

## HEAT MEDIUM CIRCULATION SYSTEM, AND CHILLED WATER CIRCULATION SYSTEM

### CROSS-REFERENCE TO RELATED APPLICATION

[0001] This international application claims the benefit of Japanese Patent Applications No. 2016-238359 and No. 2016-238360 filed on December 8, 2016 with the Japan Patent Office, and the entire disclosures of Japanese Patent Applications No. 2016-238359 and No. 2016-238360 are incorporated in this international application by reference.

### TECHNICAL FIELD

[0002] The present disclosure relates to an airtight heat medium circulation system and a chilled water circulation system in which a heat medium (chilled water) is circulated between a thermal source machine that generates cold energy and a heat exchanger and cools a cooling target.

### BACKGROUND ART

[0003] For example, a chilled water circulation system described in Patent Document 1 includes a heat storing and radiating device provided to a bypass route connecting a chilled-water inflow side of a heat exchanger and a chilled-water outflow side of the heat exchanger, and is capable of air conditioning with the cold energy and the like stored in the heat storing and radiating device. In the invention described in Patent Document 1, air conditioning with the cold energy and the like stored in the heat storing and radiating device is performed when the difference between the pressure of an outgoing water header and that of a returning water header becomes less than a preset pressure difference.

### PRIOR ART DOCUMENTS

### PATENT DOCUMENTS

[0004] Patent Document 1: Japanese Unexamined Patent Application  
Publication No. 2014-81167

## SUMMARY OF THE INVENTION

### PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] The present disclosure provides a heat medium circulation system and a chilled water circulation system that can save more power.

### MEANS FOR SOLVING THE PROBLEMS

[0006] In the present disclosure, a chilled water circulation system comprises a cooling device comprising: a thermal source machine that cools a chilled water; a heat exchanger that performs heat exchange between the chilled water, which is chilled, and a cooling target and cools the cooling target; and a bypass pipe connecting a chilled-water inflow side of the heat exchanger and a chilled-water outflow side of the heat exchanger. The system further comprises: a parameter detector that detects a value of a parameter indicating a state of the cooling target; a temperature detector that detects a temperature of the chilled water supplied to the heat exchanger; and a control device that controls an operational state of the cooling device. Signals outputted from the parameter detector and the temperature detector are inputted to the control device.

[0007] In the case where an operation mode in which the chilled water in the bypass pipe is supplied to the heat exchanger so that a cooling capacity is demonstrated by the heat exchanger is defined as a pipe residual temperature operation mode, the control device can perform: a first determination process to determine whether a value based on a detection value of the parameter detector satisfies a management condition preset for the parameter; a second determination process to determine whether a value based on a detection value of the temperature detector satisfies a preset capacity condition; and a residual temperature operation process in which the cooling device is

operated in the pipe residual temperature operation mode when at least the management condition and the capacity condition are satisfied.

[0008] In other words, in the present disclosure, when at least the management condition and the capacity condition are satisfied, the cooling device is operated in the pipe residual temperature operation mode. Accordingly, a chilled water circulation system that can save more power can be provided.

[0009] The "pipe residual temperature operation mode" is an operation mode in which the chilled water in the bypass pipe is supplied to the heat exchanger so that the cooling capacity is demonstrated by the heat exchanger. Accordingly, cooling can be performed with, for example, the chilled water existing in the bypass pipe and the cold energy accumulated in the bypass pipe and so on (hereinafter referred to as pipe residual temperature).

[0010] Then, if it is not in a state sufficient to perform cooling with the pipe residual temperature, that is, if the pipe residual temperature operation mode is performed while the capacity condition is not satisfied, sufficient cooling capacity cannot be demonstrated, and thus it may not be possible to perform cooling that satisfies the management condition.

[0011] On the other hand, in the present disclosure, the cooling device is operated in the pipe residual temperature operation mode, when at least the management condition and the capacity condition are satisfied. Thus, while further facilitating energy saving, indoor air conditioning can be reliably performed.

[0012] Embodiments of the present disclosure will be described below with reference to the drawings. Arrows and the like provided in each drawing indicating directions are depicted to facilitate an understanding of the correlation between the drawings, and thus do not limit the scope of the present disclosure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a diagram showing one example of a heat medium circulation

system (chilled water circulation system) according to an embodiment.

FIG. 2 is a diagram illustrating switching of control modes according to the embodiment.

FIG. 3 is a flowchart of a third control mode according to a first embodiment.

FIG. 4 is a flowchart of a second control mode according to the first embodiment.

FIG. 5 is a flowchart of the second control mode according to the first embodiment.

FIG. 6 is a flowchart of the second control mode according to the first embodiment.

FIG. 7 is a flowchart of a first control mode according to the first embodiment.

FIG. 8 is a flowchart of a second control mode according to a second embodiment.

#### EXPLANATION OF REFERENCE NUMERALS

[0014] 10...air conditioning device, 11...thermal source machine, 11A...cooling tower, 11B...cooling water pump, 11C...three-way valve, 12...FCU (fan coil unit), 12A...heat exchanger, 12B...air blower, 12C...valve, 13...bypass pipe, 14A...primary outgoing water header, 14B...primary returning water header, 15B...secondary returning water header, 15A...secondary outgoing water header, 20...control device, P1...primary pump, P2...secondary pump, SE1...temperature sensor, SE3...first chilled water temperature sensor, SE4...second chilled water temperature sensor, SE5...third chilled water temperature sensor, SE6...fourth chilled water temperature sensor, SE7...first cooling water temperature sensor, SE8...second cooling water temperature sensor

#### MODE FOR CARRYING OUT THE INVENTION

[0015] (First Embodiment)

A chilled water circulation system will be described as a first embodiment of the present disclosure. The chilled water circulation system of the present disclosure may be an air conditioning system (air conditioning cooler system) that cools the air in relatively large space (interior) of commercial facilities, office buildings, and so on.

[0016] 1. Structure of Chilled Water Circulation System (see FIG. 1)

An air conditioning device 10 is one example of a cooling device that cools the air inside a room. The air conditioning device 10 comprises at least one device each of, for example, a thermal source machine 11, a heat exchanger 12A, and a bypass pipe 13. The thermal source machine 11 generates energy for cooling or heating a heat medium.

[0017] The thermal source machine 11 generates cold energy for cooling a heat medium. The present embodiment describes an example in which the heat medium cooled by the thermal source machine 11 is chilled water. The thermal source machine 11 may be composed of, for example, a refrigerator such as a vapor compression type refrigerator.

[0018] In a case where the maximum amount of cold energy required of the thermal source machine 11 is larger than a specified amount, the thermal source machine 11 may be composed of a plurality of refrigerators. Due to the specification of the thermal source machine 11, the minimum amount of cold energy that the thermal source machine 11 can produce is predetermined.

[0019] In a case where the thermal source machine 11 is composed of a single refrigerator, the minimum amount of cold energy that can be generated by the single refrigerator is the minimum amount of cold energy of the thermal source machine 11. In a case where the thermal source machine 11 is composed of a plurality of refrigerators, the minimum amount of cold energy, generated by the refrigerator that generates the smallest amount of cold energy among the plurality of refrigerators when the aforementioned

refrigerator alone is working, is the minimum amount of cold energy of the thermal source machine 11.

[0020] Wasted energy produced when the cold energy is generated is released from a cooling tower 11A into the atmospheric air through the cooling water. A cooling water pump 11B sends the cooling water to circulate between the thermal source machine 11 and the cooling tower 11A. A three-way valve 11C is a valve that adjusts the amount of flow of the cooling water that is discharged from the thermal source machine 11, runs through the cooling tower 11A, and returns to the thermal source machine 11.

[0021] The heat exchanger 12A exchanges the heat between the air supplied to a room, which is one example of the cooling target, and the chilled water and cools the air. A fan coil unit 12 (hereinafter referred to as FCU 12) is composed of the integration (unitization) of the heat exchanger 12A and an air blower 12B that sends air to the heat exchanger 12A.

[0022] At least one heat exchanger 12A, in other words, FCU 12 is installed on each of multiple floors or in each of multiple rooms. Each FCU 12 is provided with a valve 12C that adjusts the amount of the chilled water that flows through the heat exchanger 12A.

[0023] Each floor, for example, is provide with a controller (not shown) for adjusting the air conditioning capacity of the FCU 12 installed on the floor. A user can operate the controller to adjust the air conditioning capacity (cooling capacity) of the FCU 12.

[0024] In a case where the user operates the controller to enhance the cooling capacity, the controller increases the degree of opening of the valve 12C so as to increase the amount of the chilled water to be introduced into the heat exchanger 12A. When the user operates the controller to reduce the cooling capacity, the controller reduces the degree of opening of the valve 12C so as to reduce the amount of the chilled water to be introduced into the heat exchanger 12A.

[0025] The bypass pipe 13 is a pipe connecting a chilled-water inflow side of

the plurality of heat exchangers 12A and a chilled-water outflow side of the plurality of heat exchangers 12A. A primary pump P1 and a secondary pump P2 are pumps for circulating the chilled water between the thermal source machine 11 and the multiple heat exchangers 12A.

[0026] The primary pump P1 is a pump that sends the chilled water discharged from the plurality of heat exchangers 12A to the thermal source machine 11. The secondary pump P2 is a pump that sends the chilled water supplied from the thermal source machine 11 to each of the heat exchangers 12A.

[0027] In FIG. 1, the primary pump P1 is composed of a single pump, and the secondary pump P2 is composed of a plurality of pumps. However, the structures of the primary pump P1 and of the secondary pump P2 are not limited to those in FIG. 1.

[0028] For example, the primary pump P1 also may be composed of a plurality of pumps. In a case where the thermal source machine 11 is composed of a plurality of refrigerators, usually, the primary pump P1 is also composed of a plurality of pumps.

[0029] The bypass pipe 13 couples the suction side of the secondary pump P2 and the suction side of the primary pump P1. The bypass pipe 13 according to the present embodiment is arranged so as to connect a primary outgoing water header 14A and a primary returning water header 14B.

[0030] In a case where, for example, the thermal source machine 11 is composed of a plurality of refrigerators, the primary outgoing water header 14A collects the chilled water discharged from the plurality of refrigerators. Furthermore, the primary outgoing water header 14A distributes the chilled water to each of the pumps composing the secondary pump P2.

[0031] For example, in a case where the thermal source machine 11 is composed of a plurality of refrigerators and the primary pump P1 is correspondingly composed of a plurality of pumps, the primary returning water header 14B distributes the chilled water discharged from the secondary returning water header 15B to each of the pumps composing the primary

pump P1.

[0032] The secondary returning water header 15B is a collecting device that collects the chilled water discharged from the plurality of heat exchangers 12A and discharges the collected chilled water toward the primary returning water header 14B. A secondary outgoing water header 15A is a collector-distributor that collects the chilled water ejected from each of the pumps composing the secondary pump P2 and distributes the chilled water to each of the heat exchangers 12A.

[0033] 2. Controlling Chilled Water Circulation System

#### 2.1 Control Structure

A control device 20 directly and indirectly controls the operational state of the primary pump P1, the secondary pump P2, each of the air blowers 12B, the thermal source machine 11, and so on, that is, the operational state of the air conditioning device 10. The control device 20 is a microcomputer composed of, for example, a CPU 20a, a ROM 20b, and a RAM 20c, and controls the operation of the air conditioning device 10 in accordance with a program (software) prestored in a nonvolatile storage section, such as the ROM 20b.

[0034] "Indirectly controls" means a state, for example, in which the control device 20 controls the volume of the air blown by the air blowers 12B (the number of revolution of the fans) and the degree of opening of the valves 12C, that is, a state where the control device 20 controls the operation of the FCUs 12.

When the control device 20 controls the FCUs 12, the control device 20 transmits control command signals to the controllers provided to the FCUs 12 and does not transmit the signals directly to the air blowers 12B and so on. In other words, the control device 20 indirectly controls the air blowers 12B and so on via the controllers.

[0035] In the control device 20, signals indicating values of parameters (which can be also understood as management items) are inputted. The parameters

(management items) means parameters directly or indirectly indicate the state of the rooms. The parameters (management items) are, for example, (1) the temperature and the relative humidity of the room air, (2) the difference between a set temperature and the actual room-air temperature, and (3) the degree of opening and the like of each of the valves 12C. The management items correspond to one example of the parameters.

[0036] The temperature and the relative humidity of the room air are detected with, for example, a temperature sensor SE1 that detects the temperature of the air drawn into the FCU 12. The temperature sensor SE1 and the like are provided to each FCU 12. A set temperature (hereinafter, an SV value) is a target room-air temperature (air conditioning capacity) set via the controller by the user or a superintendent. The actual room-air temperature is a temperature detected by the temperature sensor SE1 (hereinafter, a PV value).

[0037] When any one of (a) "the temperature or the relative humidity of the room air exceeds a preset room-air temperature or relative humidity", (b) "the difference between the SV value and the PV value exceeds a preset temperature difference", and (c) "the degree of opening of the valve 12C exceeds a preset degree of opening (for example, 80%)" takes place, each controller outputs a signal indicating the corresponding state (hereinafter to be referred to as an alarm signal) to the control device 20.

[0038] In the control device 20, signals indicating the temperature of the chilled water and the temperature of the cooling water are also inputted. A first chilled water temperature sensor SE3 is one example of the temperature detector that detects the temperature of the chilled water supplied to each heat exchanger 12A. The first chilled water temperature sensor SE3 according to the present first embodiment detects the temperature of the chilled water in the secondary outgoing water header 15A.

[0039] A second chilled water temperature sensor SE4 is one example of the temperature detector that detects the temperature of the chilled water

discharged from the secondary returning water header 15B. The second chilled water temperature sensor SE4 according to the present first embodiment detects the temperature of the chilled water in the primary returning water header 14B.

[0040] A third chilled water temperature sensor SE5 is one example of the temperature detector that detects the temperature of the chilled water supplied from the thermal source machine 11 toward the secondary pump P2. A fourth chilled water temperature sensor SE6 is one example of the temperature detector that detects the temperature of the chilled water returning to the thermal source machine 11.

[0041] The control device 20 controls the operational state of the thermal source machine 11 such that the temperature detected by the third chilled water temperature sensor SE5 falls in a preset temperature range. The control device 20 may control the operational state of the thermal source machine 11 such that the difference between the temperature detected by the third chilled water temperature sensor SE5 and the temperature detected by the fourth chilled water temperature sensor SE6 falls in a preset range.

[0042] A first cooling water temperature sensor SE7 is one example of the temperature detector that detects the temperature of the cooling water returning from the cooling tower 11A to the thermal source machine 11. A second cooling water temperature sensor SE8 is one example of the temperature detector that detects the temperature of the cooling water sent from the thermal source machine 11 to the cooling tower 11A.

[0043] The control device 20 controls the cooling water pump 11B and the three-way valve 11C such that the temperature detected by the first cooling water temperature sensor SE7 falls in a preset temperature range. The control device 20 may control the cooling water pump 11B and the three-way valve 11C such that the difference between the temperature detected by the first cooling water temperature sensor SE7 and the temperature detected by the second cooling water temperature sensor SE8 falls in a preset range.

[0044] 2.2 General Outline of Control

The control device 20 controls, for example, the operational state of the air conditioning device 10 and the amount of flow of the chilled water circulated toward the heat exchanger 12A in at least three separate control modes (a first control mode, a second control mode, and a third control mode).

[0045] The operational state of each FCU 12, that is, the state of the heat exchanger 12A and the air blower 12B of each FCU 12 is directly controlled by the controller provided to the FCU 12 as described above.

[0046] <First Control Mode>

The first control mode is one example of the power saving operation mode. In a case where the power consumed by the air conditioning device 10 in the second control mode is defined as a power during residual temperature use, the power saving operation mode, that is, the first control mode is an operation mode in which operation is possible with a power smaller than the power in the residual temperature use.

[0047] Specifically, the control device 20 stops the primary pump P1, the secondary pump P2, the thermal source machine 11, and the cooling water pump 11B while allowing at least the operation of each air blower 12B. Accordingly, in the first control mode, the chilled water is not supplied to the heat exchanger 12A irrespective of the degree of opening of the valve 12C, and thus the FCU 12 can only perform an air-blowing function.

[0048] "The power consumed by the air conditioning device 10 in the second control mode" means, for example, the maximum power consumed by the air conditioning device 10 in the second control mode, or the average power consumed by the air conditioning device 10 in the second control mode.

[0049] <Second Control Mode>

The second control mode is one example of "the pipe residual temperature operation mode". The pipe residual temperature operation mode, that is, the second control mode is an operation mode in which the

chilled water inside the bypass pipe 13 is supplied to each of the heat exchangers 12A and the cooling capacity is demonstrated by the aforementioned heat exchangers 12A.

[0050] Specifically, the control device 20 stops the primary pump P1, the thermal source machine 11, and the cooling water pump 11B. Thereby, in the second control mode, the chilled water mainly staying in the bypass pipe 13 is supplied to each of the heat exchangers 12A via the secondary pump P2. Each controller controls the air blower 12B and the valve 12C based on the SV value in accordance with the prestored program.

[0051] <Third Control Mode>

The third control mode is one example of the normal operation mode. In a case where the cooling capacity that can be demonstrated by the heat exchangers 12A in the second control mode (in the pipe residual temperature operation mode) is defined as the capacity of residual temperature, the third control mode is an operation mode in which a cooling capacity larger than the capacity of residual temperature can be demonstrated by the heat exchangers 12A.

[0052] Specifically, the control device 20 bring all the components of the air conditioning device 10, that is, the primary pump P1, the secondary pump P2, the thermal source machine 11, the cooling water pump 11B, and so on into the operable state. This enables the cooling capacity larger than the capacity of residual temperature to be demonstrated by the heat exchangers 12A.

[0053] <Selecting Control Mode (when Enhancing Capacity)>

In a case where, while the control device 20 is performing any one of the three control modes, the alarm signal is transmitted, the control device 20 first performs a process to enhance the cooling capacity demonstrated by the heat exchanger 12A of the FCU 12.

[0054] If it is determined that the alarm signal is transmitted even after the process to enhance the cooling capacity is performed, the control device 20

stops the current control mode and performs a control mode in which a larger cooling capacity can be demonstrated as compared to that in the current control mode.

[0055] In other words, in a case where the current control mode is the first control mode, the control device 20 performs the second control mode or the third control mode as a subsequent control mode. In a case where the current control mode is the second control mode, the control device 20 performs the third control mode as the subsequent control mode (see FIG. 2).

[0056] For example, in a case where, while the second control mode is performed, the alarm signal is transmitted, the control device 20 first increases a discharge amount from the secondary pump P2 so as to perform the process to enhance the cooling capacity demonstrated by the heat exchanger 12A of the FCU 12 from which the alarm signal is outputted.

[0057] The control device 20 increases discharge amount from the secondary pump P2 by (A) performing a process to increase the frequency of the voltage applied to an electric motor that operates the secondary pump P2, or (B) performing a process to increase the number of operating pumps.

[0058] In the present first embodiment, the number of revolution of the aforementioned electric motor is controlled through frequency control by an inverter. Accordingly, to increase the discharge amount from the secondary pump P2, the control device 20 first increases the frequency of applied voltage.

[0059] The minimum number of revolution (the smallest discharge amount) and the maximum number of revolution (the largest discharge amount) for each of the pumps composing the secondary pump P2 are predetermined due to the characteristics of the device. Accordingly, when the frequency of the applied voltage exceeds the frequency corresponding to the maximum number of revolution, the control device 20 increases the number of operating pumps so as to increase the discharge amount.

[0060] While the second control mode is performed, if the alarm signal is

transmitted despite that the discharge amount from the secondary pump P2 has increased to the largest discharge amount, the control device 20 stops the second control mode and performs the third control mode.

[0061] In a case where the current control mode is the first control mode, when the alarm signal is transmitted, the control device 20 performs the process to enhance the cooling capacity demonstrated by the heat exchanger 12A of the FCU 12 by first increasing the number of revolution of the air blower 12B so as to increase the air volume for blowing.

[0062] Then, when the number of revolution of the air blower 12B reaches the preset maximum number of revolution, the control device 20 stops the first control mode and performs the second control mode. If it is in a second-control-mode executable state, the control device 20 performs the third control mode.

[0063] The "second-control-mode executable state" means, for example, (I) a state where execution of the second control mode (pipe residual temperature operation mode) is not permitted by the superintendent, or (II) a state where the temperature of the chilled water in the bypass pipe 13 (the temperature detected by the first chilled water temperature sensor SE3) does not satisfy the preset capacity condition.

[0064] The "state where the temperature of the chilled water in the bypass pipe 13 does not satisfied the capacity condition" means a state, for example, where the temperature of the chilled water exceeds the preset temperature, which is a state where it is predictable that enough cooling capacity cannot be achieved by the heat exchanger 12A.

[0065] <Selecting Control Mode (when Reducing Capacity)>

While the control device 20 is performing any one of the three control modes, if no alarm signal is transmitted, the control device 20 first performs a process to reduce the cooling capacity demonstrated by the heat exchanger 12A of the FCU 12.

[0066] Even after the process to reduce the cooling capacity is performed, if

no alarm signal is transmitted and if it is determined that the cooling capacity cannot be further reduced in the current control mode, the control device 20 stops the current control mode and performs a control mode in which a smaller cooling capacity can be demonstrated as compared to that in the current control mode (see FIG. 2).

[0067] The thermal source machine 11, due to its structure, cannot generate cold energy smaller than the minimum cold energy generation amount. The minimum number of revolution (smallest discharge amount) and the maximum number of revolution (largest discharge amount) of the primary pump P1 are also predetermined as well as those of the secondary pump P2.

[0068] Accordingly, the control device 20 adjusts the cooling capacity demonstrated by the heat exchanger 12A by adjusting the discharge amount from the secondary pump P2 similarly to the process to enhance the cooling capacity. In other words, the control device 20 performs a process to reduce the cooling capacity by reducing the discharge amount from the secondary pump P2.

[0069] Specifically, the control device 20 first reduces the frequency of the applied voltage. When the frequency of the applied voltage becomes smaller than the frequency corresponding to the minimum number of revolution, the control device 20 reduces the number of operating pumps so as to reduce the discharge amount from the secondary pump P2.

[0070] For example, while the third control mode is performed, if no alarm signal is transmitted, the control device 20 decreases the discharge amount from the secondary pump P2 so as to reduce the cooling capacity demonstrated by the heat exchanger 12A.

[0071] If no alarm signal is transmitted even after the process to reduce the cooling capacity is performed and if the discharge amount from the secondary pump P2 is reduced to the smallest discharge amount and the control device 20 determines that the cooling capacity cannot be further decreased in the third control mode, the control device 20 stops the third

control mode and performs the second control mode.

[0072] If it is not in the second-control-mode executable state, the control device 20 performs the first control mode. The second-control-mode executable state means the same as in "when Enhancing Capacity".

[0073] While the second control mode is performed, if no alarm signal is transmitted even after the process to reduce the cooling capacity is performed, and if it is determined that the cooling capacity cannot be further reduced in the second control mode, the control device 20 stops the second control mode and performs the first control mode.

[0074] <Determination to Select Control Mode etc.>

After the control device 20 performs the process to change the cooling capacity demonstrated by the heat exchanger 12A, when a time period determined under a preset rule (hereinafter referred to as effect waiting time) passes, the control device 20 performs any one of (x) a process to determine whether the alarm signal is transmitted, (y) a process to determine whether to further change the cooling capacity, and (z) a process to determine whether to change the control mode.

[0075] In other words, the control device 20 performs any one of the processes (x), (y), and (z) when, for example, the effect waiting time passes from when a command signal to increase the discharge amount is transmitted to the secondary pump P2.

[0076] The "preset rule" means, for example, (i) a rule to set a preset fixed value for the effect waiting time, (ii) in a case where the plurality of FCUs 12 is provided, a function (rule) to determine the statistics based on the SV value of each FCU 12, and so on.

[0077] 2.3 Detail of Control

<Third Control Mode (see FIG. 3)>

In the chilled water circulation system according to the present first embodiment, when a start switch (not shown) of the system is turned on by the superintendent, the control device 20 first performs the third control

mode.

[0078] When the third control mode is started, the control device 20 determines, when the effect waiting time passes, whether the chilled water temperature in the secondary outgoing water header 15A, that is, the temperature detected by the first chilled water temperature sensor SE3 (hereinafter referred to as outgoing water header temperature) is equal to or lower than the upper limit value in the preset temperature range (S1).

[0079] If it is determined that the outgoing water header temperature exceeds the upper limit value (S1:NO), the control device 20 continues to perform the third control mode (S9). If it is determined that the outgoing water header temperature is equal to or lower than the upper limit value (S1:YES), the control device 20 determines whether the amount of the cold energy is the minimum amount of cold energy that can be generated by the thermal source machine 11, that is, whether the cooling capacity is the minimum cooling capacity that can be supplied by the thermal source machine 11 (S3).

[0080] If it is determined that the amount of the cold energy is not the minimum amount of cold energy (S3:NO), the control device 20 continues to perform the third control mode (S9). If it is determined that the amount of the cold energy is the minimum amount of cold energy (S3:YES), the control device 20 determines whether the alarm signal is transmitted (S5).

[0081] The determination process in S1 is performed when the effect waiting time passes, and the determination process in S5 is performed after S1 is performed. Accordingly, S5 is performed when or after the effect waiting time passes.

[0082] If it is determined that the alarm signal is transmitted (S5:YES), the control device 20 continues to perform the third control mode (S9). In this case, the control device 20 performs the process to enhance the cooling capacity by increasing the cold energy generated by the thermal source machine 11.

[0083] While this process to enhance the cooling capacity is performed, the

control device 20 increases the discharge amounts of the primary pump P1 and of the cooling water pump 11B if needed. If it is determined that no alarm signal is transmitted (S5:NO), the control device 20 determines whether it is in the second-control-mode (the pipe residual temperature operation mode) executable state (S7).

[0084] The determination whether it is in the second-control-mode executable state is made in the same manner as described in the aforementioned "Selecting Control Mode". The determination process in S7 is performed similarly to S5, when or after the effect waiting time passes.

[0085] If it is determined that it is in the second-control-mode executable state (S7:YES), the control device 20 performs the second control mode. If it is determined that it is not in the second-control-mode executable state (S7:NO), the control device 20 determines whether it is in a first-control-mode executable state (S11).

[0086] The determination whether it is in the first-control-mode executable state is made based on whether execution of the first control mode is allowed in the presetting by the superintendent and the like. For example, under some circumstances where the air conditioning load is large, such as the circumstances in summer, the superintendent usually sets not to allow execution of the first control mode.

[0087] If it is determined that it is in the first-control-mode executable state (S11:YES), the control device 20 performs the first control mode. If the control device 20 determines that it is not in the first-control-mode executable state (S11:NO), the process goes back to S1 and the control device 20 continues to perform the third control mode. The determination process in S11 is also performed similarly to S5 when or after the effect waiting time passes.

[0088] If the process goes back to S1 and the control device 20 continues to perform the third control mode, since no alarm signal is transmitted, the control device 20 performs the process to reduce the cooling capacity

generated by the thermal source machine 11. While this process to reduce the cooling capacity is performed, the control device 20 reduces the discharge amounts of the primary pump P1 and of the cooling water pump 11B if needed.

[0089] <Second Control Mode (see FIG. 4 to FIG. 6)>

After the control device 20 shifts the control to the control for the second control mode and when the effect waiting time passes, the control device 20 determines, as shown in FIG. 4, whether it is in a pipe-residual-temperature-operation-mode (the second control mode) executable state (S21).

[0090] If the control device 20 determines that it is not in the pipe-residual-temperature-operation-mode executable state (S21:NO), the control device 20 performs the third control mode (S25). If the control device 20 determines that it is in the pipe-residual-temperature-operation-mode executable state (S21:YES), the control device 20 determines whether the outgoing water header temperature is equal to or lower than the upper limit value in the preset temperature range, that is, whether the outgoing water header temperature satisfies the capacity condition (S23).

[0091] If it is determined that the outgoing water header temperature is not equal to or lower than the upper limit value in the preset temperature range (S23:NO), the control device 20 performs the third control mode (S25). If it is determined that the outgoing water header temperature is equal to or lower than the upper limit value (S23:YES), the control device 20 determines whether the alarm signal is transmitted, that is, the management items satisfy preset management condition (S27).

[0092] Since the determination process in S21 is performed when the effect waiting time passes, the determination processes in S23 and S27 are also performed when or after the effect waiting time passes.

If it is determined that the alarm signal is transmitted (S27:YES), the

control device 20 increases the number of revolution for the operating pumps among the plurality of pumps composing the secondary pump P2 so as to increase the discharge amount (S29).

[0093] Then, the control device 20 determines, regarding each of the accelerated pumps, whether the number of revolution (the frequency of the applied voltage) exceeds the preset maximum number of revolution (S33). If it is determined that the number of revolution for at least one of the accelerated pumps does not exceed the maximum number of revolution (S33:NO) and when the effect waiting time passes (S31), the control device 20 performs S21.

[0094] If it is determined, regarding each of the accelerated pumps, that the number of revolution exceeds the maximum number of revolution (S33:YES), the control device 20 activates the inactive pump(s), as shown in FIG. 5, so as to increase the number of operating pumps of the secondary pump P2 (S41).

[0095] It is preferable that the pumps included in the secondary pump P2 have identical specifications and coupled in parallel. The control device 20 may apply alternating voltage having the same frequency to each of the pumps. In other words, the control device 20 may, not individually but, collectively control the pumps. In this case, based on the premise that the pumps work in a synchronized state, the control device 20 may determine, with regard to one of the accelerated pumps, whether the number of revolution (the frequency of the applied voltage) exceeds the preset maximum number of revolution (S33). Then, if it is determined that the number of revolution for the aforementioned one of the pumps exceeds the maximum number of revolution (S33:YES), the inactive pumps may be activated so as to increase the number of operating pumps of the secondary pump P2 (S41).

[0096] Subsequently, the control device 20 changes the number of revolution (the frequency of the applied voltage) for each operating pump to a preset number of revolution for adjustment (frequency for adjustment) (S47), and

then determines whether the number of operating pumps is equal to or larger than a preset maximum number (S45).

[0097] The number of revolution for adjustment means the number of revolution preset according to the number of operating pumps after an increase in the number of operating pumps. In the present first embodiment, the number of revolution for adjustment is set to decrease as the number of operating pumps after the increase becomes larger. The number of revolution for adjustment used in S47 is smaller than the number of revolution before the increase.

[0098] If it is determined that the number of operating pumps is equal to or larger than the maximum number (S45:YES), the control device 20 performs the third control mode. If it is determined that the number of operating pumps is not equal to or larger than the maximum number (S45:NO) and when the effect waiting time passes (S43), the control device 20 performs S21.

[0099] On the other hand, if it is determined in S27 that no alarm signal is transmitted (S27:NO), as shown in FIG. 4, the control device 20 reduces the number of revolution for the operating pumps among the plurality of pumps composing the secondary pump P2 so as to reduce the discharge amount (S35).

[0100] Then, the control device 20 determines, regarding each of decelerated pumps, whether the number of revolution (the frequency of the applied voltage) is smaller than the preset minimum number of revolution (S39). If it is determined that the number of revolution for at least one of the decelerated pumps is not smaller than the minimum number of revolution (S39:NO) and when the effect waiting time passes (S37), the control device 20 performs S21.

[0101] If it is determined, regarding each of the decelerated pumps, that the number of revolution is smaller than the minimum number of revolution (S39:YES), the control device 20 stops the operating pump(s), as shown in

FIG. 6, so as to decrease the number of operating pump(s) of the secondary pump P2 (S51).

[0102] As described above, it is preferable that the pumps included in the secondary pump P2 have identical specifications and coupled in parallel. The control device 20 may apply alternating voltage having the same frequency to each of the pumps. In other words, the control device 20 may, not individually but, collectively control the pumps. In this case, based on the premise that the pumps work in a synchronized state, the control device 20 may determine, with regard to one of the decelerated pumps, whether the number of revolution (the frequency of the applied voltage) is smaller than the preset minimum number of revolution (S39). Then, if it is determined that the number of revolution of the aforementioned one of the pumps is smaller than the minimum number of revolution (S39:YES), the operating pumps may be stopped so as to reduce the number of operating pumps of the secondary pump P2 (S51).

[0103] Subsequently, the control device 20 changes the number of revolution (the frequency of the applied voltage) for each operating pump (S59) to the preset number of revolution for adjustment (frequency for adjustment), and then determines whether the number of operating pumps is equal to or smaller than the preset minimum number (S55).

[0104] The number of revolution for adjustment means the number of revolution preset according to the number of operating pump after a decrease in the number of operating pumps. In the present embodiment, the number of revolution for adjustment is set to increase as the number of operating pumps after the decrease becomes smaller. The number of revolution for adjustment used in S59 is a number of revolution larger than the number of revolution before the decrease.

[0105] If it is determined that the number of operating pumps is equal to or smaller than the minimum number (S55:YES), the control device 20 determines whether it is in the first-control-mode executable state (S57). If

it is determined that it is in the first-control-mode executable state (S57:YES), the control device 20 performs the first control mode.

[0106] If it is determined that it is not in the first-control-mode executable state (S57:NO) and when the effect waiting time passes (S53), the control device 20 performs S21. If it is determined that the number of operating pumps is not equal to or larger than the minimum number (S55:NO) and when the effect waiting time passes (S53), the control device 20 performs S21.

[0107] <First Control Mode (see FIG. 7)>

After the control device 20 shifts the control to the first control mode, the control device 20 determines, when the effect waiting time passes, whether the alarm signal is transmitted (S61). If it is determined that no alarm signal is transmitted (S61:NO), the control device 20 repeats S61.

[0108] If it is determined that the alarm signal is transmitted (S61:YES), the control device 20 determines whether the outgoing water header temperature is equal to or lower than the upper limit value in the preset temperature range (S65). If it is determined that the outgoing water header temperature is not equal to or lower than the upper limit value (S65:NO), the control device 20 performs the third control mode.

[0109] If it is determined that the outgoing water header temperature is equal to or lower than the upper limit value (S65:YES), the control device 20 determines whether it is in the second-control-mode (the pipe residual temperature operation mode) executable state (S63).

[0110] If it is determined that it is in the second-control-mode executable state (S63:YES), the control device 20 performs the second control mode (the pipe residual temperature operation mode). If it is determined that it is not in the second-control-mode executable state (S63:NO), the control device 20 performs the third control mode.

[0111] 3. Features of Chilled Water Circulation System according to Present First Embodiment

The control device 20 according to the present first embodiment determines (a1) whether the alarm signal is transmitted, that is, whether the management condition for the management items is satisfied (S27), and (a2) whether the chilled water temperature in the bypass pipe 13 is equal to or lower than the upper limit value in the preset temperature range, that is, whether the detection temperature of the first chilled water temperature sensor SE3 satisfies the capacity condition.

[0112] When at least the management condition and the capacity condition are satisfied, the control device 20 can perform a residual temperature operation process in which the air conditioning device 10 is operated in the pipe residual temperature operation mode. Accordingly, a chilled water circulation system that can save more power can be provided.

[0113] The "pipe residual temperature operation mode" is an operation mode in which the chilled water in the bypass pipe 13 is supplied to the heat exchangers 12A so that the cooling capacity is demonstrated by the heat exchangers 12A. Accordingly, air conditioning can be performed with, for example, the chilled water existing in the bypass pipe 13 and the cold energy accumulated in the bypass pipe 13 and so on, that is, air conditioning can be performed with the pipe residual temperature.

[0114] Then, if it is not in a state sufficient to perform air conditioning with the pipe residual temperature, that is, if the pipe residual temperature operation mode is performed while the capacity condition is not satisfied, sufficient cooling capacity cannot be demonstrated, and thus it may not be possible to provide air conditioning capacity that satisfies the management condition.

[0115] On the other hand, in the present first embodiment, the air conditioning device 10 is operated in the pipe residual temperature operation mode when at least the management condition and the capacity condition are satisfied. Thus, while further facilitating energy saving, indoor air conditioning can be reliably performed.

[0116] It is desirable that the control device 20 performs the pipe residual temperature operation mode while the thermal source machine 11 is stopped. This can facilitate further power saving.

If it is determined that the management condition is not satisfied, that is, the alarm signal is transmitted, the control device 20 determines whether the cooling capacity that satisfies the management condition in the pipe residual temperature operation mode (the second control mode) can be demonstrated by the heat exchanger 12A, that is, whether the outgoing water header temperature is equal to or lower than the upper limit value.

[0117] If it is determined that the management condition is satisfied and the outgoing water header temperature is not equal to or lower than the upper limit value, the control device 20 can perform the normal operation process in which the air conditioning device 10 is operated in the normal operation mode (the third control mode). This can inhibit the normal operation mode from being unnecessarily performed, and thus can effectively facilitate power saving.

[0118] If it is determined that the management condition is satisfied, the control device 20 determines whether the cooling capacity demonstrated by the heat exchanger 12A in the pipe residual temperature operation mode (the second control mode) can be further reduced.

[0119] If it is determined that the management condition is satisfied and the cooling capacity cannot be further reduced, the control device 20 can perform a power saving operation process in which the air conditioning device 10 is operated in the power saving operation mode (the first control mode). This can inhibit the secondary pump P2 from being operated, and thus can effectively facilitate power saving.

[0120] While the supply of the chilled water to the heat exchanger 12A is stopped, the control device 20 can perform an operation mode, in which the air blowers 12B are operated, as the power saving operation mode. This can effectively facilitate power saving.

[0121] After the control device 20 performs a process to change the cooling capacity demonstrated by the heat exchanger 12A and when the effect waiting time passes, the control device 20 performs the determination process regarding whether the management condition is satisfied. This inhibits an occurrence of hunting and the like and can enable shifting to the second control mode at a suitable timing.

[0122] After the control device 20 performs the process to change the cooling capacity demonstrated by the heat exchanger 12A and when the effect waiting time passes, the control device 20 determines whether to perform a process to further change the cooling capacity, and whether to change the control mode. This can inhibit an occurrence of hunting and the like and thus enables, for example, shifting of the control mode to be performed at suitable timing.

[0123] In the pipe residual temperature operation mode, while the primary pump P1 is stopped, the control device 20 operates the secondary pump P2. Accordingly, no additional construction work, such as adding an extra valve, is required to carry out the pipe residual temperature operation mode. Therefore, the present embodiment can be also adopted easily in existing chilled water circulation systems.

[0124] (Second Embodiment)

In the above-described first embodiment, the discharge amount from the secondary pump P2 is controlled by changing the number of revolution for each of the plurality of pumps composing the secondary pump P2, and, when the number of revolution for each of the plurality of pump becomes the minimum number of revolution or the maximum number of revolution, the number of operating pumps is increased or decreased.

[0125] In the present second embodiment, as shown in FIG. 8, the control process to change the number of revolution for each of the plurality of pumps is eliminated, and the discharge amount from the secondary pump P2 is controlled by increasing or decreasing the number of operating pumps.

[0126] The structural requirements and so on that are identical to those in the

above-described first embodiment are provided with the same numeral references as those in the above-described first embodiment. Thus, the description of the overlapping structural requirements are omitted.

(Third Embodiment)

In the above-described the first and the second embodiments, the control mode is divided into three control modes (the first control mode to the third control mode) to control the chilled water circulation system. In the present third embodiment, the control mode is divided into four or more control modes to control the chilled water circulation system.

[0127] For example, a fourth control mode may be provided to stop all the devices including the air blowers 12B (except the sensors such as the first chilled water temperature sensor SE3). The fourth control mode may be performed if no alarm signal is transmitted in the first control mode.

[0128] (Fourth Embodiment)

In the above-described first to third embodiments, specific types of the management items and details thereof, the effect waiting time, and so on are fixed values preset by the superintendent. In the present fourth embodiment, the specific details and so on of the management items are automatically changed by the control device 20.

[0129] The processes involving the automatic change are for example, (b1) a process in which the control device 20 determines the season from calendar information in the control device 20, the temperature of outside-air, and so on, and changes the specific details (numerical values etc.) of the management items according to the season, and (b2) a process in which the specific details (numerical values etc.) of the management items are changed according to time using clock information in the control device 20.

[0130] (Other Embodiment)

In each of the above-described embodiments, the controller provided to the FCU 12 determines whether to transmit the alarm signal. However, the present disclosure is not limited to this. For example, the control device 20

may directly determine whether the condition to transmit the alarm signal is satisfied. The FCU 12 may be composed of an air handling unit (AHU) or an outdoor-air handling unit (OHU).

[0131] In each of the above-described embodiments, the effect waiting time, the management condition, the capacity condition, and so on are automatically set to preset fixed values or automatically set by the control device 20 according to the season and so on. However, the present disclosure is not limited to this. That is, for example, the setting of the management condition, the capacity condition, and so on may be changed in every season by manual operation by the superintendent.

[0132] In the above-described embodiments, the pipe residual temperature operation mode (the second control mode) is performed while the thermal source machine 11 is stopped. However, the present disclosure is not limited to this. That is, for example, the pipe residual temperature operation mode may be performed without the thermal source machine 11 being stopped. Then, it is desirable that the thermal source machine 11 is operated with the minimum output.

[0133] In the above-described embodiments, the pipe residual temperature operation mode (the second control mode) is operated while the primary pump P1 is stopped. However, the present disclosure is not limited to this. That is, for example, the pipe residual temperature operation mode may be performed, while the primary pump P1 is working, by providing a flow-path switching valve such as a three-way valve.

[0134] In the above-described embodiments, the effect waiting time and so on are the same values irrespective of the control mode. However, the present disclosure is not limited to this. That is, for example, the effect waiting time and the like may be automatically changed according to the control mode.

[0135] In the above-described embodiments, the number of revolution for the pumps, that is, the discharge amount is controlled by changing the frequency

of voltage applied to the electric motor. However, the present disclosure is not limited to this. That is, for example, the discharge amount may be controlled by changing the voltage applied to the electric motor.

[0136] In the chilled water circulation system according to the above-described embodiments, when the start switch of the system is turned on by the superintendent, the control device 20 first performs the third control mode. However, the present disclosure is not limited to this. For example, the control device 20 may first perform the first control mode when the start switch of the system is turned on by the superintendent.

[0137] In the above-described embodiments, the program for the chilled water circulation system is prestored in the nonvolatile storage section of the chilled water circulation system. However, the present disclosure is not limited to this. That is, for example, the aforementioned program may be installed in an existing chilled water circulation system through a medium in which the program for the chilled water circulation system is recorded.

[0138] Moreover, the present disclosure is only required to conform to the gist of the matters described in claims, and is not limited to the above-described embodiments. For example, at least two embodiments of the aforementioned embodiments may be combined. Furthermore, the chilled water circulation system according to the present disclosure may be an airtight heat medium circulation system. The heat medium circulation system is a system that cools or heats a target of temperature management by circulating a chilled or heated heat medium. More specifically, the present disclosure can be adopted in a heat medium circulation system that supplies warm heat of a heating device, for example, to a heating target.

[0139] Moreover, the present disclosure can be achieved in various forms including a nonvolatile tangible recording medium, such as a semiconductor memory, in which the program for the chilled water circulation system is recorded, and a control method carried out by execution of the program for the chilled water circulation system.

## CLAIMS

1. A chilled water circulation system comprising:
  - a cooling device comprising:
    - a thermal source machine that cools a chilled water;
    - a heat exchanger that performs heat exchange between the chilled water, which is chilled, and a cooling target, and cools the cooling target; and
    - a bypass pipe connecting a chilled-water inflow side of the heat exchanger and a chilled-water outflow side of the heat exchanger;
  - a parameter detector that detects a value of a parameter indicating a state of the cooling target;
  - a temperature detector that detects a temperature of the chilled water supplied to the heat exchanger; and
  - a control device that controls an operational state of the cooling device, signals outputted from the parameter detector and the temperature detector being inputted to the control device,
- wherein an operation mode in which the chilled water in the bypass pipe is supplied to the heat exchanger so that a cooling capacity is demonstrated by the heat exchanger is defined as a pipe residual temperature operation mode, and
- wherein the control device can perform:
  - a first determination process to determine whether a value based on a detection value of the parameter detector satisfies a preset management condition for the parameter;
  - a second determination process to determine whether a value based on a detection value of the temperature detector satisfies a preset capacity condition;
- and
- a residual temperature operation process in which the cooling device is operated in the pipe residual temperature operation mode when at least the

management condition and the capacity condition are satisfied.

2. The chilled water circulation system according to claim 1,  
wherein the control device performs the pipe residual temperature operation mode while the thermal source machine is in a stopped state.

3. The chilled water circulation system according to claim 1 or 2,  
wherein the cooling capacity that can be demonstrated by the heat exchanger in the pipe residual temperature operation mode is defined as a capacity of residual temperature,

wherein an operation mode in which the cooling capacity larger than the capacity of residual temperature can be demonstrated by the heat exchanger is a normal operation mode, and

wherein the control device can perform:

a third determination process to determine, if the management condition is determined to be unsatisfied, whether the cooling capacity that satisfies the management condition can be demonstrated by the heat exchanger in a current operation mode; and

a normal operation process to operate the cooling device in the normal operation mode if the management condition is determined to be unsatisfied and if a determination is made in the third determination process that the cooling capacity that satisfies the management condition cannot be demonstrated by the heat exchanger in the current operation mode.

4. The chilled water circulation system according to any one of claims 1 to 3,  
wherein a power consumed by the cooling device in the pipe residual

temperature operation mode is defined as a power during residual temperature use, and an operation mode in which operation is possible with a power smaller than the power during residual temperature use is defined as a power saving operation mode, and

wherein the control device can perform:

a fourth determination process to determine, if the management condition is determined to be satisfied, whether the cooling capacity demonstrated by the heat exchanger in the current operation mode can be further reduced; and

a power saving operation process to operate the cooling device in the power saving operation mode if the management condition is determined to be satisfied and if a determination is made in the fourth determination process that the cooling capacity demonstrated by the heat exchanger in the current operation mode cannot be further reduced.

5. The chilled water circulation system according to claim 4,

wherein the cooling device comprises an air blower that can cool an air discharged into a room as the cooling target and sends the air to the heat exchanger, and

wherein the control device can perform, as the power saving operation mode, an operation mode in which the air blower is operated while a supply of the chilled water to the heat exchanger is stopped.

6. The chilled water circulation system according to any one of claims 1 to 5,

wherein, after the control device performs a process to change the cooling capacity demonstrated by the heat exchanger and when a period of time determined under a preset rule passes, the control device can perform the first determination

process.

7. The chilled water circulation system according to any one of claims 1 to 6,

wherein, after the control device performs a process to change the cooling capacity demonstrated by the heat exchanger and when a period of time determined under a preset rule passes, the control device can perform at least one of a process to determine whether to further change the cooling capacity and a process to determine whether to change the current operation mode.

8. The chilled water circulation system according to any one of claims 1 to 7,

wherein the control device can perform a process to change the parameter.

9. The chilled water circulation system according to any one of claims 1 to 8 further comprising:

a primary pump that sends the chilled water discharged from the heat exchanger to the thermal source machine; and

a secondary pump that sends the chilled water supplied from the thermal source machine to the heat exchanger, a suction side of the secondary pump being coupled to the bypass pipe,

wherein the control device operates the secondary pump in the pipe residual temperature operation mode, while the primary pump is in a stopped state.

10. The chilled water circulation system according to claim 9,

wherein the control device can perform a process to enhance the cooling capacity demonstrated by the heat exchanger by increasing a discharge amount from

the secondary pump.

11. The chilled water circulation system according to claim 10, wherein the secondary pump is composed on a plurality of pumps, and wherein the control device can increase the discharge amount from the secondary pump by increasing the number of operating pumps among the plurality of pumps.

12. The chilled water circulation system according to claim 10 or 11, wherein the control device can control the discharge amount from the secondary pump by controlling a frequency of voltage applied to an electric motor that operates the secondary pump, and wherein the control device can increase the discharge amount from the secondary pump by increasing the frequency of voltage applied.

13. The chilled water circulation system according to any one of claims 9 to 12, wherein the control device can perform a process to reduce the cooling capacity demonstrated by the heat exchanger by decreasing the discharge amount from the secondary pump.

14. The chilled water circulation system according to claim 13, wherein the secondary pump is composed on a plurality of pumps, and wherein the control device can decrease the discharge amount from the secondary pump by decreasing the number of operating pumps among the plurality of pumps.

15. The chilled water circulation system according to claim 13 or 14, wherein the control device can control the discharge amount from the secondary pump by controlling a frequency of voltage applied to an electric motor that operates the secondary pump, and

wherein the control device can decrease the discharge amount from the secondary pump by decreasing the frequency of voltage applied.

16. A program for a chilled water circulation system, the chilled water circulation system including:

a cooling device including:

a thermal source machine that cools a chilled water;

a heat exchanger that performs heat exchange between the chilled water, which is chilled, and a cooling target and cools the cooling target; and

a bypass pipe connecting a chilled-water inflow side of the heat exchanger and a chilled-water outflow side of the heat exchanger;

a parameter detector that detects a value of a parameter indicating a state of the cooling target;

a temperature detector that detects a temperature of the chilled water supplied to the heat exchanger; and

a control device that controls an operational state of the cooling device, signals outputted from the parameter detector and the temperature detector being inputted to the control device,

the program being adopted in the chilled water circulation system and installed in the control device,

wherein an operation mode in which the chilled water in the bypass pipe is supplied to the heat exchanger so that a cooling capacity is demonstrated by the heat exchanger is defined as a pipe residual temperature operation mode, and

wherein the program for the chilled water circulation system causes the control device to perform:

- a first determination process to determine whether a value based on a detection value of the parameter detector satisfies a preset management condition for the parameter;

- a second determination process to determine whether a value based on a detection value of the temperature detector satisfies a preset capacity condition; and

- a residual temperature operation process in which the cooling device is operated in the pipe residual temperature operation mode when at least the management condition and the capacity condition are satisfied.

17. A heat medium circulation system comprising:

- a cooling device comprising:

- a thermal source machine that cools a heat medium;

- a heat exchanger that performs heat exchange between the heat medium, which is chilled, and a cooling target and cools the cooling target; and

- a bypass pipe connecting a heat-medium inflow side of the heat exchanger and a heat-medium outflow side of the heat exchanger;

- a parameter detector that detects a value of a parameter indicating a state of the cooling target;

- a temperature detector that detects a temperature of the heat medium supplied to the heat exchanger; and

- a control device that controls an operational state of the cooling device, and signals outputted from the parameter detector and the temperature detector being inputted to the control device,

- wherein an operation mode in which the heat medium in the bypass pipe is

supplied to the heat exchanger so that a cooling capacity is demonstrated by the heat exchanger is defined as a pipe residual temperature operation mode, and

wherein the control device can perform:

a first determination process to determine whether a value based on a detection value of the parameter detector satisfies a preset management condition for the parameter;

a second determination process to determine whether a value based on a detection value of the temperature detector satisfies a preset capacity condition; and

a residual temperature operation process in which the cooling device is operated in the pipe residual temperature operation mode when at least the management condition and the capacity condition are satisfied.