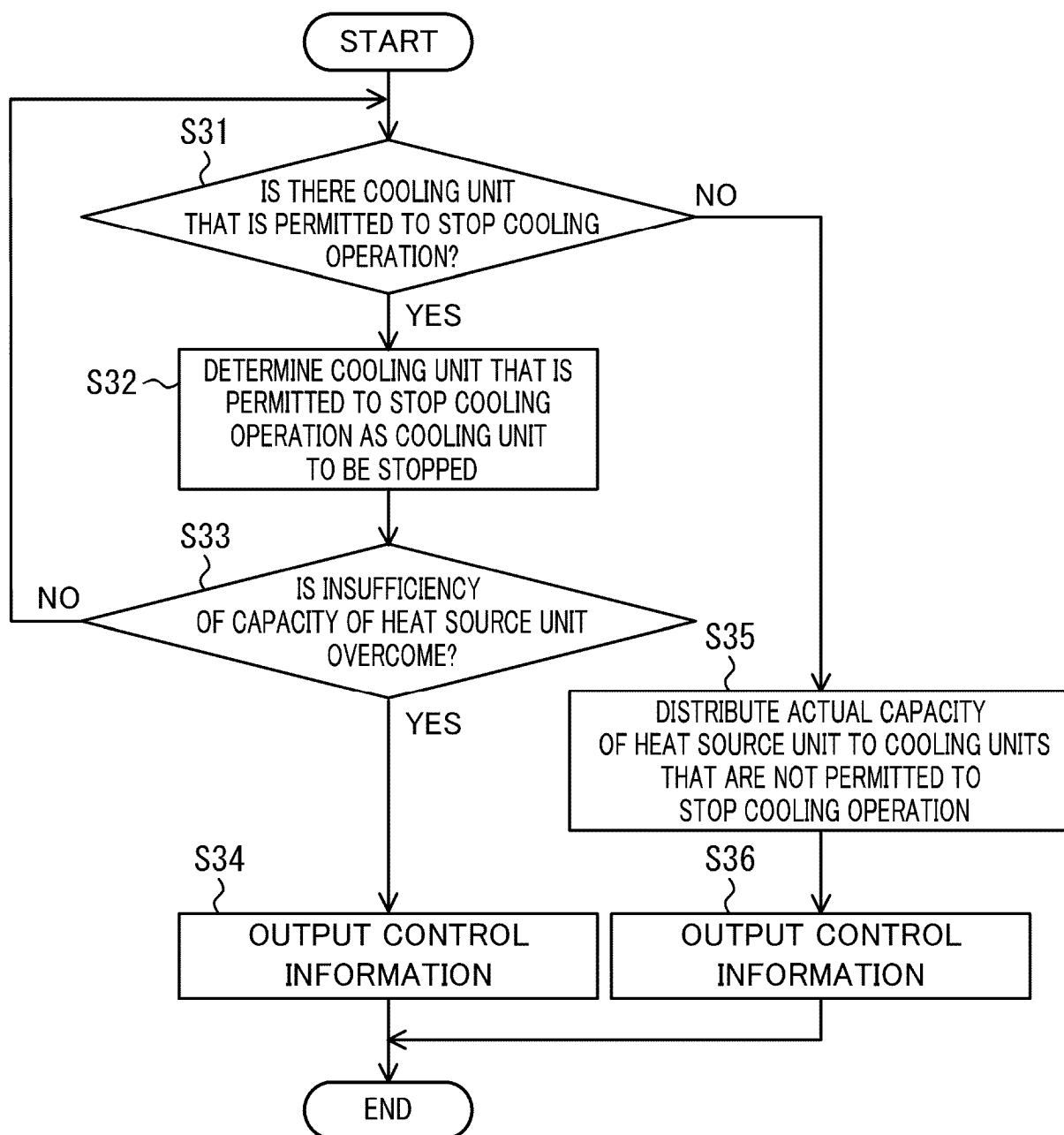


FIG.8

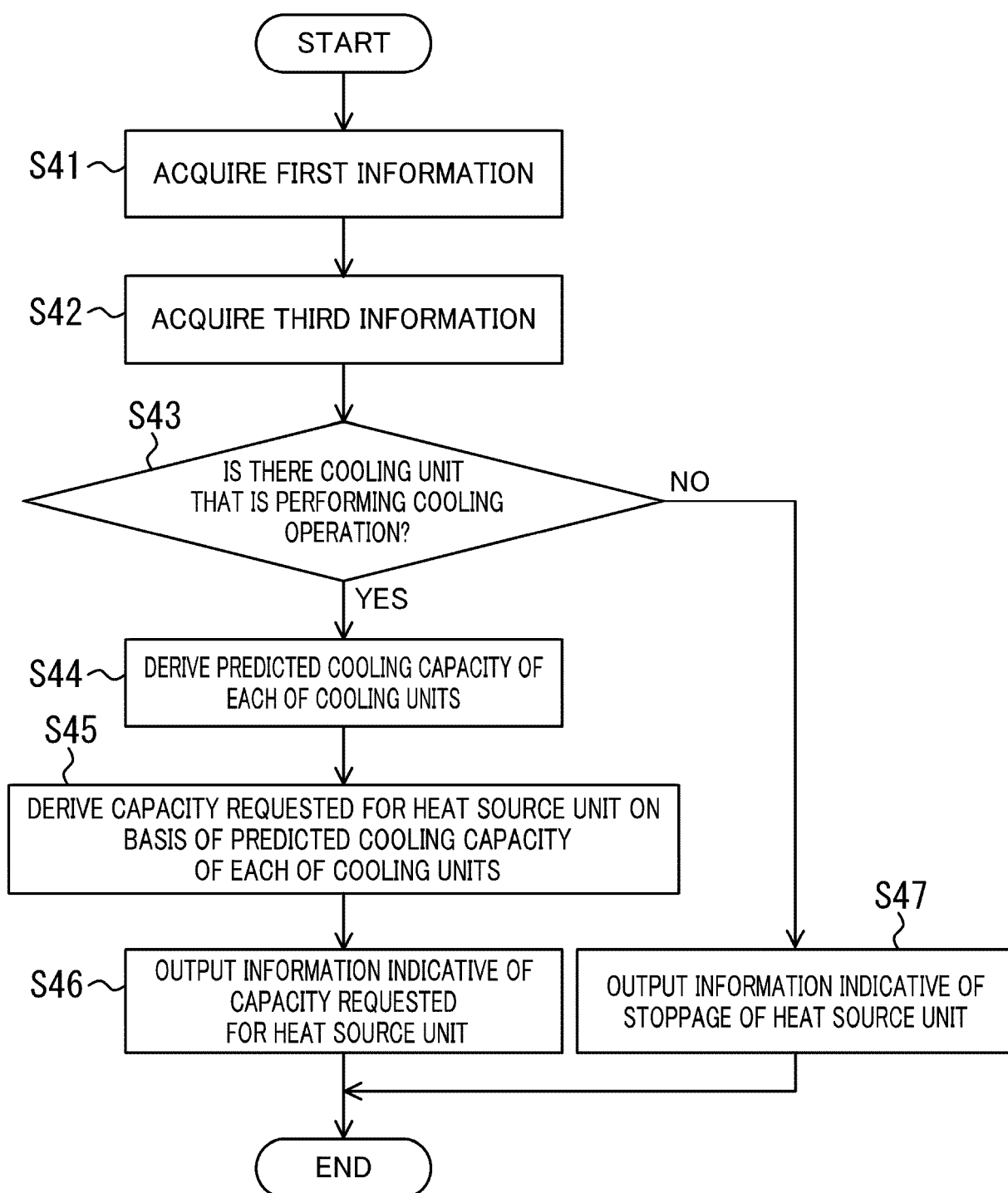


FIG.9

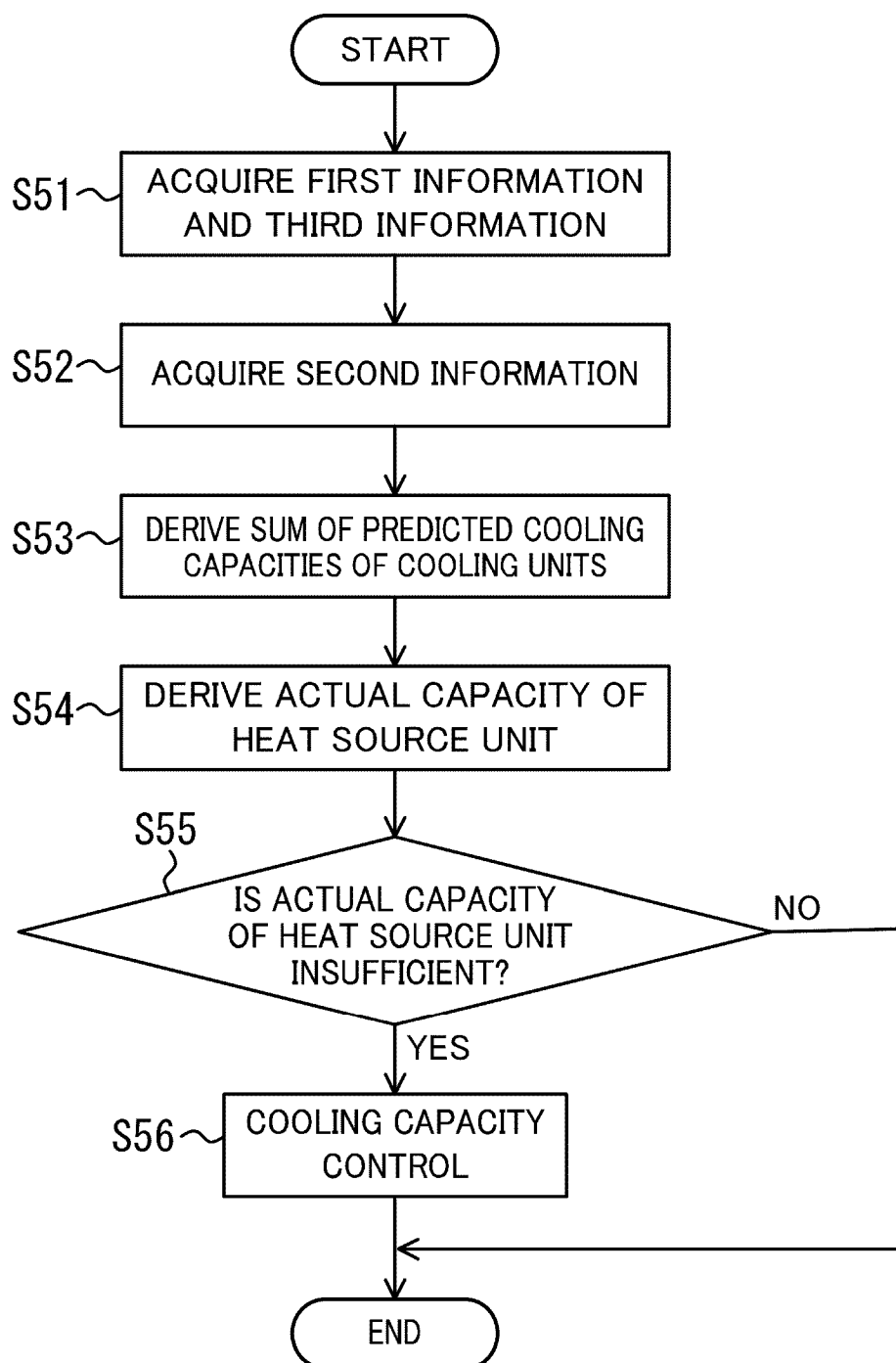


FIG.10

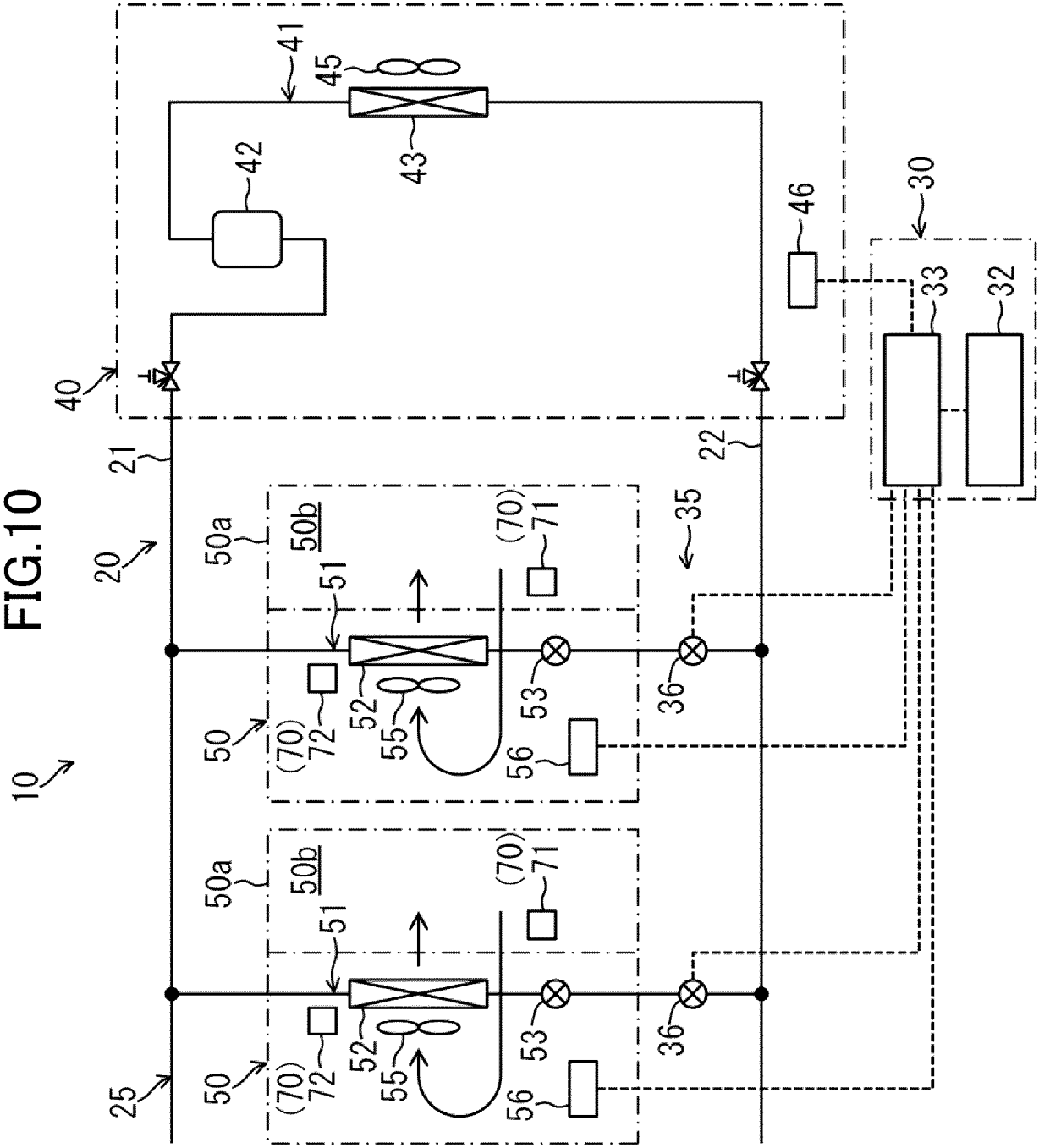
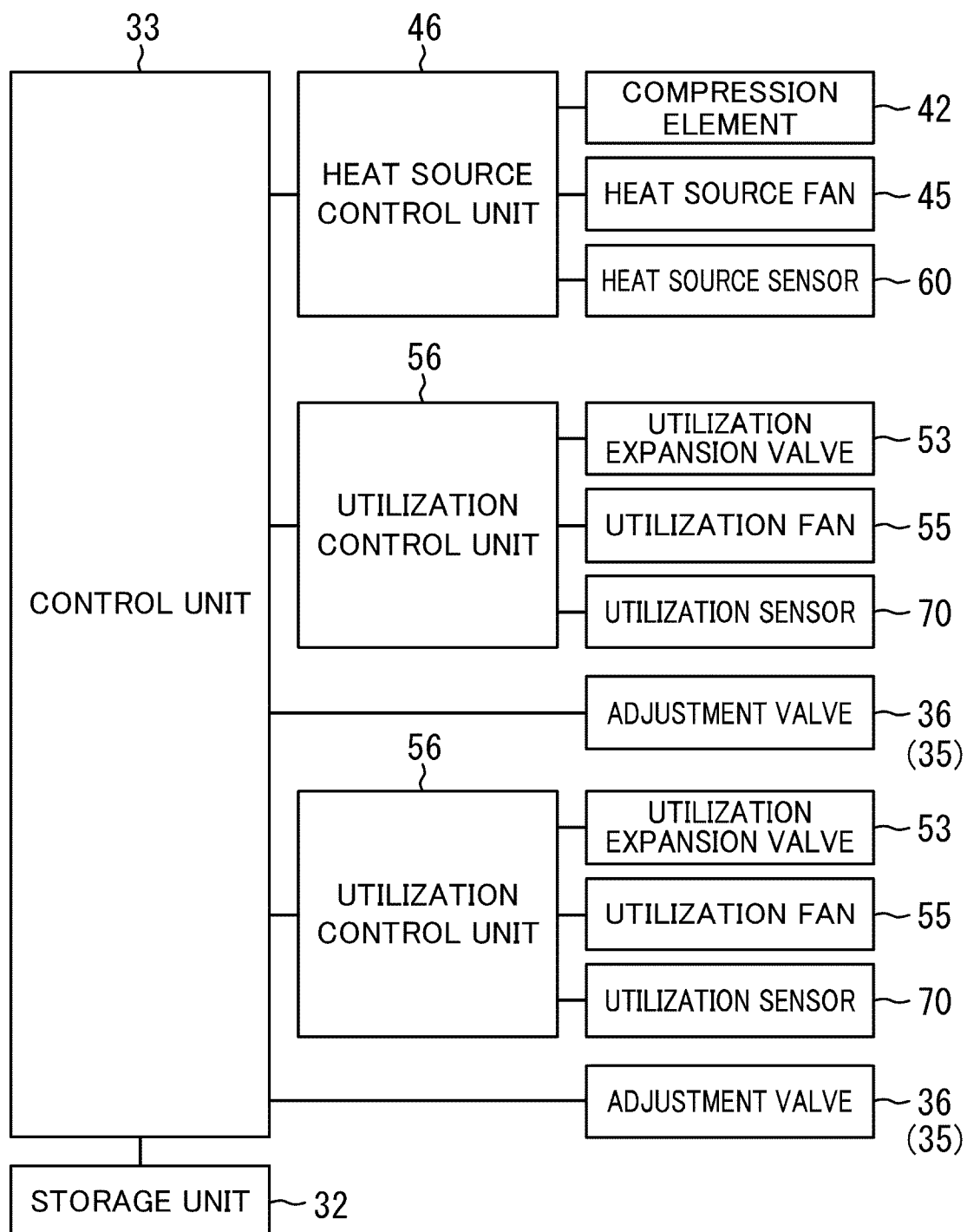


FIG.11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/034773

A. CLASSIFICATION OF SUBJECT MATTER

F25B 49/02(2006.01)i; **F25B 1/00**(2006.01)i; **F25B 5/02**(2006.01)i; **F25D 11/00**(2006.01)i
FI: F25B49/02 A; F25B1/00 351Z; F25B1/00 361Z; F25B1/00 371E; F25B5/02 B; F25D11/00 101E

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)

F25B1/00-49/02; F25D1/00-31/00; A47F3/04

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2024
Registered utility model specifications of Japan 1996-2024
Published registered utility model applications of Japan 1994-2024

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.
X	JP 10-170121 A (FUJI ELECTRIC CO., LTD.) 26 June 1998 (1998-06-26) paragraphs [0001]-[0006], [0016]-[0022], fig. 1-10	1-5, 9
Y	paragraphs [0001]-[0006], [0016]-[0022], fig. 1-10	6-8
X	JP 08-271017 A (SANYO ELECTRIC CO., LTD.) 18 October 1996 (1996-10-18) paragraphs [0013]-[0043], fig. 1-6	1, 3-6, 8-9
Y	paragraphs [0013]-[0043], fig. 1-6	6-8
A	paragraphs [0013]-[0043], fig. 1-6	2
Y	WO 2020/261360 A1 (HITACHI-JOHNSON CONTROLS AIR CONDITIONING, INC.) 30 December 2020 (2020-12-30) paragraphs [0025]-[0026], fig. 2	7
A	JP 2014-219152 A (MITSUBISHI ELECTRIC CORPORATION) 20 November 2014 (2014-11-20) entire text, all drawings	1-9

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

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“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

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“&” document member of the same patent family

Date of the actual completion of the international search

11 November 2024

Date of mailing of the international search report

19 November 2024

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
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Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2024/034773

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 07-180924 A (KABUSHIKI KAISHA TOSHIBA) 18 July 1995 (1995-07-18) entire text, all drawings	1-9
A	JP 55-056545 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 25 April 1980 (1980-04-25) entire text, all drawings	1-9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2024/034773

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
JP	10-170121	A	26 June 1998	CN	1179531	A	
				KR	10-1998-0032635	A	
JP	08-271017	A	18 October 1996	(Family: none)			
WO	2020/261360	A1	30 December 2020	CN	113728205	A	
				JP	6730536	B1	
JP	2014-219152	A	20 November 2014	(Family: none)			
JP	07-180924	A	18 July 1995	(Family: none)			
JP	55-056545	A	25 April 1980	(Family: none)			

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013011423 A [0004]