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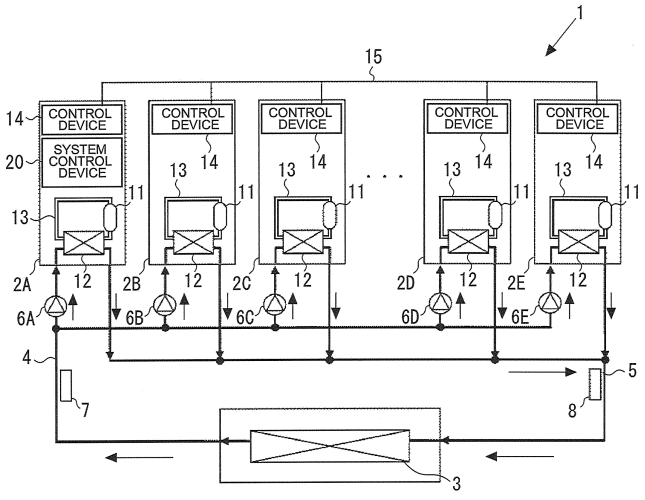
(54) HEAT PUMP CHILLING SYSTEM AND CONTROL METHOD THEREFOR

(57) A heat pump chilling system includes an inlet temperature sensor that detects an inlet temperature of a heat medium flowing into a plurality of heat pump chilling devices, an outlet temperature sensor that detects an outlet temperature of flow from the plurality of heat pump chilling devices to a load, and a system control device that controls operation of the plurality of heat pump chilling devices based on the inlet temperature and the outlet temperature. The system control device includes a storage unit that stores an operating capacity for each of the plurality of heat pump chilling devices, a requested-capacity calculating unit that calculates a requested capacity based on the inlet temperature or the outlet temperature and a set target temperature, a number-of-devices calculating unit that calculates the number of devices to be activated among the plurality of heat pump chilling devices satisfying the requested capacity based on the operating capacity of each of the plurality of heat pump chilling devices, and an activation control unit that activates the plurality of heat pump chilling devices of the number of devices to be activated calculated in the number-of-devices calculating unit.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to heat pump chilling systems equipped with a plurality of heat pump chilling devices and methods of controlling the heat pump chilling systems.

Background Art

[0002] In the related art, a heat pump chilling system equipped with a plurality of heat source devices, such as a water heater system for supplying, for example, hot water or cold water, is known. The overall operation of the plurality of heat source devices is controlled so that a predetermined requested capacity is obtained from the plurality of heat source devices (e.g., see Patent Literatures 1 and 2). Patent Literature 1 discloses a connected water heater system that fills a bathtub with an accurate amount of hot water by using hot water supplied from a plurality of heat source devices (water heater devices). To achieve this configuration, the connected water heater system first injects hot water by simultaneously activating the plurality of heat source devices, operates only a single one of the heat source devices immediately before a target amount of hot water is reached at an intermediate stage of hot-water filling control, and stops the operation of some of the heat source devices. Patent Literature 2 discloses a water heater system that preliminarily stores the number of devices to be operated depending on the time required for boiling water and the required amount of hot water in the form of a data table, and sequentially activates the heat source devices of the number of devices based on the data table while shifting the activation time by a predetermined time period.

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Patent No. 4257596 (paragraph [0044])
Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2012-127633 (paragraphs [0038] and [0039])

Summary of Invention

Technical Problem

[0004] However, because all of the heat source devices are activated at the time of activation in Patent Literature 1, the overall operating capacity of the plurality of heat source devices sometimes becomes excessive. On the other hand, in the case where the plurality of heat source devices are successively activated by a predetermined time period, as in Patent Literature 2, it takes too much time for completing the activation in a water heater system having a large number of heat source devices. Thus, when the power is to be restored from a power-off state, a significant time period is similarly spent for recovering to the original heating or cooling capacity.

[0005] The present invention has been made to solve the problems mentioned above, and an object thereof is to provide a heat pump chilling system and a method of controlling the heat pump chilling system in which a plurality of heat pump chilling devices of the number of devices that is neither too large nor too small for the requested capacity can be activated within a short period of time, regardless of the number of heat pump chilling devices.

Solution to Problem

[0006] In a heat pump chilling system according to an embodiment of the present invention, a plurality of heat pump chilling devices provided with refrigeration cycles through which refrigerant flows are connected in parallel with a load and a heat medium that has exchanged heat with the refrigerant in the plurality of heat pump chilling devices circulates to the load. The heat pump chilling system includes an inlet temperature sensor that detects a temperature of the heat medium flowing into the plurality of heat pump chilling devices from the load as an inlet temperature, an outlet temperature sensor that detects a temperature of water flowing into the load from the plurality of heat pump chilling devices as an outlet temperature, and a system control device that controls operation of the plurality of heat pump chilling devices based on the inlet temperature detected in the inlet temperature sensor and the outlet temperature detected in the outlet temperature sensor. The system control device includes a storage unit that stores an operating capacity for each of the plurality of heat pump chilling devices, a requested-capacity calculating unit that calculates a requested capacity based on the inlet temperature or the outlet temperature and a set target temperature, a number-of-devices calculating unit that calculates the number of devices to be activated among the plurality of heat pump chilling devices satisfying the requested capacity calculated by the requested-capacity calculating unit based on the operating capacity stored in the storage unit for each of the plurality of heat pump chilling devices, and an activation control unit that activates the plurality of heat pump chilling devices of the number of devices to be activated calculated in the number-of-devices calculating unit.

Advantageous Effects of Invention

[0007] In the heat pump chilling system and the method of controlling the heat pump chilling system according to an embodiment of the present invention, the number of

devices with which the requested capacity is obtained is calculated based on the operating capacity of each of the plurality of heat pump chilling devices stored in the storage unit, and the heat pump chilling devices are simultaneously activated, so that the heat pump chilling devices of the number of devices that is neither too large nor too small can be activated within a short period of time.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a schematic diagram illustrating a heat pump chilling system according to Embodiment 1 of the present invention.
[Fig. 2] Fig. 2 is a block diagram illustrating an example of a system control device in the heat pump chilling system in Fig. 1.
[Fig. 3] Fig. 3 is a flowchart illustrating an operational example of the heat pump chilling system in Fig. 1.
[Fig. 4] Fig. 4 illustrates an example of an activation time in the heat pump chilling system in Figs. 1 and 2.
[Fig. 5] Fig. 5 illustrates an example of an activation time in a heat pump chilling system in the related art.
[Fig. 6] Fig. 6 is a block diagram illustrating an example of a system control device in a heat pump chilling system according to Embodiment 2 of the present invention.
[Fig. 7] Fig. 7 is a flowchart illustrating an operational example of the system control device in the heat pump chilling system in Fig. 6.
[Fig. 8] Fig. 8 is a block diagram illustrating an example of a system control device in a heat pump chilling system according to Embodiment 3 of the present invention.
[Fig. 9] Fig. 9 is a flowchart illustrating an operational example of the heat pump chilling system in Fig. 8.
[Fig. 10] Fig. 10 is a block diagram illustrating an example of a system control device in a heat pump chilling system according to Embodiment 4 of the present invention.
[Fig. 11] Fig. 11 is a flowchart illustrating an operational example of the heat pump chilling system in Fig. 10.

Description of Embodiments

Embodiment 1

[0009] A heat pump chilling system according to the present invention will be described below in detail with reference to the drawings. Fig. 1 is a schematic diagram illustrating a heat pump chilling system according to Embodiment 1 of the present invention. In a heat pump chilling system 1 in Fig. 1, a plurality of heat pump chilling devices 2A to 2E are connected in parallel with a load 3 by using an inlet pipe 4 and an outlet pipe 5, and a heat medium, such as water and an antifreeze solution, serving as a medium for exchanging heat energy circulates between the plurality of heat pump chilling devices 2A to 2E and the load 3. The load 3 is constituted of, for example, a load-side heat exchanger, and, for example, air-conditioning or supplying of hot water is performed by using the load-side heat exchanger. Although the load 3 is described as being constituted of a load-side heat exchanger, the load 3 may alternatively be constituted of, for example, a hot-water tank or a cold-water tank, or may be constituted of a heat storage tank.

[0010] The inlet pipe 4 starts from the load 3 and branches off toward the plurality of heat pump chilling devices 2A to 2E and allows the heat medium to flow therethrough. Pumps 6A to 6E are each attached to a corresponding one of sections of the inlet pipe 4 branching off toward the heat pump chilling devices 2A to 2E. The outlet pipe 5 causes the heat medium that has exchanged heat in the plurality of heat pump chilling devices 2A to 2E to merge and flow toward the load 3. By driving the pumps 6A to 6E, the heat medium circulates between the heat pump chilling devices 2A to 2E and the load 3 via the inlet pipe 4 and the outlet pipe 5.

[0011] The plurality of heat pump chilling devices 2A to 2E are constituted of, for example, heat-pump-type heat source devices and have, for example, identical configurations and the same operating capacities. The heat pump chilling devices 2A to 2E are each provided with a refrigeration cycle including a compressor 11, a heat-source-side heat exchanger 12, and a refrigerant pipe 13. The compressor 11 compresses refrigerant to a high-temperature high-pressure state. The heat-source-side heat exchanger 12 is constituted of, for example, a plate-type heat exchanger and causes the refrigerant flowing through the refrigeration cycle and the heat medium flowing in from the inlet pipe 4 to exchange heat with each other.

[0012] The plurality of heat pump chilling devices 2A to 2E are individually provided with control devices 14 that control the operation of the heat pump chilling devices 2A to 2E. The control devices 14 are connected to one another via a communication network 15 to be capable of transferring, for example, control information to and from one another. Furthermore, one representative device (e.g., the heat pump chilling device 2A in Fig. 1) among the plurality of heat pump chilling devices 2A to 2E is provided with a system control device 20 that controls the entire heat pump chilling system 1. The system control device 20 controls the operation of the heat pump chilling devices 2A to 2E via the communication network 15. Although the system control device 20 is described as being provided in the heat pump chilling device 2A as an example, the system control device 20 may be installed as an independent device separate from the heat pump chilling device 2A.

[0013] Furthermore, the heat pump chilling system 1 includes an inlet temperature sensor 7 that detects the temperature of water, as an inlet temperature Ti, in the

inlet pipe 4 immediately before the water is distributed to the plurality of heat pump chilling devices 2A to 2E, and also includes an outlet temperature sensor 8 that detects the temperature of water, as an outlet temperature To, in the outlet pipe 5 immediately after the water is merged from the plurality of heat pump chilling devices 2A to 2E. In other words, the inlet temperature sensor 7 detects the temperature of the heat medium that is to flow into the load 3 as the inlet temperature Ti, and the outlet temperature sensor 8 detects the temperature of the heat medium flowing out from the load 3 as the outlet temperature To.

[0014] The system control device 20 has a function of controlling the activation of the plurality of heat pump chilling devices 2A to 2E based on the inlet temperature Ti and the outlet temperature To. In particular, the system control device 20 performs control to activate the single heat pump chilling device 2A among the plurality of heat pump chilling devices 2A to 2E at the start of operation. Subsequently, if an operation capacity does not satisfy the requested capacity, the system control device 20 simultaneously activates the heat pump chilling devices 2B to 2E of a predetermined number to compensate for the deficiency for the requested capacity. Although the following description relates to a case where the heat pump chilling device 2A serving as the representative device is the single device to be activated at the start of operation, another one of the heat pump chilling devices 2B to 2E may be selected as the single device to be activated at the start of operation.

[0015] Fig. 2 is a block diagram illustrating an example of the system control device in the heat pump chilling system in Fig. 1. The system control device 20 will be described with reference to Figs. 1 and 2. The system control device 20 controls the operation of the plurality of heat pump chilling devices 2A to 2E and particularly has a function of controlling the activation of the plurality of heat pump chilling devices 2A to 2E. In detail, the system control device 20 has a requested-capacity calculating unit 21, a target-temperature setting unit 22, an operating-capacity calculating unit 23, a storage unit 24, a number-of-devices calculating unit 25, and an activation control unit 26.

[0016] The requested-capacity calculating unit 21 calculates a requested capacity Tdg based on a target temperature Tref and the inlet temperature Ti. In detail, the requested-capacity calculating unit 21 calculates an absolute value of a difference between the target temperature Tref and the inlet temperature Ti as the requested capacity Tdg. The target temperature Tref is set in the target-temperature setting unit 22. For example, the target-temperature setting unit 22 may acquire the target temperature Tref from an information input unit, such as a keyboard and a touchscreen, or may have the target temperature Tref stored in advance.

[0017] With regard to each of the plurality of heat pump chilling devices 2A to 2E, the operating-capacity calculating unit 23 calculates an operating capacity indicating the capacity for heating or cooling the heat medium based on the inlet temperature Ti and the outlet temperature To and stores the operating capacity into the storage unit 24. As described above, the plurality of heat pump chilling devices 2A to 2E have the same operating capacities Td, and the heat pump chilling device 2A activated alone at the start of operation is activated. The operating-capacity calculating unit 23 calculates the operating capacity Td of the heat pump chilling device 2A activated alone at the start of operation and stores the calculated operating capacity Td of the heat pump chilling device 2A as the operating capacity Td of each of the remaining heat pump chilling devices 2B to 2E into the storage unit 24. In detail, the operating-capacity calculating unit 23 calculates an absolute value |Ti - To| of a temperature difference between the inlet temperature Ti and the outlet temperature To as the operating capacity Td of the heat pump chilling device 2A and stores it into the storage unit 24. Moreover, the operating-capacity calculating unit 23 stores the operating capacity Td of the heat pump chilling device 2A as the operating capacity of each of the remaining heat pump chilling devices 2B to 2E into the storage unit 24.

[0018] Based on the operating capacity Td of each of the plurality of heat pump chilling devices 2A to 2E stored in the storage unit 24, the number-of-devices calculating unit 25 calculates the number n of devices to be activated for obtaining the requested capacity Tdg calculated by the requested-capacity calculating unit 21. In detail, the number-of-devices calculating unit 25 calculates the number n of devices to be activated by using a ceiling function (Tdg/Td) in which the requested capacity (target temperature difference) Tdg is divided by the operating capacity (temperature difference) Td. Thus, in a case where the operating capacity Td satisfies the requested capacity Tdg ($Tdg \leq Td$), the number n of devices to be activated, which is an output value of the ceiling function, is equal to 1. In contrast, in a case where the operating capacity Td is deficient for the requested capacity Tdg ($Tdg > Td$), the number n of devices to be activated, which is an output value of the ceiling function, is larger than or equal to 2. If the number n of devices to be activated exceeds a total number N of installed devices among the plurality of heat pump chilling devices 2A to 2E, the number-of-devices calculating unit 25 sets the total number of devices as the number n of devices to be activated.

[0019] As mentioned above, the activation control unit 26 performs control to activate the single heat pump chilling device 2A alone at the start of operation or when the operation is resumed at the time of a power restoring process. Furthermore, the activation control unit 26 activates the heat pump chilling devices 2B to 2E of the number n of devices to be activated calculated in the number-of-devices calculating unit 25. In this case, the activation control unit 26 simultaneously activates the devices of the number (n - 1), excluding the single already-activated device, among the heat pump chilling devices 2B to 2E. For example, in a case where the number n of

devices to be activated calculated in the number-of-devices calculating unit 25 is equal to 1, this implies that the requested capacity is already satisfied by activating the single device. In this case, the activation control unit 26 does not activate the remaining heat pump chilling devices 2B to 2E. On the other hand, if the number n of devices to be activated calculated in the number-of-devices calculating unit 25 is larger than or equal to 2, the activation control unit 26 performs control to simultaneously activate the devices of the number (n - 1) among the heat pump chilling devices 2B to 2E. In this case, the order of priority in which the heat pump chilling devices 2B to 2E are to be activated may be preset in the activation control unit 26 or may be determined randomly.

[0020] Thus, control can be performed so that the operating capacity Td of the entire system is increased if the operating capacity Td is deficient for the requested capacity Tdg and that the operating capacity Td is decreased if the operating capacity Td exceeds the requested capacity Tdg. If the operating capacity Td is deficient for the requested capacity Tdg, the number-of-devices calculating unit 25 subsequently makes an activation plan for determining the operating capacity of each of the plurality of remaining heat pump chilling devices 2B to 2E, and when the plan is set, the activation control unit 26 commands the respective control devices 14 to perform activation via the communication network 15.

[0021] Fig. 3 is a flowchart illustrating an operational example at the time of activation in the heat pump chilling system 1. The operational example of the heat pump chilling system 1 will be described with reference to Figs. 1 to 3. First, any one (e.g., the heat pump chilling device 2A) of the heat pump chilling devices 2A to 2E is activated with the maximum capacity under the control of the activation control unit 26 (step ST1). Then, when the activation of the single heat pump chilling device 2A is completed, the inlet temperature Ti detected in the inlet temperature sensor 7 and the outlet temperature To detected in the outlet temperature sensor 8 are acquired and are stored into the storage unit 24 (step ST2).

[0022] Subsequently, based on the inlet temperature Ti and the outlet temperature To, the operating-capacity calculating unit 23 calculates an absolute value of a temperature difference given by the single heat pump chilling device 2A as the operating capacity Td. Then, this operating capacity Td is stored as the operating capacity Td of each of the plurality of heat pump chilling devices 2A to 2E into the storage unit 24 (step ST3).

[0023] Then, the temperature difference between the target temperature Tref and the inlet temperature Ti is calculated as the requested capacity Tdg in the requested-capacity calculating unit 21 and is stored into the storage unit 24 (step ST4). The calculation of the operating capacity Td (step ST3) and the calculation of the requested capacity Tdg (step ST4) may be performed in no particular order and may be performed concurrently with each other. Subsequently, the number-of-devices calculating unit 25 reads the operating capacity Td and the requested capacity Tdg from the storage unit 24 and calculates the number n of heat pump chilling devices 2B to 2E to be activated (step ST5). The activation control unit 26 simultaneously activates the heat pump chilling devices 2B to 2E of the calculated number n of devices to be activated (step ST6).

[0024] According to Embodiment 1 described above, since the devices of the calculated number n of heat pump chilling devices 2B to 2E to be activated necessary for the requested capacity are simultaneously activated, activation can be performed within a short period of time in a fixed period even in a system in which the number of heat pump chilling devices 2A to 2E is large, and the devices of the number n among the heat pump chilling devices 2A to 2E that is neither too large nor too small for the requested capacity Tdg can be activated.

[0025] In detail, Fig. 4 illustrates an example of an activation time in the heat pump chilling system in Figs. 1 and 2. In Fig. 4, for example, if the compressor 11 at the start of operation or when the power is restored from a power-off state is in a stopped state, activation of the heat pump chilling devices 2A to 2E starts after an activation protection time period tw (e.g., about five minutes), which is a standby state of the compressor 11, for protecting the compressor 11. Subsequently, the heat pump chilling devices 2A to 2E start operating after a time period ts (e.g., about three minutes) required for the activation. Thus, the heat pump chilling devices 2A to 2E require a time period of (tw + ts) from the start of activation to the start of operation.

[0026] As mentioned above, in the heat pump chilling system 1, the single heat pump chilling device 2A is activated alone at the start of operation, and then the remaining heat pump chilling devices 2B to 2E are simultaneously activated. The activation protection time period tw progresses concurrently with respect to all of the heat pump chilling devices 2A to 2E. Thus, the time taken until a plurality of the heat pump chilling devices 2A to 2E, with which the requested capacity Tdg is obtained, start operating is a fixed time period (tw + 2ts) obtained by adding the time period (tw + ts) from the start of activation to the start of operation of the single heat pump chilling device 2A to the time period tw taken until the second device and onward start operating.

[0027] Fig. 5 illustrates an example of an activation time in a heat pump chilling system in the related art. In Fig. 5, an activation standby time period td (e.g., about two to three minutes) in which the heat pump chilling devices 2B to 2E wait for activation is set. In the related art, the time taken for activating the first device is also (ts + tw). However, since the second device and onward are sequentially activated, a time period of (ts + tw + (n - 1) x td) is required. Thus, the larger the number of heat pump chilling devices 2A to 2E, the longer it takes to activate the system for satisfying the requested capacity. Thus, in the heat pump chilling system 1, a plurality of the heat pump chilling devices 2A to 2E for satisfying the requested capacity Tdg can be activated within a short

period of time.

[0028] In particular, to calculate the operating capacity Td of each of the plurality of heat pump chilling devices 2B to 2E from the operating capacity Td of the single heat pump chilling device 2A activated alone at the start of operation, since the number n of devices to be activated can be calculated based on the operating capacity Td in actual operation, the number n of devices to be activated satisfying the requested capacity Tdg can be calculated with high accuracy. Specifically, the locations where the plurality of heat pump chilling devices 2A to 2E are installed and the connected load 3 vary. Thus, if the operating capacity Td of each of the heat pump chilling devices 2A to 2E is stored as a fixed value in the storage unit 24 at the time of shipment, the actual operating capacity Td may sometimes deviate from the operating capacity Td stored in the storage unit 24. In contrast, in the heat pump chilling system 1, the operating capacity Td is stored in the storage unit 24 after the installation locations of the heat pump chilling devices 2A to 2E are set and the load 3 connected to the heat pump chilling devices 2A to 2E is specified. Consequently, the operating capacity Td corresponding to the load 3 can be calculated with high accuracy.

Embodiment 2

[0029] Fig. 6 is a block diagram illustrating a system control device in a heat pump chilling system according to Embodiment 2 of the present invention. A system control device 120 in the heat pump chilling system will be described with reference to Fig. 6. In the system control device 120 according to Embodiment 2, sections having configurations identical to those in the system control device 20 according to Embodiment 1 are given the same reference signs, and descriptions thereof will be omitted. The system control device 120 according to Embodiment 2 differs from the system control device 20 according to Embodiment 1 in that the plurality of heat pump chilling devices 2A to 2E are simultaneously activated from the start of operation.

[0030] In the system control device 120 in Fig. 6, the storage unit 24 stores the operating capacity Td for each of the plurality of heat pump chilling devices 2A to 2E. Similar to Embodiment 1, the operating capacities Td stored in the storage unit 24 are stored when, for example, the heat pump chilling device 2A is activated alone. Alternatively, the operating capacities Td may be stored in the storage unit 24 at the time of shipment.

[0031] Based on the operating capacities stored in the storage unit 24 for the respective heat pump chilling devices 2A to 2E, a number-of-devices calculating unit 125 calculates the number n of devices to be simultaneously activated for obtaining the requested capacity Tdg calculated by the requested-capacity calculating unit 21 by using a ceiling function (Tdg/Td). In this case, the calculated number n of devices to be activated is directly used as the number of devices to be simultaneously activated since not a single one of the plurality of heat pump chilling devices 2A to 2E is activated. Then, an activation control unit 126 performs control to simultaneously activate the heat pump chilling devices 2A to 2E of the number n of devices to be activated calculated in the number-of-devices calculating unit 125.

[0032] Fig. 7 is a flowchart illustrating an operational example of the system control device in the heat pump chilling system in Fig. 6. The operational example of the system control device 120 will be described with reference to Figs. 6 and 7. First, the number-of-devices calculating unit 25 reads the operating capacities (temperature differences) Td of the plurality of heat pump chilling devices 2A to 2E stored in the storage unit 24 (step ST11). At the same time, the inlet temperature Ti is acquired from the inlet temperature sensor 7 and is stored into the storage unit 24 (step ST12).

[0033] Subsequently, the requested capacity Tdg is calculated from the target temperature Tref set in the target-temperature setting unit 22 and the acquired inlet temperature Ti and is stored into the storage unit 24 (step ST13). Then, the number-of-devices calculating unit 125 calculates the number n of devices to be simultaneously activated based on the operating capacities Td of the plurality of heat pump chilling devices 2A to 2E and the requested capacity Tdg (step ST14). Subsequently, the devices of the number n among the heat pump chilling devices 2A to 2E are simultaneously activated by the activation control unit 126 (step ST15).

[0034] According to Embodiment 2 described above, the number n of devices to be activated among the heat pump chilling devices 2A to 2E required for the requested capacity Tdg is calculated based on the operating capacities Td stored in the storage unit 24 for the respective heat pump chilling devices 2A to 2E, so that the devices of the number n to be activated can be simultaneously activated. Thus, activation can be performed within a shorter period of time even in a heat pump chilling system in which the number of heat pump chilling devices 2A to 2E is large, and the devices of the number among the heat pump chilling devices 2A to 2E that is neither too large nor too small for the requested capacity Tdg can be activated, as in Embodiment 1.

Embodiment 3

[0035] Fig. 8 is a block diagram illustrating a system control device in a heat pump chilling system according to Embodiment 3 of the present invention. A system control device 220 in the heat pump chilling system will be described with reference to Fig. 8. In the system control device 220 according to Embodiment 3, sections having configurations identical to those in the system control device 20 according to Embodiment 1 are given the same reference signs, and descriptions thereof will be omitted. The system control device 220 according to Embodiment 3 differs from the system control device 20 according to Embodiment 1 in that an operating-capacity calculating

unit 223 learns the operating capacities of the heat pump chilling devices 2A to 2E and stores the operating capacities into a storage unit 224.

[0036] The operating-capacity calculating unit 223 in Fig. 8 calculates the operating capacity Td of the heat pump chilling device 2A activated alone at the start of operation and stores a value obtained by optimizing calculated results corresponding to the number of learning times as an optimized operating capacity Tds into the storage unit 224. In detail, a value that specifies the number of learning times is preset in the operating-capacity calculating unit 223. On the other hand, the number of learning times already experienced for each of the heat pump chilling devices 2A to 2E is stored in the storage unit 24. For example, if the operating-capacity calculating unit 223 determines that the number of learning times of the heat pump chilling device 2A activated at the start of operation has reached the specified value, the number-of-devices calculating unit 25 calculates the number n of devices to be activated based on the optimized operating capacity Tds stored in the storage unit 224.

[0037] If the number of learning times has not reached the specified value, the operating-capacity calculating unit 223 optimizes the operating capacity Tds stored in the storage unit 224. The operating-capacity calculating unit 223 calculates the operating capacity Td of the heat pump chilling device 2A activated alone at the start of operation and stores the operating capacity Td into the storage unit 24. An average value of operating capacities Td corresponding to the number of learning times is stored in the storage unit 224. Optimization is performed by calculating an average value in which a newly calculated operating capacity Td is incorporated, and the optimized operating capacity Tds stored in the storage unit 224 is updated.

[0038] Furthermore, if the number of learning times has reached the specified value, an activation control unit 226 performs control to simultaneously activate the devices of the number n that satisfy the requested capacity Tdg at the start of operation, as in Embodiment 2. If the number of learning times is smaller than or equal to the specified value, the activation control unit 226 activates the single heat pump chilling device 2A alone at the start of operation so that the operating capacity Td is learned. Subsequently, the activation control unit 226 performs control to simultaneously activate the devices of the number (n - 1) among the heat pump chilling devices 2B to 2E that satisfy the requested capacity Tdg.

[0039] Fig. 9 is a flowchart illustrating an operational example of the system control device in the heat pump chilling system in Fig. 8. The operational example of the system control device 220 will be described with reference to Figs. 8 and 9. First, the operating-capacity calculating unit 223 reads the number of learning times from the storage unit 224 (step ST21), and it is determined whether or not the read number of learning times satisfies the specified value (step ST22). If the number of learning times is larger than or equal to the specified value, it is determined that the learning is already completed, and the optimized operating capacity Tds stored in the storage unit 224 is used as the operating capacity Td of each of the heat pump chilling devices 2A to 2E (step ST23). Subsequently, the inlet temperature sensor 7 detects the inlet temperature Ti (step ST24).

[0040] If the number of learning times is smaller than the specified value, a new number of learning times obtained by adding 1 to the number of learning times is stored into the storage unit 24 (step ST25). Then, the activation control unit 226 activates the single heat pump chilling device 2A with the maximum operating capacity (step ST26). When the activation of the single heat pump chilling device 2A is completed, the inlet temperature sensor 7 detects the inlet temperature Ti (step ST27). Subsequently, the absolute value of the temperature difference between the inlet temperature Ti and the outlet temperature To is calculated as an operating capacity Td, and an average value of operating capacities Td corresponding to the number of learning times is stored as the optimized operating capacity Tds into the storage unit 224 (step ST28).

[0041] Then, the requested capacity Tdg is calculated in the requested-capacity calculating unit 21 (step ST29), and the number n of devices to be activated using the optimized operating capacity Tds is calculated in a number-of-devices calculating unit 225 (step ST30). Then, the activation control unit 226 determines whether or not the single heat pump chilling device 2A is already activated alone (step ST31). In other words, it is determined whether or not the operating capacity Tds has been learned.

[0042] If the single heat pump chilling device 2A is already activated alone (if the operating capacity Tds has been learned), the devices of the number (n - 1) among the heat pump chilling devices 2B to 2E are activated (step ST32). If the single heat pump chilling device 2A is not activated alone (if the number of learning times is larger than or equal to the specified value), the devices of the number n among the heat pump chilling devices 2A to 2E are simultaneously activated (step ST33).

[0043] According to Embodiment 3, the operating capacity (temperature difference) Td of the single heat pump chilling device 2A operating with the maximum capacity is learned and is stored into the storage unit 24 so that the activation can be performed within the shortest activation time after the learning. Furthermore, since the optimized operating capacity Tds is stored in the storage unit 24, a difference from the actual operating capacity Td is small, whereby the number n of devices to be activated can be calculated with high accuracy. Moreover, the devices of the number n among the heat pump chilling devices 2A to 2E that is neither too large nor too small for the requested capacity Tdg can be activated, as in Embodiment 1.

Embodiment 4

[0044] Fig. 10 is a block diagram illustrating a system control device in a heat pump chilling system according to Embodiment 4 of the present invention. A system control device 320 in the heat pump chilling system will be described with reference to Fig. 10. In the system control device 320 according to Embodiment 4, sections having configurations identical to those in the system control device 20 according to Embodiment 1 are given the same reference signs, and descriptions thereof will be omitted. The system control device 320 according to Embodiment 4 differs from the system control device 20 according to Embodiment 1 in that the number ns of devices to be activated and the number nf of devices to be activated are calculated in consideration of the energy efficiency of each of the heat pump chilling devices 2A to 2E.

[0045] The storage unit 24 in Fig. 10 preliminarily stores a capacity ratio A corresponding to the maximum energy efficiency, and a number-of-devices calculating unit 325 calculates the number ns of devices to be activated in consideration of the capacity ratio A. In detail, the number-of-devices calculating unit 325 calculates the number ns of devices to be activated in a case where all of the heat pump chilling devices 2A to 2E are activated at the capacity ratio A by using a ceiling function (Tdg/(Td x A)). Normally, the capacity ratio A corresponding to the maximum energy efficiency of the heat pump chilling devices 2A to 2E often ranges between 60% and 90%.

[0046] Because the heat pump chilling devices 2B to 2E operate with restricted capacities, the number ns of devices to be activated to be calculated tends to be large. If the calculated number ns of devices to be activated is larger than the total number N of installed devices, the number-of-devices calculating unit 325 calculates a combination of the number nf of devices to be activated among the heat pump chilling devices 2A to 2E operating with the maximum operating capacity (i.e., a capacity ratio of 100%) and the number ns of devices to be activated among the heat pump chilling devices 2A to 2E operating at the preset capacity ratio A, so that the requested capacity Tdg is satisfied.

[0047] In detail, the number-of-devices calculating unit 325 calculates a ceiling function ((Tdg - (N x Td x A))/((1 - A) x Td)) as the number nf of devices to be activated at a capacity ratio of 100%. Subsequently, the number-of-devices calculating unit 325 calculates the number (ns = N - nf) of devices to be activated at the capacity ratio A. Then, the activation control unit 26 controls the plurality of heat pump chilling devices 2A to 2E to activate the devices of the number of ns at the capacity ratio of 100% and to activate the devices of the number nf at the capacity ratio A among the total number N of installed devices.

[0048] Fig. 11 is a flowchart illustrating an operational example of the heat pump chilling system in Fig. 10. First, for example, the single heat pump chilling device 2A among the heat pump chilling devices 2A to 2E is activated with the maximum capacity of 100% (step ST41). Then, the inlet temperature Ti and the outlet temperature To immediately upon completion of the activation of the single heat pump chilling device 2A are detected and stored into the storage unit 24 (step ST42). Subsequently, the operating capacity Td of the single heat pump chilling device 2A based on the inlet temperature Ti and the outlet temperature To is stored into the storage unit 24, and the operating capacities of the remaining heat pump chilling devices 2B to 2E are similarly stored as the operating capacities Td into the storage unit 24 (step ST43).

[0049] Then, the requested capacity (target temperature difference) Tdg is calculated by the requested-capacity calculating unit 21 based on the target temperature Tref set in the target-temperature setting unit 22 and the inlet temperature Ti and is stored into the storage unit 24 (step ST44). The number-of-devices calculating unit 325 calculates the number ns of devices to be activated in a case where all of the heat pump chilling devices 2A to 2E are activated at the capacity ratio A so that the required capacity is obtained (step ST45). Then, the number-of-devices calculating unit 325 determines whether or not the number n of devices to be activated at the calculated capacity ratio A is larger than the total number N of installed devices (step ST46).

[0050] If the number ns of devices to be activated is smaller than or equal to the total number N of installed devices, the devices of the number (n - 1) among the heat pump chilling devices 2B to 2E, excluding the already-activated single device, are activated at the capacity ratio A (step ST47). On the other hand, if the number ns of devices to be activated at the capacity ratio A exceeds the total number N of installed devices (ns > N), the number nf of devices that have to be activated with the maximum capacity is calculated to compensate for the shortage amount even when all of the installed devices of the total number N are activated at the capacity ratio A (step ST48), and the number ns of devices to be activated at the capacity ratio A is recalculated (step ST49). Subsequently, under the control of the activation control unit 26, the devices of the number (nf - 1), excluding the already-activated single device, among the heat pump chilling devices 2B to 2E are activated with the maximum capacity, and the devices of the number of ns among the heat pump chilling devices 2B to 2E are activated at the capacity ratio A (step ST49).

[0051] According to Embodiment 4 described above, activation of the plurality of heat pump chilling devices 2A to 2E is controlled in consideration of the energy efficiency, so that the overall heat pump chilling system can be activated in an operational state with good energy efficiency. Furthermore, the devices of the number n among the heat pump chilling devices 2A to 2E that is neither too large nor too small for the requested capacity Tdg can be activated within a short period of time, as in Embodiment 1.

[0052] Although Fig. 11 corresponds to a case where the single heat pump chilling device 2A is activated alone

at the start of operation, the number n of devices to be activated may be calculated in consideration of the aforementioned capacity ratio A even when the heat pump chilling devices 2A to 2E are to be simultaneously activated for the requested capacity Tdg, as in Embodiment 2. Furthermore, the requested capacity stored in the storage unit 24 may be optimized, as in Embodiment 3.

[0053] Embodiments of the present invention are not limited to Embodiments described above. For example, although, in the foregoing description, the requested-capacity calculating unit 21 calculates an absolute value of a difference between the target temperature Tref and the inlet temperature Ti as the requested capacity Tdg, the requested-capacity calculating unit 21 may calculate an absolute value |Tref - To| of a difference between the target temperature Tref and the outlet temperature To as the requested capacity Tdg. In this case, if the single heat pump chilling device 2A is activated alone at the start of operation, the requested capacity Tdg being a positive value implies shortage, whereas a negative value implies that the requested capacity Tdg is satisfied. Thus, the number-of-devices calculating unit 25 is only required to calculate the number of devices that satisfy the shortage amount of the requested capacity Tdg. If a single device among the heat pump chilling devices 2A to 2E is not activated at the start of operation, operation similar to that in Embodiment 2 described above is performed since the inlet temperature Ti and the outlet temperature To are the same value.

[0054] Furthermore, although the same operating capacities Td are stored in the storage unit 24 corresponding to the plurality of heat pump chilling devices 2A to 2E in Figs. 6 and 7, the devices may have different operating capacities Td. In this case, the number-of-devices calculating unit 25 may determine the number n of devices to be activated so that a combination of the heat pump chilling devices 2A to 2E satisfying the requested capacity is achieved.

[0055] Furthermore, although Embodiment 3 describes, as an example, a case where the activation control unit 26 activates the heat pump chilling device 2A and the operation capacity Td of the heat pump chilling device 2A is learned, the activation control unit 26 may randomly set a heat pump chilling device to be activated alone at the start of operation from among the plurality of heat pump chilling devices 2A to 2E. Moreover, each of the heat pump chilling devices 2A to 2E may be activated alone, and the operating capacity Td thereof may be calculated and stored into the storage unit 24.

Reference Signs List

[0056] 1 heat pump chilling system 2A to 2E heat pump chilling device 3 load 4 inlet pipe 5 outlet pipe 6A to 6E pump 7 inlet temperature sensor 8 outlet temperature sensor 11 compressor 12 heat-source-side heat exchanger 13 refrigerant pipe 14 control device 15 communication network 20, 120, 220, 320 system control device 21 requested-capacity calculating unit 22 target-temperature setting unit 23, 223 operating-capacity calculating unit 24, 224 storage unit 25, 125, 225, 325 number-of-devices calculating unit 26, 126, 226 activation control unit A capacity ratio n, nf, ns number of devices to be activated N total number of installed devices Td operating capacity Tdg requested capacity Tds optimized operating capacity Ti inlet temperature To outlet temperature Tref target temperature

Claims

1. A heat pump chilling system in which a plurality of heat pump chilling devices provided with refrigeration cycles through which refrigerant flows are connected in parallel with a load and in which a heat medium having exchanged heat with the refrigerant in the plurality of heat pump chilling devices circulates to the load, the heat pump chilling system comprising:

   an inlet temperature sensor detecting a temperature of the heat medium flowing into the plurality of heat pump chilling devices from the load as an inlet temperature;
   an outlet temperature sensor detecting a temperature of water flowing into the load from the plurality of heat pump chilling devices as an outlet temperature; and
   a system control device configured to control operation of the plurality of heat pump chilling devices based on the inlet temperature detected in the inlet temperature sensor and the outlet temperature detected in the outlet temperature sensor,
   the system control device including
   a storage unit configured to store an operating capacity for each of the plurality of heat pump chilling devices,
   a requested-capacity calculating unit configured to calculate a requested capacity based on the inlet temperature or the outlet temperature and a set target temperature,
   a number-of-devices calculating unit configured to calculate the number of devices to be activated among the plurality of heat pump chilling devices satisfying the requested capacity calculated by the requested-capacity calculating unit based on the operating capacity stored in the storage unit for each of the plurality of heat pump chilling devices, and
   an activation control unit configured to activate the plurality of heat pump chilling devices of the number of devices to be activated calculated in the number-of-devices calculating unit.

2. The heat pump chilling system of claim 1, wherein

the activation control unit is configured to simultaneously activate the plurality of heat pump chilling devices of the number of devices calculated in the number-of-devices calculating unit at a start of operation.

3. The heat pump chilling system of claim 1,
wherein the plurality of heat pump chilling devices are configured to have the same operating capacities,
wherein the activation control unit is configured to activate a single one of the plurality of heat pump chilling devices alone at a start of operation, and
wherein the heat pump chilling system further comprises an operating-capacity calculating unit configured to calculate the operating capacity of the single activated heat pump chilling device based on the inlet temperature and the outlet temperature after the single heat pump chilling device is activated, and store the calculated operating capacity into the storage unit as the operating capacity of each of the plurality of heat pump chilling devices.

4. The heat pump chilling system of claim 3, wherein, after the single heat pump chilling device is activated, the activation control unit is configured to simultaneously activate the plurality of heat pump chilling devices of the remaining number of the number of devices to be activated corresponding to the requested capacity calculated by the requested-capacity calculating unit.

5. The heat pump chilling system of claim 3 or 4, wherein the activation control unit is configured to activate the single heat pump chilling device with a maximum operating capacity.

6. The heat pump chilling system of any one of claims 3 to 5, wherein the operating-capacity calculating unit is configured to calculate a difference between the inlet temperature and the outlet temperature as the operating capacity of the single heat pump chilling device.

7. The heat pump chilling system of any one of claims 3 to 6, wherein, based on a plurality of the operating capacities, the operating-capacity calculating unit is configured to optimize the operating capacity stored in the storage unit, each of the plurality of the operating capacities being calculated every time the single heat pump chilling device is activated.

8. The heat pump chilling system of claim 7,
wherein the storage unit is configured to store the number of times the operating capacity stored in the storage unit is optimized as the number of learning times, and
wherein when the number of learning times is smaller than or equal to a preset specified number, the operating-capacity calculating unit is configured to optimize the operating capacity.

9. The heat pump chilling system of claim 8,
wherein when the number of learning times is smaller than or equal to the preset specified number, the activation control unit is configured to activate the single heat pump chilling device alone at the start of operation and then activate zero or more of the plurality of heat pump chilling devices of the remaining number of the number of devices to be activated calculated in the number-of-devices calculating unit based on the optimized operating capacity, and
wherein when the number of learning times is larger than the preset specified number, the activation control unit is configured to activate the plurality of heat pump chilling devices of the number of devices to be activated calculated in the number-of-devices calculating unit at the start of operation based on the optimized operating capacity.

10. The heat pump chilling system of any one of claims 1 to 9, wherein the number-of-devices calculating unit is configured to calculate the number of devices to be activated in a case where the plurality of heat pump chilling devices operate at a preset capacity ratio being lower than a maximum operating capacity.

11. The heat pump chilling system of claim 10, wherein when the calculated number of devices to be activated when the operation is performed at the capacity ratio is larger than the total number of installed devices among the plurality of heat pump chilling devices, the number-of-devices calculating unit is configured to calculate a combination of the number of devices among the plurality of heat pump chilling devices to be operated with the maximum operating capacity and the number of devices to be activated among the plurality of heat pump chilling devices to be operated at the preset capacity ratio so that the requested capacity is satisfied.

12. A method of controlling a heat pump chilling system in which a plurality of heat pump chilling devices provided with refrigeration cycles through which refrigerant flows are connected in parallel with a load so that a heat medium circulates to the load and in which the plurality of heat pump chilling devices cause the refrigerant and the heat medium to exchange heat with each other, the method comprising:

calculating a requested capacity based on an inlet temperature of flow from the load to the plurality of heat pump chilling devices, an outlet temperature of flow from the plurality of heat pump chilling devices to the load, and a set tar-

get temperature;
calculating the number of devices to be activated among the plurality of heat pump chilling devices with which the calculated requested capacity is obtained based on an operating capacity stored in a storage unit for each of the plurality of heat pump chilling devices; and
activating the plurality of heat pump chilling devices of the calculated number of devices to be activated.

FIG. 1

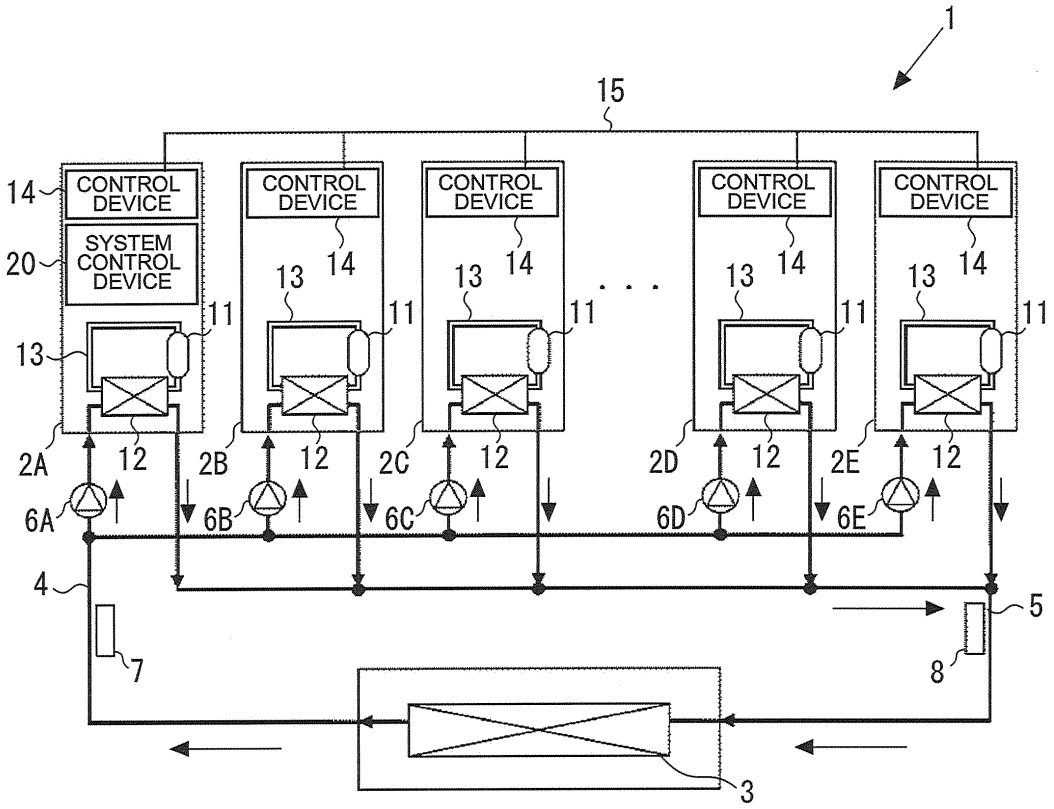

1
15
14
CONTROL DEVICE
20
SYSTEM CONTROL DEVICE
13
11
12
2A
2B
2C
2D
2E
6A
6B
6C
6D
6E
4
5
7
8
3

FIG. 2

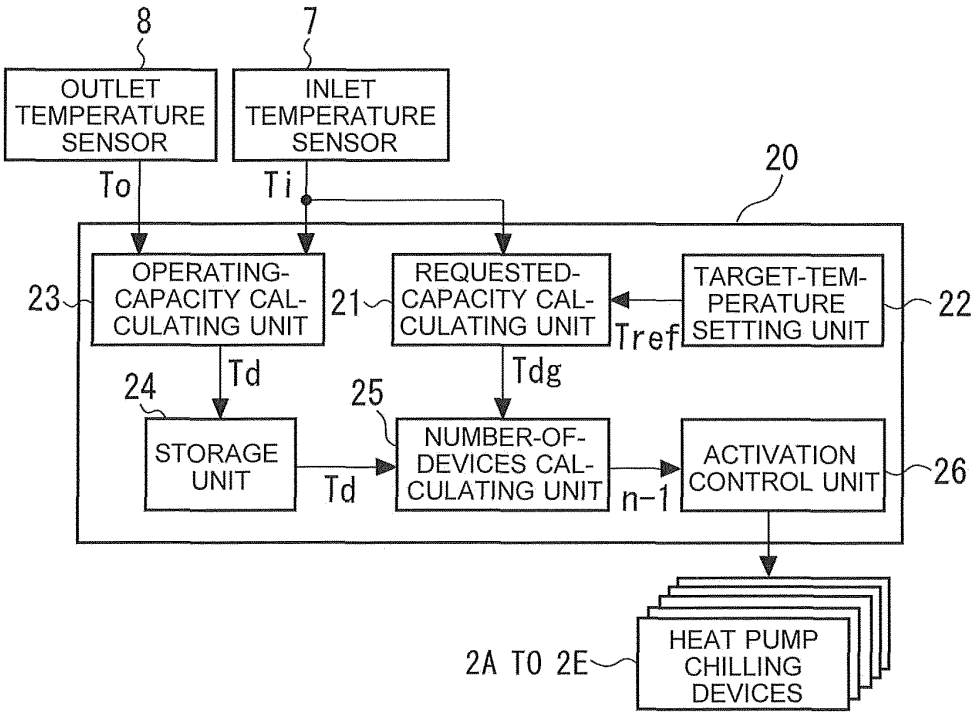

8
7
OUTLET TEMPERATURE SENSOR
INLET TEMPERATURE SENSOR
To
Ti
20
23
OPERATING-CAPACITY CALCULATING UNIT
21
REQUESTED-CAPACITY CALCULATING UNIT
Tref
TARGET-TEMPERATURE SETTING UNIT
22
Td
Tdg
24
STORAGE UNIT
25
Td
NUMBER-OF-DEVICES CALCULATING UNIT
n-1
ACTIVATION CONTROL UNIT
26
2A TO 2E
HEAT PUMP CHILLING DEVICES

FIG. 3

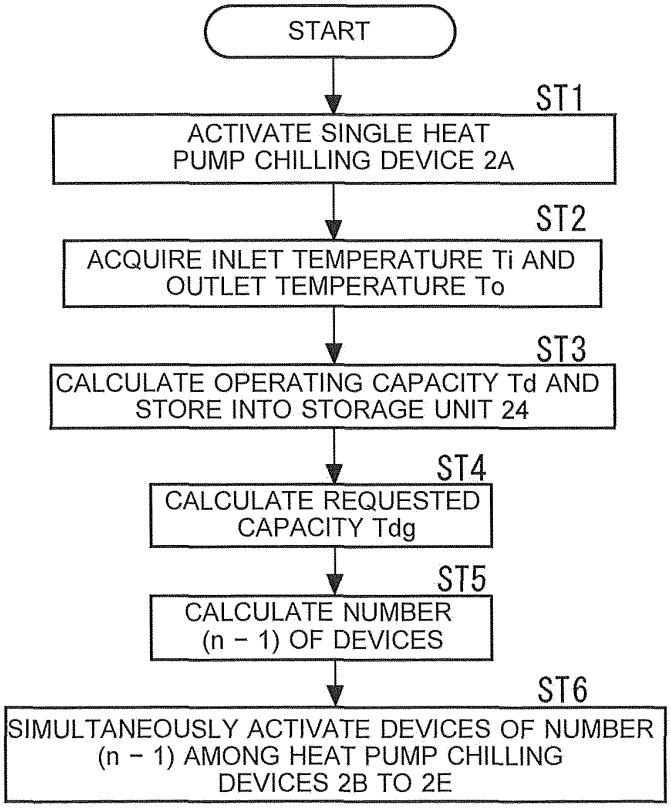

START
ST1
ACTIVATE SINGLE HEAT PUMP CHILLING DEVICE 2A
ST2
ACQUIRE INLET TEMPERATURE Ti AND OUTLET TEMPERATURE To
ST3
CALCULATE OPERATING CAPACITY Td AND STORE INTO STORAGE UNIT 24
ST4
CALCULATE REQUESTED CAPACITY Tdg
ST5
CALCULATE NUMBER (n − 1) OF DEVICES
ST6
SIMULTANEOUSLY ACTIVATE DEVICES OF NUMBER (n − 1) AMONG HEAT PUMP CHILLING DEVICES 2B TO 2E

FIG. 4

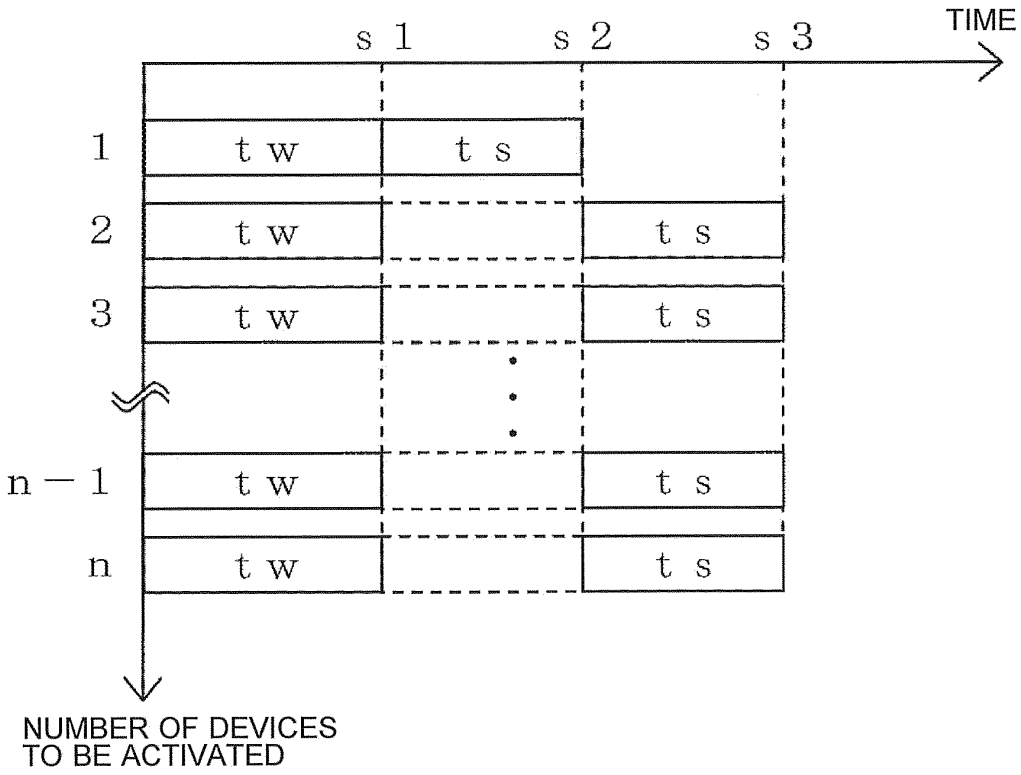

s 1
s 2
s 3
TIME
1
2
3
n − 1
n
t w
t s
NUMBER OF DEVICES
TO BE ACTIVATED

FIG. 5

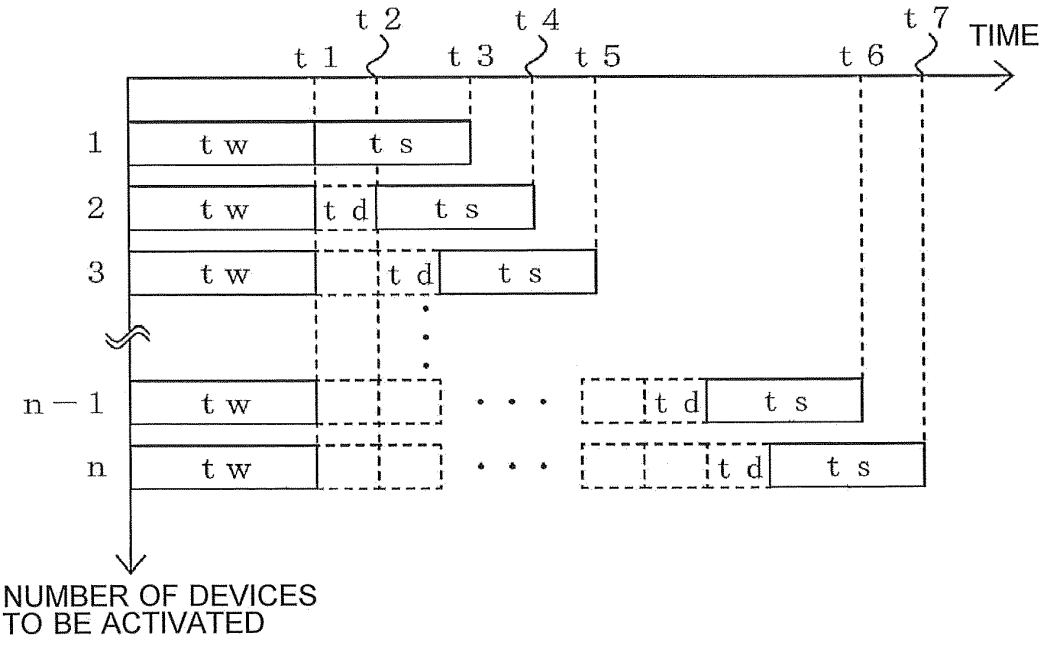

t 1
t 2
t 3
t 4
t 5
t 6
t 7
TIME
1
2
3
n − 1
n
t w
t d
t s
NUMBER OF DEVICES
TO BE ACTIVATED

FIG. 6

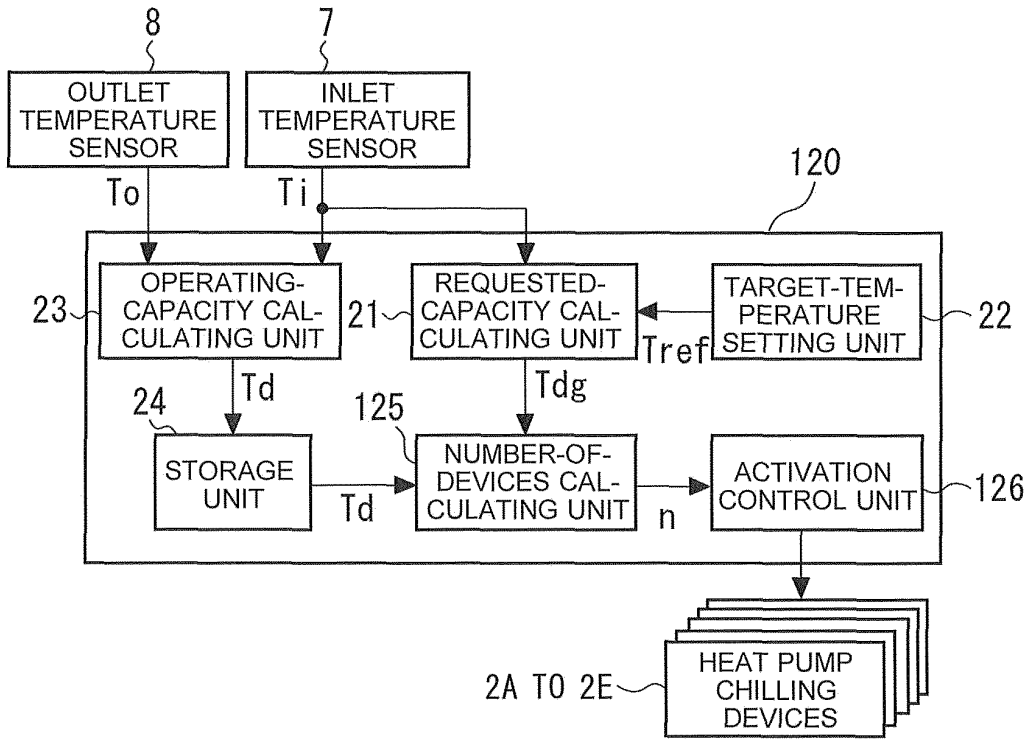

8
7
OUTLET TEMPERATURE SENSOR
INLET TEMPERATURE SENSOR
To
Ti
120
23
OPERATING-CAPACITY CALCULATING UNIT
21
REQUESTED-CAPACITY CALCULATING UNIT
Tref
TARGET-TEMPERATURE SETTING UNIT
22
Td
Tdg
24
125
STORAGE UNIT
Td
NUMBER-OF-DEVICES CALCULATING UNIT
n
ACTIVATION CONTROL UNIT
126
2A TO 2E
HEAT PUMP CHILLING DEVICES

FIG. 7

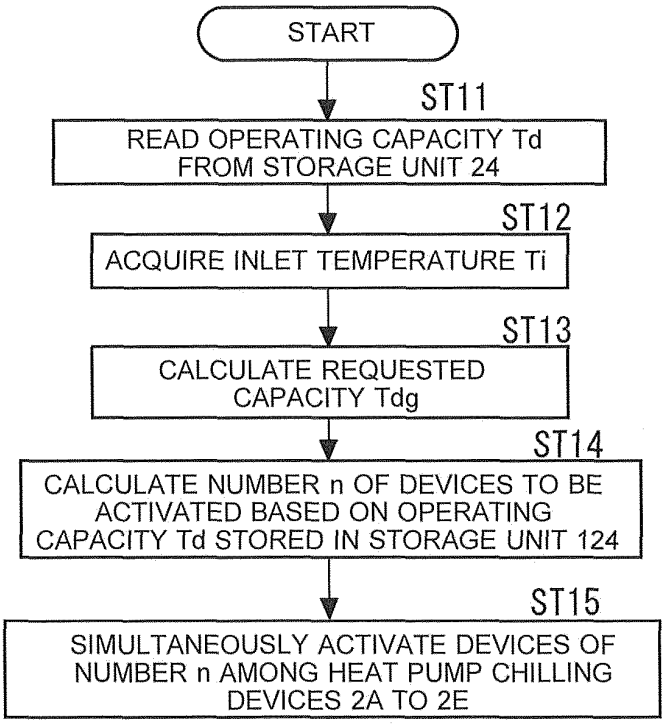

START
ST11
READ OPERATING CAPACITY Td FROM STORAGE UNIT 24
ST12
ACQUIRE INLET TEMPERATURE Ti
ST13
CALCULATE REQUESTED CAPACITY Tdg
ST14
CALCULATE NUMBER n OF DEVICES TO BE ACTIVATED BASED ON OPERATING CAPACITY Td STORED IN STORAGE UNIT 124
ST15
SIMULTANEOUSLY ACTIVATE DEVICES OF NUMBER n AMONG HEAT PUMP CHILLING DEVICES 2A TO 2E

FIG. 8

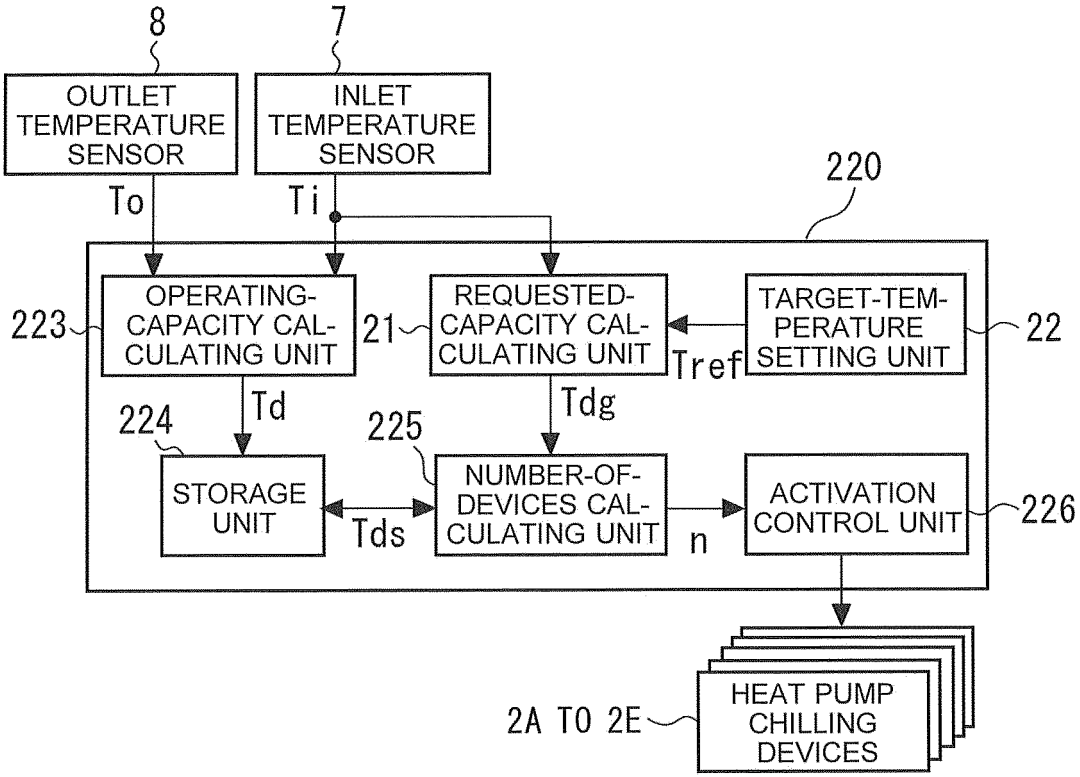

8
7
OUTLET TEMPERATURE SENSOR
INLET TEMPERATURE SENSOR
To
Ti
220
223
OPERATING-CAPACITY CALCULATING UNIT
21
REQUESTED-CAPACITY CALCULATING UNIT
Tref
TARGET-TEMPERATURE SETTING UNIT
22
Td
Tdg
224
225
STORAGE UNIT
Tds
NUMBER-OF-DEVICES CALCULATING UNIT
n
ACTIVATION CONTROL UNIT
226
2A TO 2E
HEAT PUMP CHILLING DEVICES

FIG. 9

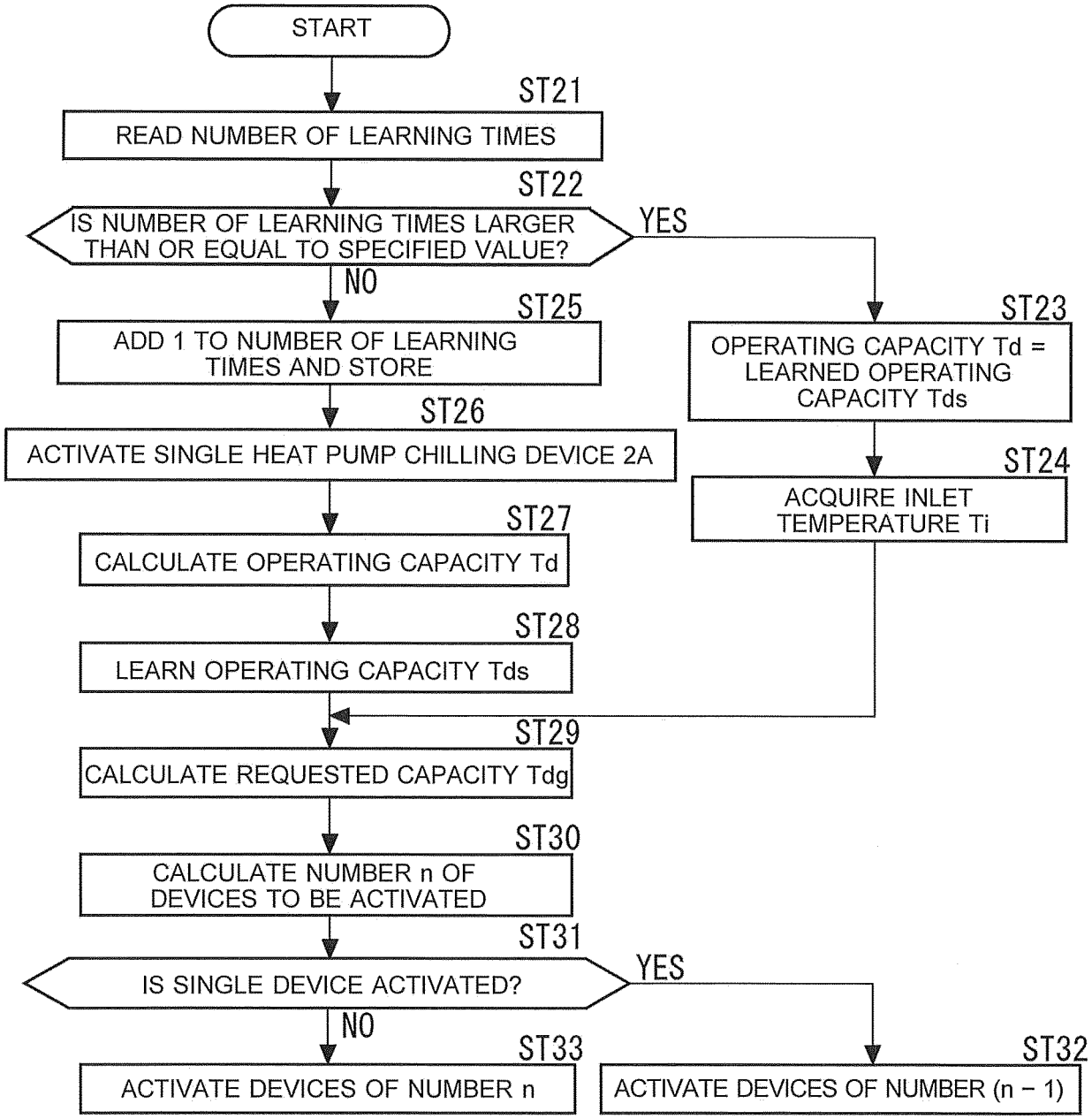

START
ST21
READ NUMBER OF LEARNING TIMES
ST22
IS NUMBER OF LEARNING TIMES LARGER THAN OR EQUAL TO SPECIFIED VALUE?
YES
NO
ST25
ADD 1 TO NUMBER OF LEARNING TIMES AND STORE
ST23
OPERATING CAPACITY Td = LEARNED OPERATING CAPACITY Tds
ST26
ACTIVATE SINGLE HEAT PUMP CHILLING DEVICE 2A
ST24
ACQUIRE INLET TEMPERATURE Ti
ST27
CALCULATE OPERATING CAPACITY Td
ST28
LEARN OPERATING CAPACITY Tds
ST29
CALCULATE REQUESTED CAPACITY Tdg
ST30
CALCULATE NUMBER n OF DEVICES TO BE ACTIVATED
ST31
IS SINGLE DEVICE ACTIVATED?
YES
NO
ST33
ACTIVATE DEVICES OF NUMBER n
ST32
ACTIVATE DEVICES OF NUMBER (n − 1)

FIG. 10

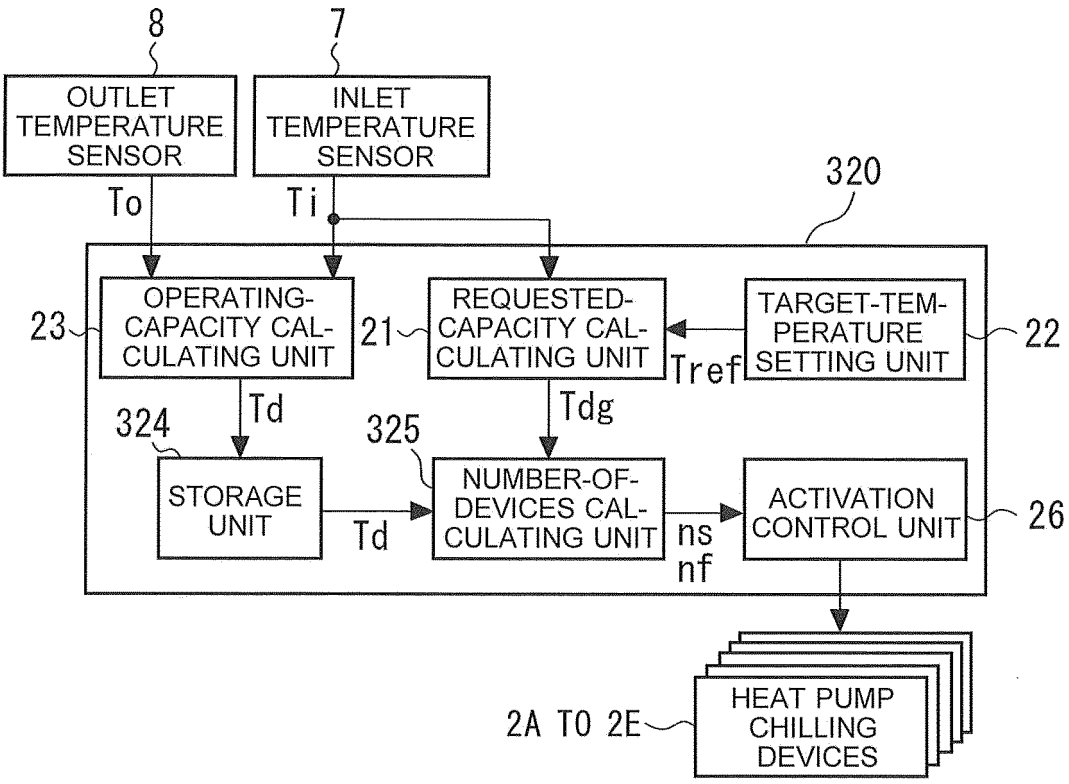
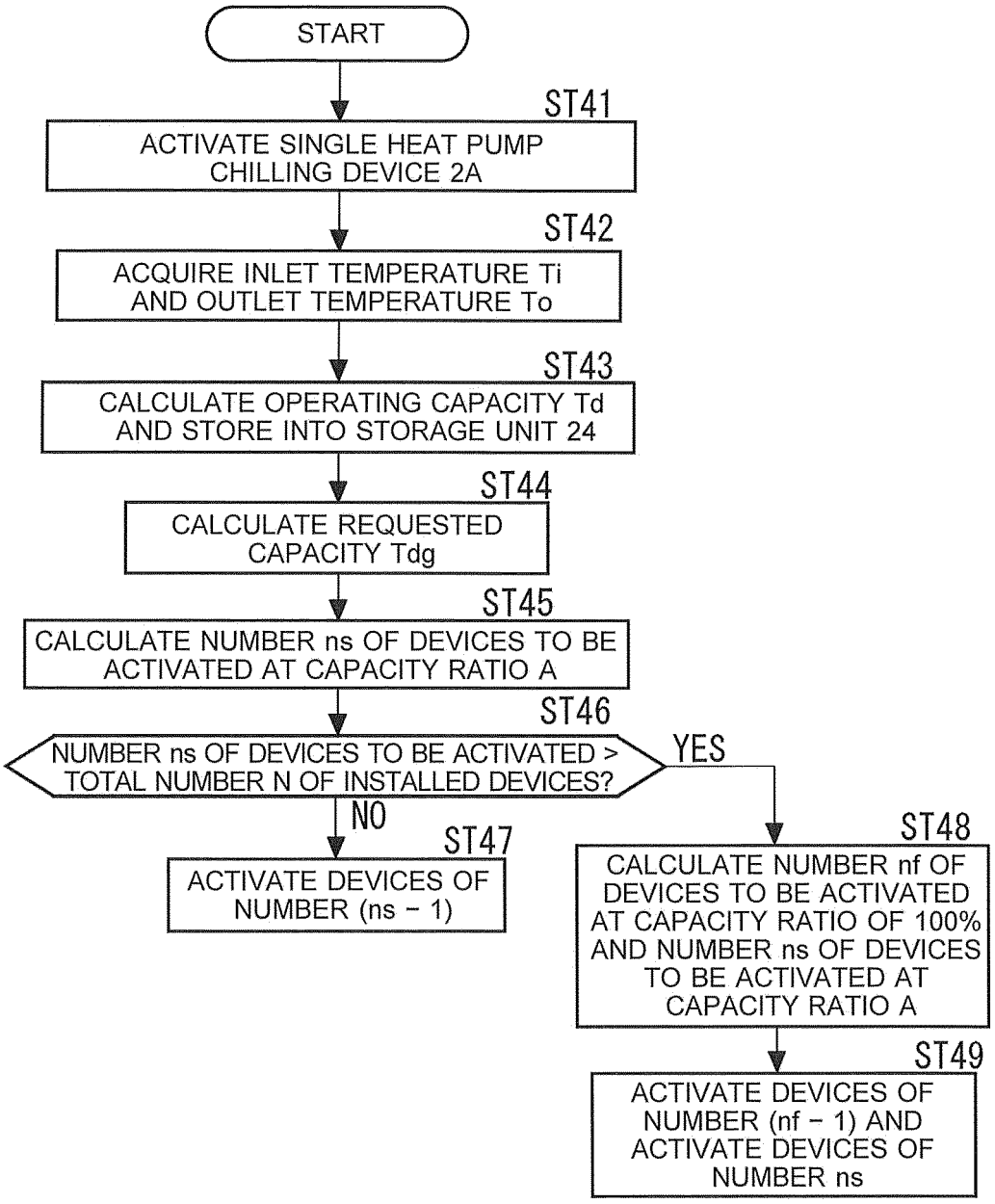

8
7
OUTLET TEMPERATURE SENSOR
INLET TEMPERATURE SENSOR
To
Ti
320
23
OPERATING-CAPACITY CALCULATING UNIT
21
REQUESTED-CAPACITY CALCULATING UNIT
TARGET-TEMPERATURE SETTING UNIT
22
Tref
Td
Tdg
324
325
STORAGE UNIT
Td
NUMBER-OF-DEVICES CALCULATING UNIT
ns
nf
ACTIVATION CONTROL UNIT
26
2A TO 2E
HEAT PUMP CHILLING DEVICES

FIG. 11


START
ST41
ACTIVATE SINGLE HEAT PUMP CHILLING DEVICE 2A
ST42
ACQUIRE INLET TEMPERATURE Ti AND OUTLET TEMPERATURE To
ST43
CALCULATE OPERATING CAPACITY Td AND STORE INTO STORAGE UNIT 24
ST44
CALCULATE REQUESTED CAPACITY Tdg
ST45
CALCULATE NUMBER ns OF DEVICES TO BE ACTIVATED AT CAPACITY RATIO A
ST46
NUMBER ns OF DEVICES TO BE ACTIVATED > TOTAL NUMBER N OF INSTALLED DEVICES?
YES
NO
ST47
ACTIVATE DEVICES OF NUMBER (ns − 1)
ST48
CALCULATE NUMBER nf OF DEVICES TO BE ACTIVATED AT CAPACITY RATIO OF 100% AND NUMBER ns OF DEVICES TO BE ACTIVATED AT CAPACITY RATIO A
ST49
ACTIVATE DEVICES OF NUMBER (nf − 1) AND ACTIVATE DEVICES OF NUMBER ns

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/061795

A. CLASSIFICATION OF SUBJECT MATTER
F24H1/00(2006.01)i, *F25B1/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24H1/00, F25B1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2010-216684 A (Toshiba Carrier Corp.), 30 September 2010 (30.09.2010), paragraphs [0008] to [0016]; fig. 1 to 3 (Family: none)	1,2,10,12
Y	JP 2010-236825 A (Daikin Industries, Ltd.), 21 October 2010 (21.10.2010), paragraphs [0057] to [0062] (Family: none)	1,2,10,12
A	JP 2009-243758 A (Noritz Corp.), 22 October 2009 (22.10.2009), paragraph [0031] (Family: none)	3-9,11

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
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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	Date of mailing of the international search report
11 July, 2014 (11.07.14)	22 July, 2014 (22.07.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/061795

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-309428 A (Mitsubishi Heavy Industries, Ltd.), 25 December 2008 (25.12.2008), paragraph [0088] (Family: none)	3-9,11
A	JP 7-83506 A (Gastar Co., Ltd.), 28 March 1995 (28.03.1995), paragraphs [0015] to [0031]; fig. 1 (Family: none)	3-9,11

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4257596 B **[0003]**
- JP 2012127633 A **[0003]**