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(54) **HEAT PUMP CHILLING SYSTEM AND CONTROL METHOD THEREFOR**

WÄRMEPUMPENKÜHLSYSTEM UND STEUERUNGSVERFAHREN DAFÜR

SYSTÈME DE REFRROIDISSEMENT DE POMPE À CHALEUR ET PROCÉDÉ DE COMMANDE ASSOCIÉ

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Description

Summary of Invention

Technical Field

Technical Problem

[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])

[0004] JP2010/216684 discloses a hot water supply system.

[0005] Document US2011315093A1 discloses a heat pump chilling system according to the preamble of claim 1.

[0006] 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.

[0007] 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

[0008] A heat pump chilling system and a method of controlling a heat pump chilling system according to the present invention are set forth in claim 1 and in claim 10.

Advantageous Effects of Invention

[0009] 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

[0010]

[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.

[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.

[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.

[0011] Heat pump chilling systems illustrated in Fig. 6, Fig. 7, Fig. 8, Fig. 9 and described in the corresponding parts of the description do not fall under the scope of the claims.

Embodiment 1

[0012] A heat pump chilling system according to an embodiment of 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 anti-freeze 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.

[0013] 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.

[0014] 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.

[0015] 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.

[0016] Furthermore, the heat pump chilling system 1 includes an inlet temperature sensor 7 that detects the temperature of water, as an inlet temperature T_i , 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 T_o , 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 T_i , and the outlet temperature sensor 8 detects the temperature of the heat medium flowing out from the load 3 as the outlet temperature T_o .

[0017] 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 T_i and the outlet temperature T_o . 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.

[0018] 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.

[0019] The requested-capacity calculating unit 21 calculates a requested capacity T_{dg} based on a target temperature T_{ref} and the inlet temperature T_i . In detail, the requested-capacity calculating unit 21 calculates an absolute value of a difference between the target temperature T_{ref} and the inlet temperature T_i as the requested capacity T_{dg} . The target temperature T_{ref} is set in the target-temperature setting unit 22. For example, the target-temperature setting unit 22 may acquire the target temperature T_{ref} from an information input unit, such as a keyboard and a touchscreen, or may have the target temperature T_{ref} stored in advance.

[0020] 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 T_i and the outlet temperature T_o 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 T_d , 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 T_d of the heat pump chilling device 2A activated alone at the start of operation and stores the calculated operating capacity T_d of the heat pump chilling device 2A as the operating capacity T_d 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 $|T_i - T_o|$ of a temperature difference between the inlet temperature T_i and the outlet temperature T_o as the operating capacity T_d 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 T_d 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.

[0021] Based on the operating capacity T_d 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 T_{dg} 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 (T_{dg}/T_d) in which the requested capacity (target temperature difference) T_{dg} is divided by the operating capacity (temperature difference) T_d . Thus, in a case where the operating capacity T_d satisfies the requested capacity T_{dg} ($T_{dg} \leq T_d$), 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 T_d is deficient for the requested capacity T_{dg} ($T_{dg} > T_d$), 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.

[0022] 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.

[0023] Thus, control can be performed so that the operating capacity T_d of the entire system is increased if the operating capacity T_d is deficient for the requested capacity T_{dg} and that the operating capacity T_d is decreased if the operating capacity T_d exceeds the requested capacity T_{dg} . If the operating capacity T_d is deficient

for the requested capacity T_{dg} , 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.

[0024] 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 T_i detected in the inlet temperature sensor 7 and the outlet temperature T_o detected in the outlet temperature sensor 8 are acquired and are stored into the storage unit 24 (step ST2).

[0025] Subsequently, based on the inlet temperature T_i and the outlet temperature T_o , 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 T_d . Then, this operating capacity T_d is stored as the operating capacity T_d of each of the plurality of heat pump chilling devices 2A to 2E into the storage unit 24 (step ST3).

[0026] Then, the temperature difference between the target temperature T_{ref} and the inlet temperature T_i is calculated as the requested capacity T_{dg} in the requested-capacity calculating unit 21 and is stored into the storage unit 24 (step ST4). The calculation of the operating capacity T_d (step ST3) and the calculation of the requested capacity T_{dg} (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 T_d and the requested capacity T_{dg} 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).

[0027] 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 T_{dg} can be activated.

[0028] 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 t_w (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 t_s (e.g., about three minutes) required for the activation. Thus, the heat pump chilling devices 2A to 2E require a time period of $(t_w + t_s)$ from the start of activation to the start of operation.

[0029] 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 t_w 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 T_{dg} is obtained, start operating is a fixed time period $(t_w + 2t_s)$ obtained by adding the time period $(t_w + t_s)$ from the start of activation to the start of operation of the single heat pump chilling device 2A to the time period t_w taken until the second device and onward start operating.

[0030] 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 t_d (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 $(t_s + t_w)$. However, since the second device and onward are sequentially activated, a time period of $(t_s + t_w + (n - 1) \times t_d)$ 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 T_{dg} can be activated within a short period of time.

[0031] In particular, to calculate the operating capacity T_d of each of the plurality of heat pump chilling devices 2B to 2E from the operating capacity T_d 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 T_d in actual operation, the number n of devices to be activated satisfying the requested capacity T_{dg} 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 T_d 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 T_d may sometimes deviate from the operating capacity T_d stored in the storage unit 24. In contrast, in the heat pump chilling system 1, the operating capacity T_d 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 T_d corresponding to the load 3 can be calculated with high accuracy.

[0032] Fig. 6 is a block diagram illustrating a system control device in a heat pump chilling system. 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, sections having configurations identical to those in the system control device 20 are given the same reference signs, and descriptions thereof will be omitted. The system control device 120 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.

[0033] In the system control device 120 in Fig. 6, the storage unit 24 stores the operating capacity T_d for each of the plurality of heat pump chilling devices 2A to 2E. Similar to Embodiment 1, the operating capacities T_d stored in the storage unit 24 are stored when, for example, the heat pump chilling device 2A is activated alone. Alternatively, the operating capacities T_d may be stored in the storage unit 24 at the time of shipment.

[0034] 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 T_{dg} calculated by the requested-capacity calculating unit 21 by using a ceiling function (T_{dg}/T_d). 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.

[0035] 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) T_d 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 T_i is acquired from the inlet temperature sensor 7 and is stored into the storage unit 24 (step ST12).

[0036] Subsequently, the requested capacity T_{dg} is calculated from the target temperature T_{ref} set in the target-temperature setting unit 22 and the acquired inlet temperature T_i 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 T_d of the plurality of heat pump chilling devices 2A to 2E and the requested capacity T_{dg} (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).

[0037] According to the system described above, the number n of devices to be activated among the heat pump chilling devices 2A to 2E required for the requested capacity T_{dg} is calculated based on the operating capacities T_d 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 T_{dg} can be activated, as in Embodiment 1.

[0038] Fig. 8 is a block diagram illustrating a system control device in a heat pump chilling system. 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, 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 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.

[0039] The operating-capacity calculating unit 223 in Fig. 8 calculates the operating capacity T_d 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 T_{ds} 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 T_{ds} stored in the storage unit 224.

[0040] If the number of learning times has not reached the specified value, the operating-capacity calculating unit 223 optimizes the operating capacity T_{ds} stored in the storage unit 224. The operating-capacity calculating unit 223 calculates the operating capacity T_d of the heat pump chilling device 2A activated alone at the start of operation and stores the operating capacity T_d into the storage unit 24. An average value of operating capacities T_d 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 T_d is incorporated, and the optimized operating capacity T_{ds} stored in the storage unit 224 is updated.

[0041] 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 T_{dg} at the start of operation. 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 T_d 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 T_{dg} .

[0042] 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 T_{ds} stored in the storage unit 224 is used as the operating capacity T_d of each of the heat pump chilling devices 2A to 2E (step ST23). Subsequently, the inlet temperature sensor 7 detects the inlet temperature T_i (step ST24).

[0043] 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 T_i (step ST27). Subsequently, the absolute value of the temperature difference between the inlet temperature T_i and the outlet temperature T_o is calculated as an operating capacity T_d , and an average value of operating capacities T_d corresponding to the number of learning times is stored as the optimized operating capacity T_{ds} into the storage unit 224 (step ST28).

[0044] Then, the requested capacity T_{dg} 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 T_{ds} 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 T_{ds} has

been learned.

[0045] If the single heat pump chilling device 2A is already activated alone (if the operating capacity T_{ds} 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).

[0046] The operating capacity (temperature difference) T_d 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 T_{ds} is stored in the storage unit 24, a difference from the actual operating capacity T_d 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 T_{dg} can be activated, as in Embodiment 1.

Embodiment 4

[0047] 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 n_s of devices to be activated and the number n_f of devices to be activated are calculated in consideration of the energy efficiency of each of the heat pump chilling devices 2A to 2E.

[0048] 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 n_s of devices to be activated in consideration of the capacity ratio A . In detail, the number-of-devices calculating unit 325 calculates the number n_s 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 ($T_{dg}/(T_d \times A)$). 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%.

[0049] Because the heat pump chilling devices 2B to 2E operate with restricted capacities, the number n_s of devices to be activated to be calculated tends to be large. If the calculated number n_s 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 n_f 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 n_s 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 T_{dg} is satisfied.

[0050] In detail, the number-of-devices calculating unit 325 calculates a ceiling function $((T_{dg} - (N \times T_d \times A)) / ((1 - A) \times T_d))$ as the number n_f of devices to be activated at a capacity ratio of 100%. Subsequently, the number-of-devices calculating unit 325 calculates the number $(n_s = N - n_f)$ 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 n_s at the capacity ratio of 100% and to activate the devices of the number n_f at the capacity ratio A among the total number N of installed devices.

[0051] 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 T_i and the outlet temperature T_o 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 T_d of the single heat pump chilling device 2A based on the inlet temperature T_i and the outlet temperature T_o 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 T_d into the storage unit 24 (step ST43).

[0052] Then, the requested capacity (target temperature difference) T_{dg} is calculated by the requested-capacity calculating unit 21 based on the target temperature T_{ref} set in the target-temperature setting unit 22 and the inlet temperature T_i and is stored into the storage unit 24 (step ST44). The number-of-devices calculating unit 325 calculates the number n_s 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).

[0053] If the number n_s 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 n_s of devices to be activated at the capacity ratio A exceeds the total number N of installed devices ($n_s > N$), the number n_f 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 n_s 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 $(n_f - 1)$, 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 n_s among the heat pump chilling devices 2B to 2E are activated at the capacity ratio A (step ST49).

[0054] 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 T_{dg} can be activated within a short period of time, as in Embodiment 1.

[0055] 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 T_{dg} . Furthermore, the requested capacity stored in the storage unit 24 may be optimized.

[0056] 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 T_{ref} and the inlet temperature T_i as the requested capacity T_{dg} , the requested-capacity calculating unit 21 may calculate an absolute value $|T_{ref} - T_o|$ of a difference between the target temperature T_{ref} and the outlet temperature T_o as the requested capacity T_{dg} . In this case, if the single heat pump chilling device 2A is activated alone at the start of operation, which is not covered by the invention as defined in the claims, the requested capacity T_{dg} being a positive value implies shortage, whereas a negative value implies that the requested capacity T_{dg} 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 T_{dg} . 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 T_i and the outlet temperature T_o are the same value.

[0057] Furthermore, although the same operating capacities T_d 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 T_d . However, such a configuration does not fall under the scope of the claims. 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.

[0058] Furthermore, as an example, a case where the activation control unit 26 activates the heat pump chilling device 2A and the operation capacity T_d 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 T_d thereof may be calculated and stored into the storage unit 24.

Reference Signs List

[0059] 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 , n_f , n_s number of devices to be activated N total number of installed devices T_d operating capacity T_{dg} requested capacity T_d s optimized operating capacity T_i inlet temperature T_o outlet temperature T_{ref} target temperature

Claims

1. A heat pump chilling system in which a plurality of heat pump chilling devices (2A to 2E) provided with refrigeration cycles through which refrigerant flows are connected in parallel with a load (3) and in which a heat medium having exchanged heat with the refrigerant in the plurality of heat pump chilling devices (2A to 2E) circulates to the load (3), wherein the plurality of heat pump chilling devices (2A to 2E) are configured to have the same operating capacities, the heat pump chilling system comprising:

an inlet temperature sensor (7) detecting a temperature of the heat medium flowing into the plurality of heat pump chilling devices (2A to 2E) from the load (3) as an inlet temperature (T_i);
an outlet temperature sensor (8) detecting a temperature of the heat medium flowing into the load (3) from the plurality of heat pump chilling devices (2A to 2E) as an outlet temperature (T_o);
and

a system control device (20) configured to control operation of the plurality of heat pump chilling devices (2A to 2E) based on the inlet temperature (T_i) detected in the inlet temperature sensor (7) and the outlet temperature (T_o) detected in the outlet temperature sensor (8), **characterized by**

the system control device (20) including
a storage unit (24) configured to store an operating capacity (T_d) for each of the plurality of heat pump chilling devices (2A to 2E),
a requested-capacity calculating unit (21) configured to calculate a requested capacity (T_{dg}) based on the inlet temperature (T_i) or the outlet temperature (T_o) and a set target temperature (T_{ref}),
a number-of-devices calculating unit (25) configured to calculate the number of devices to be activated among the plurality of heat pump chilling devices (2A to 2E) satisfying the requested capacity (T_{dg}) calculated by the requested-capacity calculating unit (21) based on the operating capacity (T_d) stored in the storage unit (24) for each of the plurality of heat pump chilling devices (2A to 2E),
an activation control unit (26) 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 (25) by activating a single one of the plurality of heat pump chilling devices alone at a start of operation and then simultaneously activating 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 (25), and
an operating-capacity calculating unit (23) configured to calculate the operating capacity (T_d) of the single activated heat pump chilling device based on the inlet temperature (T_i) and the outlet temperature (T_o) after the single heat pump chilling device is activated, and store the calculated operating capacity (T_d) into the storage unit (24) as the operating capacity (T_d) of each of the plurality of heat pump chilling devices (2A to 2E).

2. The heat pump chilling system of claim 1, wherein, after the single heat pump chilling device is activated, the activation control unit (26) 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 (T_{dg}) calculated by the requested-capacity calculating unit (21).
3. The heat pump chilling system of any one of claims 1 or 2, wherein the activation control unit (26) is con-

figured to activate the single heat pump chilling device with a maximum operating capacity.

4. The heat pump chilling system of any one of claims 1 to 3, wherein the operating-capacity calculating unit (23) is configured to calculate a difference between the inlet temperature (T_i) and the outlet temperature (T_o) as the operating capacity (T_d) of the single heat pump chilling device.

5. The heat pump chilling system of any one of claims 1 to 4, wherein, based on a plurality of the operating capacities, the operating-capacity calculating unit (223) is configured to optimize the operating capacity stored in the storage unit (224), each of the plurality of the operating capacities being calculated every time the single heat pump chilling device is activated.

6. The heat pump chilling system of claim 5,

wherein the storage unit (224) is configured to store the number of times the operating capacity stored in the storage unit (224) 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 (223) is configured to optimize the operating capacity.

7. The heat pump chilling system of claim 6,

wherein when the number of learning times is smaller than or equal to the preset specified number, the activation control unit (26) 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 (25) 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 (26) 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 (25) at the start of operation based on the optimized operating capacity.

8. The heat pump chilling system of any one of claims 1 to 7, wherein the number-of-devices calculating unit (25) is configured to calculate the number of devices to be activated in a case where the plurality of heat pump chilling devices (2A to 2E) operate at a preset capacity ratio (A) being lower than a maximum

operating capacity.

9. The heat pump chilling system of claim 8, wherein when the calculated number of devices to be activated when the operation is performed at the capacity ratio (A) is larger than the total number of installed devices among the plurality of heat pump chilling devices (2A to 2E), the number-of-devices calculating unit (25) is configured to calculate a combination of the number of devices among the plurality of heat pump chilling devices (2A to 2E) to be operated with the maximum operating capacity and the number of devices to be activated among the plurality of heat pump chilling devices (2A to 2E) to be operated at the preset capacity ratio (A) so that the requested capacity (T_{dg}) is satisfied.

10. A method of controlling a heat pump chilling system in which a plurality of heat pump chilling devices (2A to 2E) provided with refrigeration cycles through which refrigerant flows are connected in parallel with a load (3) so that a heat medium circulates to the load (3) and in which the plurality of heat pump chilling devices (2A to 2E) cause the refrigerant and the heat medium to exchange heat with each other, wherein the plurality of heat pump chilling devices (2A to 2E) are configured to have the same operating capacities, the method comprising:

calculating a requested capacity (T_{dg}) based on an inlet temperature (T_i) of flow from the load (3) to the plurality of heat pump chilling devices (2A to 2E), an outlet temperature (T_o) of flow from the plurality of heat pump chilling devices (2A to 2E) to the load (3), and a set target temperature (T_{ref}); **characterized by**

calculating the number of devices to be activated among the plurality of heat pump chilling devices (2A to 2E) with which the calculated requested capacity (T_{dg}) is obtained based on an operating capacity stored in a storage unit (24) for each of the plurality of heat pump chilling devices (2A to 2E);

activating the plurality of heat pump chilling devices (2A to 2E) of the calculated number of devices (2A to 2E) to be activated by activating a single one of the plurality of heat pump chilling devices (2A) alone at a start of operation and then simultaneously activating zero or more of the plurality of heat pump chilling devices (2B to 2E) of the remaining number of the number of devices to be activated calculated in the step of calculating the number of devices to be activated;

calculating the operating capacity (T_d) of the single activated heat pump chilling device (2A) based on the inlet temperature (T_i) and the outlet temperature (T_o) after the single heat pump

chilling device (2A) is activated; and
storing the calculated operating capacity (Td) in-
to the storage unit (24) as the operating capacity
(Td) of each of the plurality of heat pump chilling
devices (2A to 2E).

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Patentansprüche

1. Wärmepumpen-Kühlsystem, in dem eine Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E), die mit Kältekreisläufen, durch die Kühlmittel strömt, bereitgestellt sind, einer Last (3) parallel geschaltet ist und in dem ein Wärmemedium, das mit dem Kühlmittel in der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) Wärme ausgetauscht hat, zu der Last (3) zirkuliert, wobei die Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) ausgelegt ist, um die gleichen Betriebskapazitäten aufzuweisen, wobei das Wärmepumpen-Kühlsystem Folgendes umfasst:

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einen Einlasstemperatursensor (7), der eine Temperatur des Wärmemediums, das aus der Last (3) in die Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) einströmt, als Einlasstemperatur (Ti) detektiert;

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einen Auslasstemperatursensor (8), der eine Temperatur der Wärmemediums, das aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) in die Last (3) einströmt, als Auslasstemperatur (To) detektiert; und

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eine Systemsteuervorrichtung (20), die ausgelegt ist, um den Betrieb der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) basierend auf der in dem Einlasstemperatursensor (7) detektierten Einlasstemperatur (Ti) und der in dem Auslasstemperatursensor (8) detektierten Auslasstemperatur (To) zu steuern, **dadurch gekennzeichnet, dass** die Systemsteuervorrichtung (20) Folgendes umfasst

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eine Speichereinheit (24), die ausgelegt ist, um eine Betriebskapazität (Td) für jede aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) zu speichern,

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eine Angefragte-Kapazität-Berechnungseinheit (21), die ausgelegt ist, um eine angefragte Kapazität (Tdg) basierend auf der Einlasstemperatur (Ti) oder der Auslasstemperatur (To) und einer eingestellten Solltemperatur (Tref) zu berechnen,

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eine Vorrichtungsanzahl-Berechnungseinheit (25), die ausgelegt ist, um die Anzahl von zu aktivierenden Vorrichtungen aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E), die die von der Angefragte-Kapazität-Berechnungseinheit (21) berechnete angefragte

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Kapazität (Tdg) erfüllen, basierend auf der in der Speichereinheit (24) für jede aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) gespeicherten Betriebskapazität (Td) zu berechnen,

eine Aktivierungssteuereinheit (26), die ausgelegt ist, um die Vielzahl von Wärmepumpen-Kühlvorrichtungen der Anzahl von zu aktivierenden Vorrichtungen, die in der Vorrichtungsanzahl-Berechnungseinheit (25) berechnet wurde, durch Aktivieren einer einzelnen aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen zu Beginn eines Betriebsvorgangs und anschließend gleichzeitiges Aktivieren von null oder mehr aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen der restlichen Anzahl der in der Vorrichtungsanzahl-Berechnungseinheit (25) berechneten Anzahl von zu aktivierenden Vorrichtungen zu aktivieren, und

eine Betriebskapazität-Berechnungseinheit (23) die ausgelegt ist, um die Betriebskapazität (Td) der einzelnen aktivierten Wärmepumpen-Kühlvorrichtung basierend auf der Einlasstemperatur (Ti) und der Auslasstemperatur (To) zu berechnen, nachdem die einzelne Wärmepumpen-Kühlvorrichtung aktiviert wurde, und die berechnete Betriebskapazität (Td) in der Speichereinheit (24) als Betriebskapazität (Td) jeder aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) zu speichern.

2. Wärmepumpen-Kühlsystem nach Anspruch 1, wobei, nachdem die einzelne Wärmepumpen-Kühlvorrichtung aktiviert wurde, die Aktivierungssteuereinheit (26) ausgelegt ist, um die Vielzahl von Wärmepumpen-Kühlvorrichtungen der restlichen Anzahl aus der Anzahl von zu aktivierenden Vorrichtungen, die die von der Angefragte-Kapazität-Berechnungseinheit (21) berechnete angefragte Kapazität (Tdg) erreichen, gleichzeitig zu aktivieren.

3. Wärmepumpen-Kühlsystem nach Anspruch 1 oder 2, wobei die Aktivierungssteuereinheit (26) ausgelegt ist, um die einzelne Wärmepumpen-Kühlvorrichtung mit einer Höchstbetriebskapazität zu aktivieren.

4. Wärmepumpen-Kühlsystem nach einem der Ansprüche 1 bis 3, wobei die Betriebskapazität-Berechnungseinheit (23) ausgelegt ist, um eine Differenz zwischen der Einlasstemperatur (Ti) und der Auslasstemperatur (To) als Betriebskapazität (Td) der einzelnen Wärmepumpen-Kühlvorrichtung zu berechnen.

5. Wärmepumpen-Kühlsystem nach einem der Ansprüche 1 bis 4, wobei die Betriebskapazität-Berechnungseinheit (223) basierend auf einer Vielzahl von Betriebskapazitäten ausgelegt ist, um die in der

Speichereinheit (224) gespeicherte Betriebskapazität zu optimieren, wobei jede aus der Vielzahl von Betriebskapazitäten jedes Mal, dass die einzelne Wärmepumpen-Kühlvorrichtung aktiviert wird, berechnet wird.

6. Wärmepumpen-Kühlsystem nach Anspruch 5,

wobei die Speichereinheit (224) ausgelegt ist, um die Male, die die in der Speichereinheit (224) gespeicherte Betriebskapazität optimiert wurde, als Anzahl von Lernereignissen zu speichern, und

wobei, wenn die Anzahl von Lernereignissen geringer oder gleich einer voreingestellten spezifizierten Anzahl ist, die Betriebskapazität-Berechnungseinheit (223) ausgelegt ist, um die Betriebskapazität zu optimieren.

7. Wärmepumpen-Kühlsystem nach Anspruch 6,

wobei, wenn die Anzahl von Lernereignissen geringer oder gleich der voreingestellten spezifizierten Anzahl ist, die Aktivierungssteuereinheit (26) ausgelegt ist, um basierend auf der optimierten Betriebskapazität die einzelne Wärmepumpen-Kühlvorrichtung zu Beginn des Betriebs allein zu aktivieren und anschließend null oder mehr aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen der restlichen Anzahl der in der Vorrichtungszahl-Berechnungseinheit (25) berechneten Anzahl von zu aktivierenden Vorrichtungen zu aktivieren, und

wobei, wenn die Anzahl von Lernereignissen größer ist als die voreingestellte spezifizierte Anzahl, die Aktivierungssteuereinheit (26) ausgelegt ist, um basierend auf der optimierten Betriebskapazität die Vielzahl von Wärmepumpen-Kühlvorrichtungen der Anzahl von zu aktivierenden Vorrichtungen, die in der Vorrichtungszahl-Berechnungseinheit (25) berechnet wurde, zu Beginn des Betriebs zu aktivieren.

8. Wärmepumpen-Kühlsystem nach einem der Ansprüche 1 bis 7, wobei die Vorrichtungszahl-Berechnungseinheit (25) ausgelegt ist, um die Anzahl von Vorrichtungen zu berechnen, die zu aktivieren sind, wenn die Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) in einem voreingestellten Kapazitätsverhältnis (A) arbeiten, das unter einer Höchstbetriebskapazität liegt.

9. Wärmepumpen-Kühlsystem nach Anspruch 8, wobei, wenn die berechnete Anzahl von Vorrichtungen, die zu aktivieren sind, wenn der Betrieb in dem Kapazitätsverhältnis (A) durchgeführt wird, größer ist als die Gesamtanzahl installierter Vorrichtungen aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen

(2A bis 2E), die Vorrichtungszahl-Berechnungseinheit (25) ausgelegt ist, um eine Kombination der Anzahl von Vorrichtungen aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E), die mit der Höchstbetriebskapazität zu betreiben sind, und der Anzahl von zu aktivierenden Vorrichtungen aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E), die in dem voreingestellten Kapazitätsverhältnis (A) zu betreiben sind, zu berechnen, so dass die angefragte Kapazität (T_{dg}) erreicht wird.

10. Verfahren zum Steuern eines Wärmepumpen-Kühlsystems, in dem eine Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E), die mit Kältekreisläufen, durch die Kühlmittel strömt, bereitgestellt sind, mit einer Last (3) parallel geschaltet ist, so dass ein Wärmemedium zu der Last (3) zirkuliert, und in dem die Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) bewirkt, dass das Kühlmittel und das Wärmemedium Wärme miteinander austauschen, wobei die Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) ausgelegt ist, um die gleichen Betriebskapazitäten aufzuweisen, wobei das Verfahren Folgendes umfasst:

Berechnen einer angefragten Kapazität (T_{dg}) basierend auf der Einlasstemperatur (T_i) einer Strömung von der Last (3) zu der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E), der Auslasstemperatur (T_o) einer Strömung von der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) zu der Last (3) und einer eingestellten Solltemperatur (T_{ref}); **gekennzeichnet durch**

Berechnen der Anzahl von zu aktivierenden Vorrichtungen aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E), mit der die berechnete angefragte Kapazität (T_{dg}) basierend auf einer in einer Speichereinheit (24) für jede aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) gespeicherten Betriebskapazität erhalten wird;

Aktivieren der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E) der berechneten Anzahl von zu aktivierenden Vorrichtungen (2A bis 2E), durch Aktivieren einer einzelnen aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A) allein zu Beginn eines Betriebsvorgangs und anschließend gleichzeitiges Aktivieren von null oder mehr aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2B bis 2E) der restlichen Anzahl der in dem Schritt des Berechnens der Anzahl von zu aktivierenden Vorrichtungen berechneten Anzahl von zu aktivierenden Vorrichtungen, und

Berechnen der Betriebskapazität (T_d) der einzelnen aktivierten Wärmepumpen-Kühlvorrichtung (2A) basierend auf der Einlasstemperatur

(Ti) und der Auslasstemperatur (To), nachdem die einzelne Wärmepumpen-Kühlvorrichtung (2A) aktiviert wurde; und Speichern der berechneten Betriebskapazität (Td) in der Speichereinheit (24) als Betriebskapazität (Td) jeder aus der Vielzahl von Wärmepumpen-Kühlvorrichtungen (2A bis 2E).

Revendications

1. Système de refroidissement de pompe à chaleur dans lequel une pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) munis de cycles de réfrigération à travers lesquels s'écoule un réfrigérant sont connectés en parallèle à une charge (3) et dans lequel un milieu thermique ayant échangé de la chaleur avec le réfrigérant dans la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) circule vers la charge (3), dans lequel la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) sont configurés pour avoir les mêmes capacités de fonctionnement, le système de refroidissement de pompe à chaleur comprenant :

un capteur de température d'entrée (7) détectant une température du milieu thermique s'écoulant dans la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) à partir de la charge (3) en tant que température d'entrée (Ti) ;

un capteur de température de sortie (8) détectant une température du milieu thermique s'écoulant jusque dans la charge (3) à partir de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) en tant que température de sortie (To) ; et

un dispositif de commande de système (20) configuré pour commander le fonctionnement de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) sur la base de la température d'entrée (Ti) détectée dans le capteur de température d'entrée (7) et de la température de sortie (To) détectée dans le capteur de température de sortie (8), **caractérisé par** le dispositif de commande de système (20) comprenant

une unité de stockage (24) configurée pour stocker une capacité de fonctionnement (Td) pour chacun de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E),
une unité de calcul de capacité demandée (21) configurée pour calculer une capacité demandée (Tdg) sur la base de la température d'entrée (Ti) ou de la température de sortie (To) et d'une température cible définie (Tref),
une unité de calcul de nombre de dispositifs (25) configurée pour calculer le nombre de dispositifs

à activer parmi la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) satisfaisant la capacité demandée (Tdg) calculée par l'unité de calcul de capacité demandée (21) sur la base de la capacité de fonctionnement (Td) stockée dans l'unité de stockage (24) pour chacun de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E),
une unité de commande d'activation (26) configurée pour activer la pluralité de dispositifs de refroidissement de pompe à chaleur parmi le nombre de dispositifs à activer calculé dans l'unité de calcul de nombre de dispositifs (25) en activant un unique de la pluralité de dispositifs de refroidissement de pompe à chaleur seul au début du fonctionnement puis en activant simultanément zéro ou plus de la pluralité de dispositifs de refroidissement de pompe à chaleur parmi le nombre restant du nombre de dispositifs à activer calculé dans l'unité de calcul de nombre de dispositifs (25), et
une unité de calcul de capacité de fonctionnement (23) configurée pour calculer la capacité de fonctionnement (Td) du dispositif de refroidissement de pompe à chaleur activé unique sur la base de la température d'entrée (Ti) et de la température de sortie (To) après l'activation du dispositif de refroidissement de pompe à chaleur unique, et stocker la capacité de fonctionnement calculée (Td) dans l'unité de stockage (24) en tant que capacité de fonctionnement (Td) de chacun de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E).

2. Système de refroidissement de pompe à chaleur selon la revendication 1, dans lequel, après l'activation du dispositif de refroidissement de pompe à chaleur unique, l'unité de commande d'activation (26) est configurée pour activer simultanément la pluralité de dispositifs de refroidissement de pompe à chaleur du nombre restant du nombre de dispositifs à activer correspondant à la capacité demandée (Tdg) calculée par l'unité de calcul de capacité demandée (21) .

3. Système de refroidissement de pompe à chaleur selon l'une quelconque des revendications 1 ou 2, dans lequel l'unité de commande d'activation (26) est configurée pour activer le dispositif de refroidissement de pompe à chaleur unique avec une capacité de fonctionnement maximum.

4. Système de refroidissement de pompe à chaleur selon l'une quelconque des revendications 1 à 3, dans lequel l'unité de calcul de capacité de fonctionnement (23) est configurée pour calculer une différence entre la température d'entrée (Ti) et la température de sortie (To) en tant que capacité de fonctionnement (Td) du dispositif de refroidissement de pompe

à chaleur unique.

5. Système de refroidissement de pompe à chaleur selon l'une quelconque des revendications 1 à 4, dans lequel, sur la base d'une pluralité des capacités de fonctionnement, l'unité de calcul de capacité de fonctionnement (223) est configurée pour optimiser la capacité de fonctionnement stockée dans l'unité de stockage (224), chacune de la pluralité des capacités de fonctionnement étant calculée chaque fois que le dispositif de refroidissement de pompe à chaleur unique est activé.

6. Système de refroidissement de pompe à chaleur selon la revendication 5,

dans lequel l'unité de stockage (224) est configurée pour stocker le nombre de fois où la capacité de fonctionnement stockée dans l'unité de stockage (224) est optimisée en tant que nombre d'apprentissages, et dans lequel lorsque le nombre d'apprentissages est inférieur ou égal à un nombre spécifié prédéfini, l'unité de calcul de capacité de fonctionnement (223) est configurée pour optimiser la capacité de fonctionnement.

7. Système de refroidissement de pompe à chaleur selon la revendication 6,

dans lequel lorsque le nombre d'apprentissages est inférieur ou égal au nombre spécifié prédéfini, l'unité de commande d'activation (26) est configurée pour activer le dispositif de refroidissement de pompe à chaleur unique seul au début du fonctionnement puis activer zéro ou plus de la pluralité de dispositifs de refroidissement de pompe à chaleur du nombre restant du nombre de dispositifs à activer calculé dans l'unité de calcul de nombre de dispositifs (25) sur la base de la capacité de fonctionnement optimisée, et dans lequel lorsque le nombre d'apprentissages est supérieur au nombre spécifié prédéfini, l'unité de commande d'activation (26) est configurée pour activer la pluralité de dispositifs de refroidissement de pompe à chaleur du nombre de dispositifs à activer calculé dans l'unité de calcul de nombre de dispositifs (25) au début du fonctionnement sur la base de la capacité de fonctionnement optimisée.

8. Système de refroidissement de pompe à chaleur selon l'une quelconque des revendications 1 à 7, dans lequel l'unité de calcul de nombre de dispositifs (25) est configurée pour calculer le nombre de dispositifs devant être activés dans un cas où la pluralité de dispositifs de refroidissement de pompe à chaleur

(2A à 2E) fonctionnent à un rapport de capacité prédéfini (A) qui est inférieur à une capacité de fonctionnement maximum.

9. Système de refroidissement de pompe à chaleur selon la revendication 8, dans lequel lorsque le nombre calculé de dispositifs devant être activés lorsque l'opération est effectuée au rapport de capacité (A) est supérieur au nombre total de dispositifs installés parmi la pluralité de dispositifs de refroidissement par pompe à chaleur (2A à 2E), l'unité de calcul de nombre de dispositifs (25) est configurée pour calculer une combinaison du nombre de dispositifs parmi la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) devant être actionnés avec la capacité de fonctionnement maximale et du nombre de dispositifs devant être activés parmi la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) devant être actionnés au rapport de capacité prédéfini (A) de telle sorte que la capacité demandée (Tdg) soit satisfaite.

10. Procédé de commande d'un système de refroidissement de pompe à chaleur dans lequel une pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) munis de cycles de réfrigération à travers lequel du réfrigérant s'écoule sont connectés en parallèle à une charge (3) de sorte qu'un milieu thermique circule vers la charge (3) et dans lequel la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) amènent le réfrigérant et le milieu thermique à échanger de la chaleur l'un avec l'autre, dans lequel la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) sont configurés pour avoir les mêmes capacités de fonctionnement, le procédé comprenant les étapes consistant à :

calculer une capacité demandée (Tdg) sur la base d'une température d'entrée (Ti) de l'écoulement à partir de la charge (3) vers la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E), une température de sortie (To) de l'écoulement à partir de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) vers la charge (3), et une température cible définie (Tref) ;

caractérisé par les étapes consistant à calculer le nombre de dispositifs devant être activés parmi la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) avec lequel la capacité demandée calculée (Tdg) est obtenue sur la base d'une capacité de fonctionnement stockée dans une unité de stockage (24) pour chacun de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) ; activer la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E) du nombre calculé de dispositifs (2A à 2E) devant être ac-

tivés en activant un unique de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A) seul au début du fonctionnement, puis activer simultanément zéro ou plus de la pluralité de dispositifs de refroidissement de pompe à chaleur (2B à 2E) du nombre restant du nombre de dispositifs devant être activés calculé dans l'étape de calcul du nombre de dispositifs devant être activés ; 5

calculer la capacité de fonctionnement (Td) du dispositif de refroidissement de pompe à chaleur activé unique (2A) sur la base de la température d'entrée (Ti) et de la température de sortie (To) après que le dispositif de refroidissement de pompe à chaleur activé unique (2A) ait été activé ; et 10

stocker la capacité de fonctionnement calculée (Td) dans l'unité de stockage (24) en tant que capacité de fonctionnement (Td) de chacun de la pluralité de dispositifs de refroidissement de pompe à chaleur (2A à 2E). 15 20

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FIG. 1

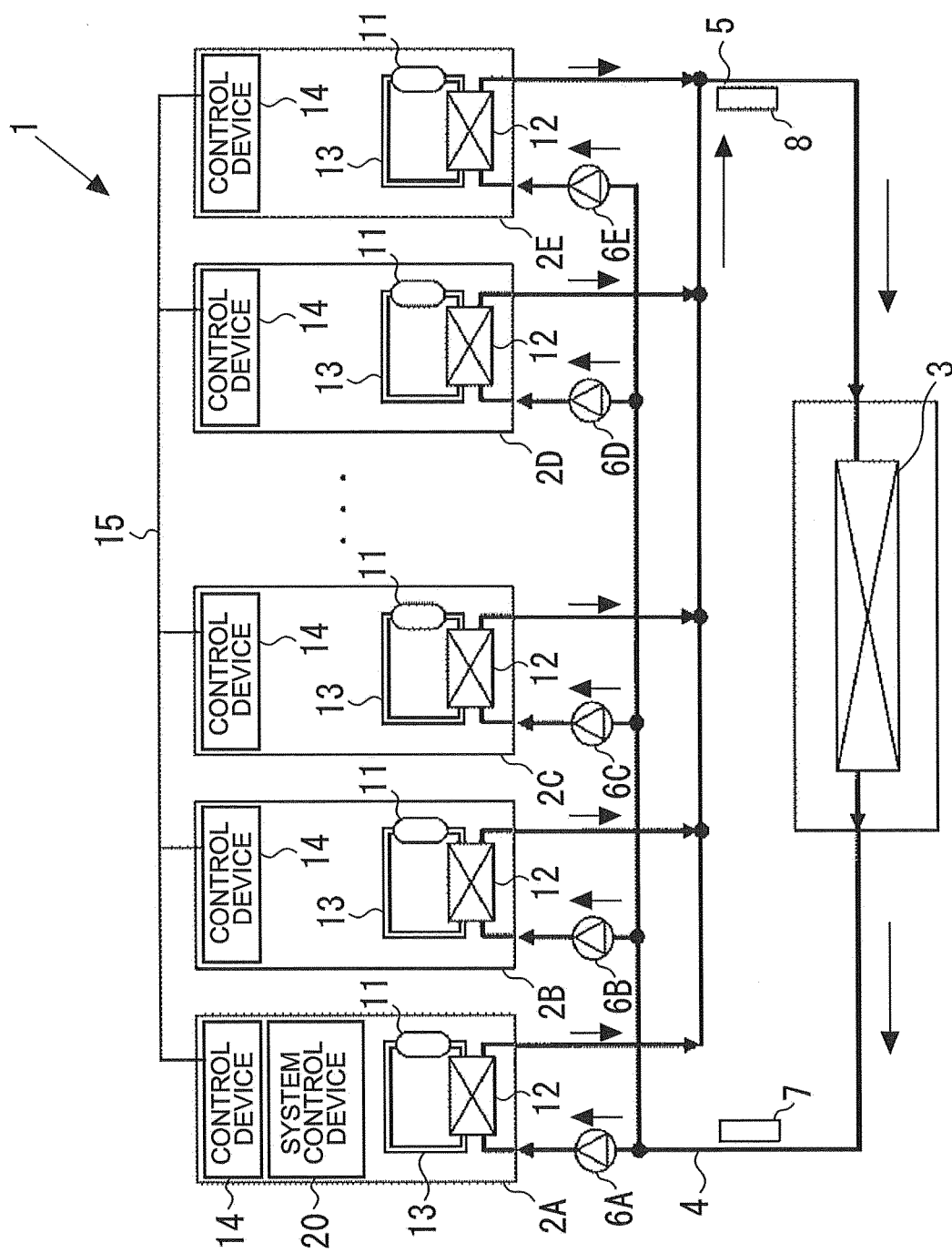


FIG. 2

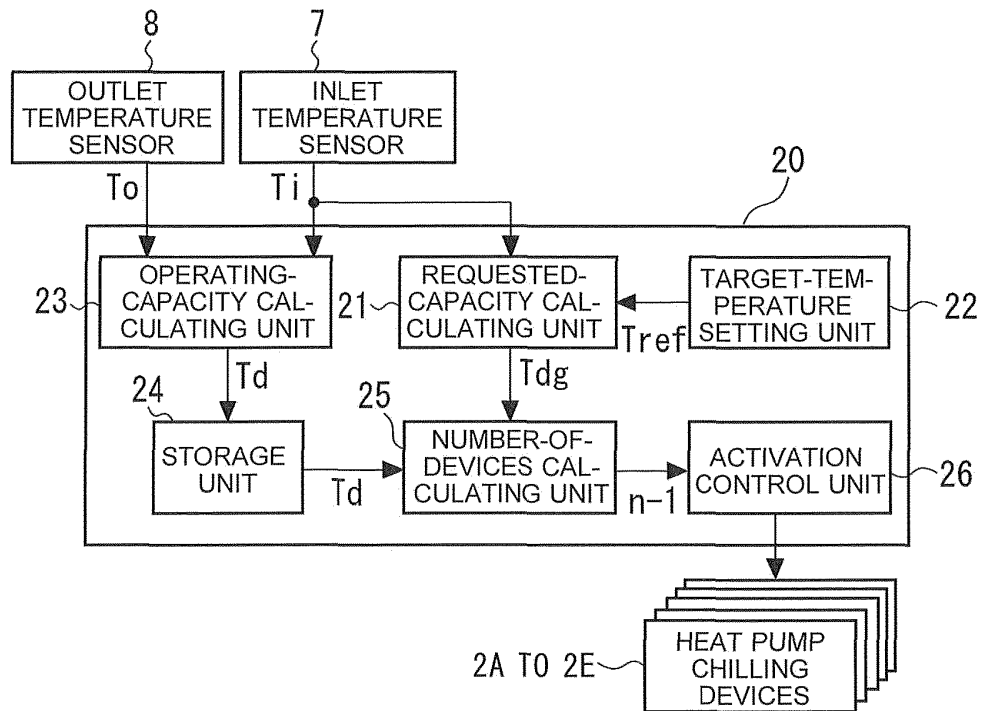


FIG. 3

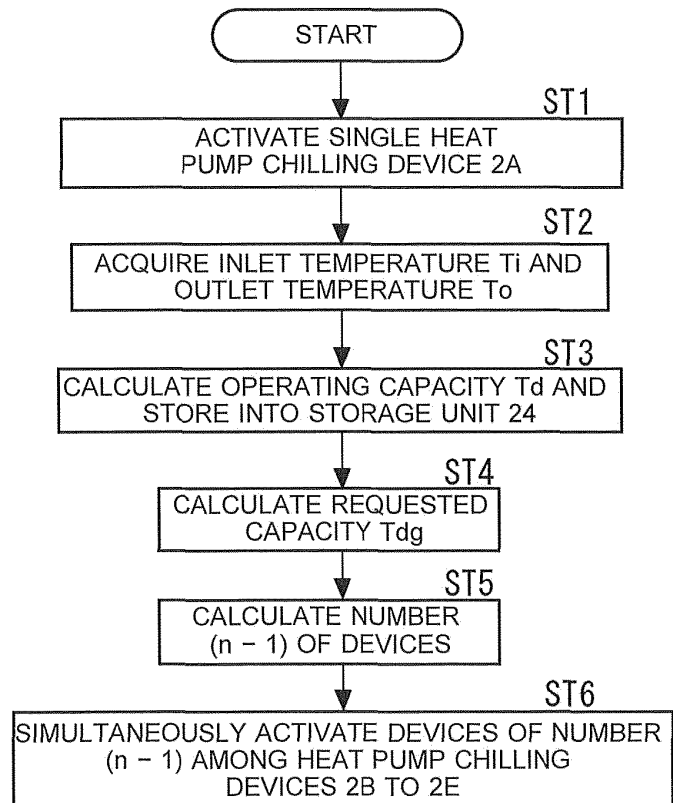


FIG. 4

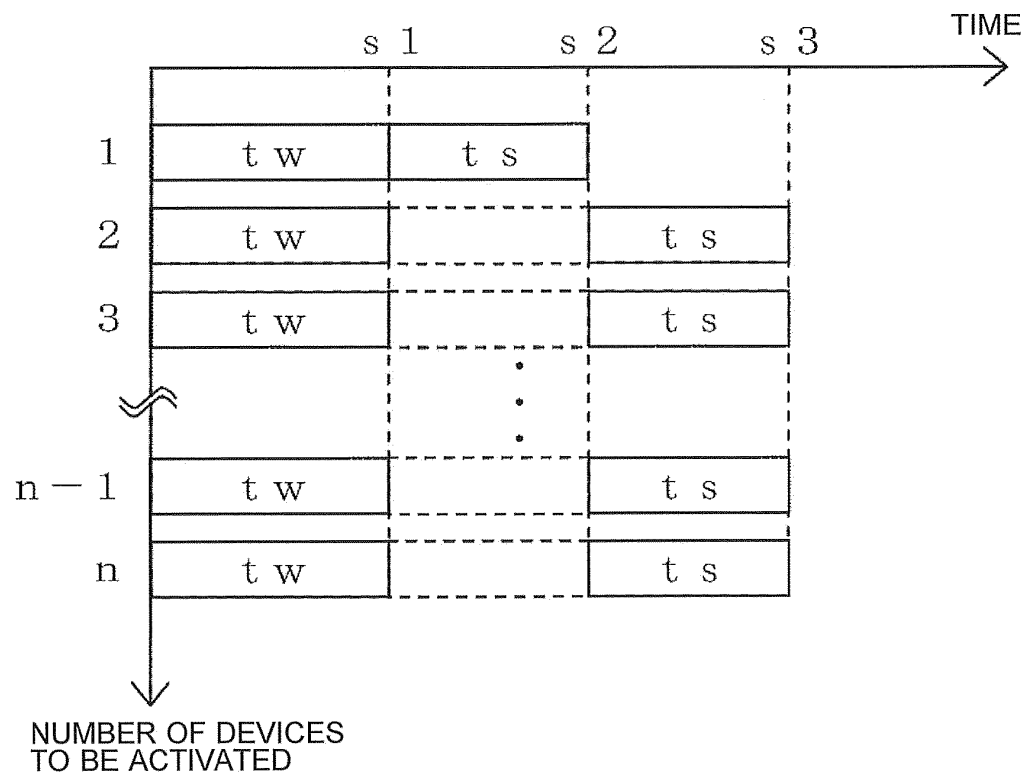


FIG. 5

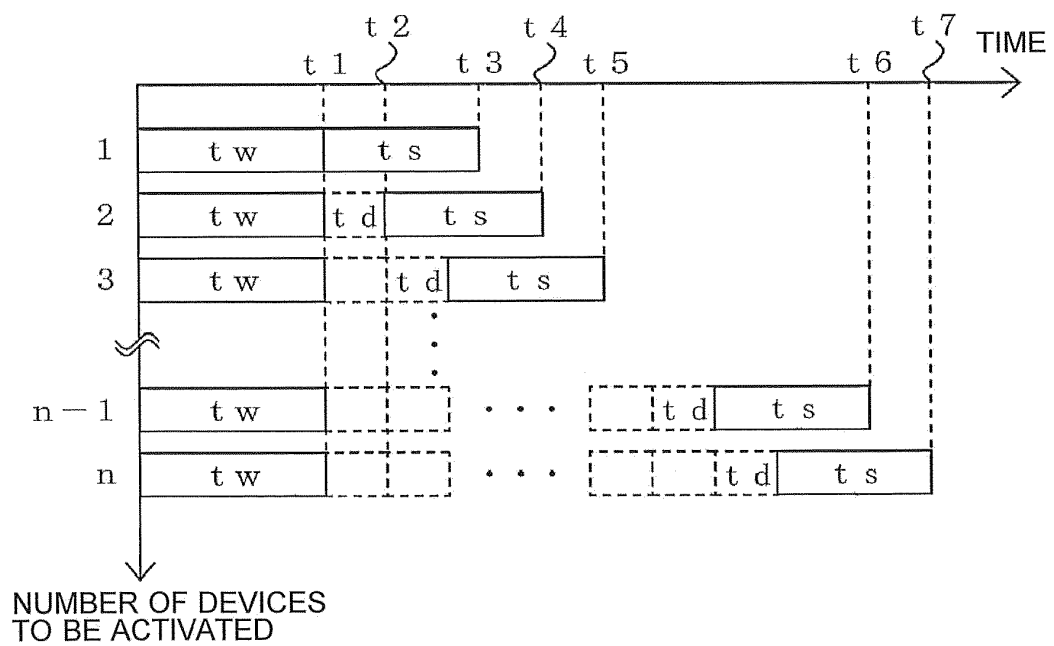


FIG. 6

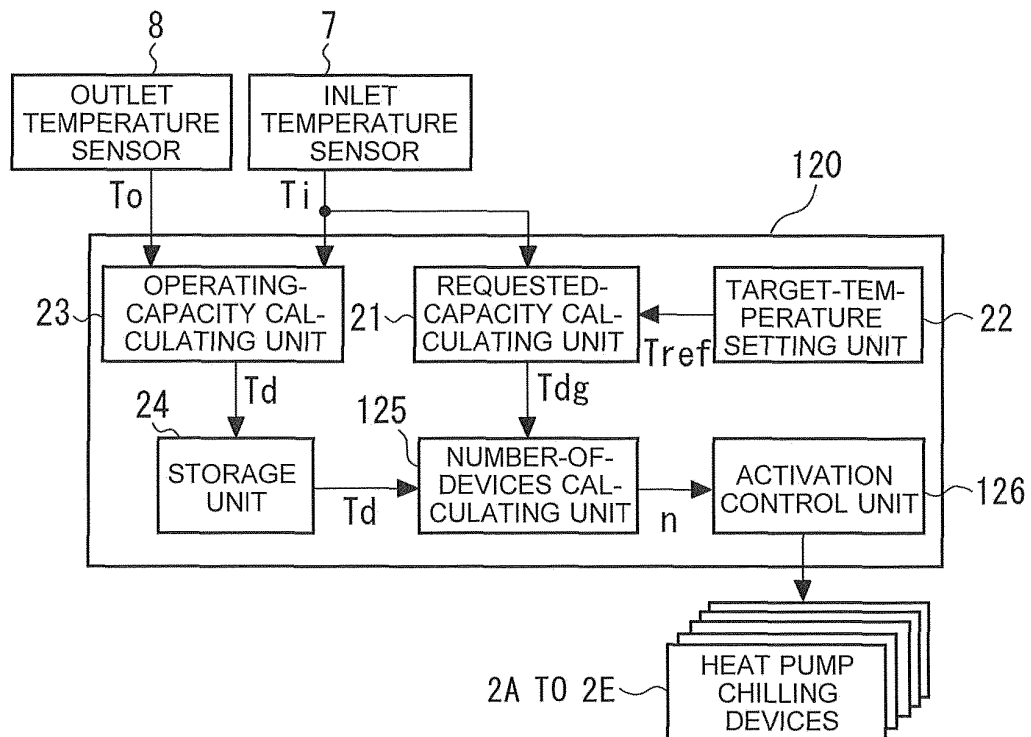


FIG. 7

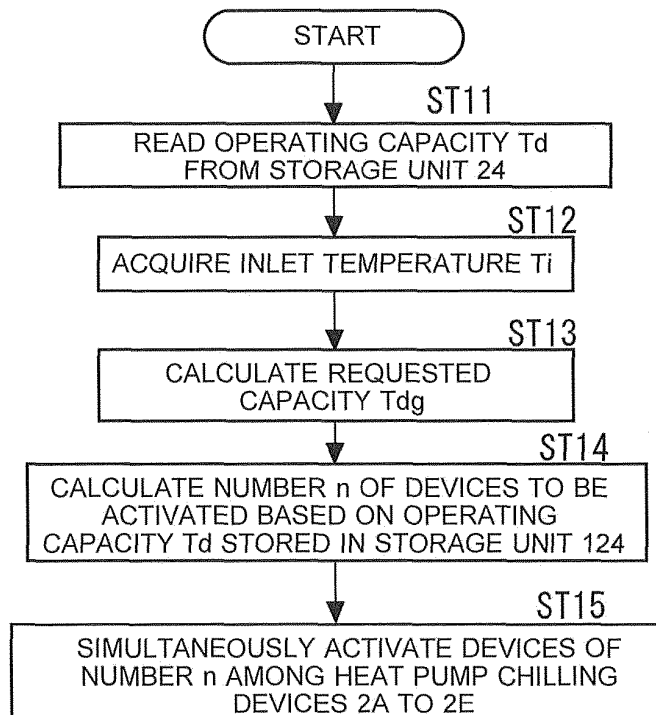


FIG. 8

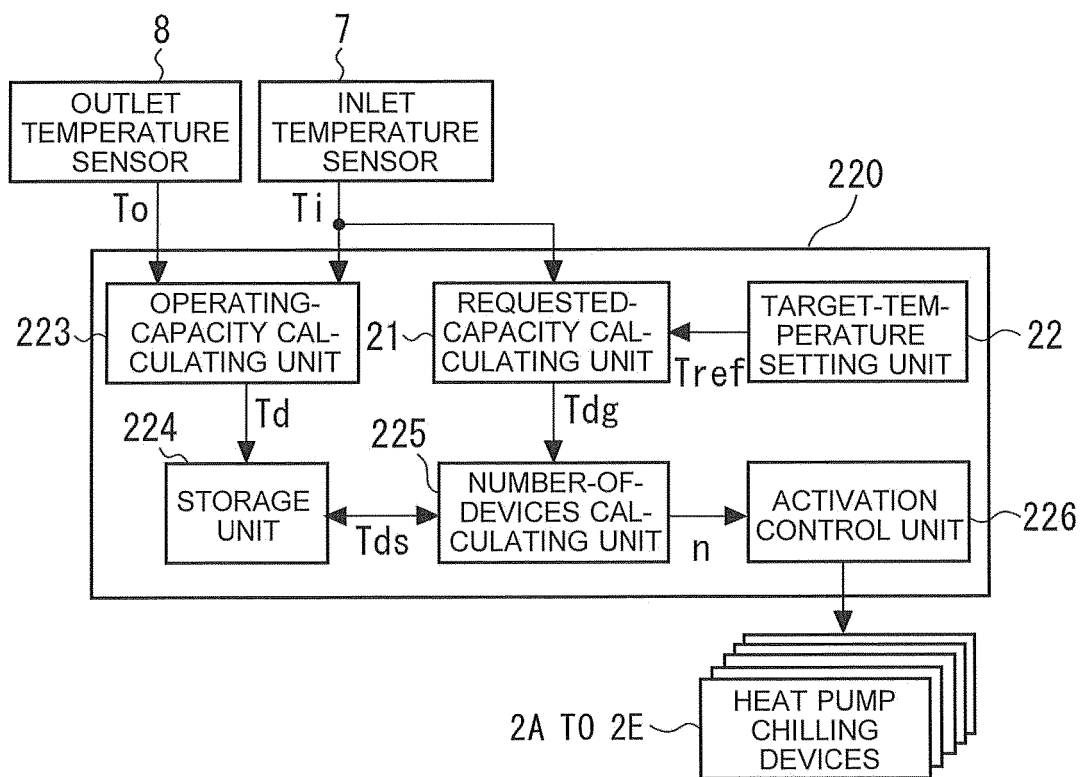


FIG. 9

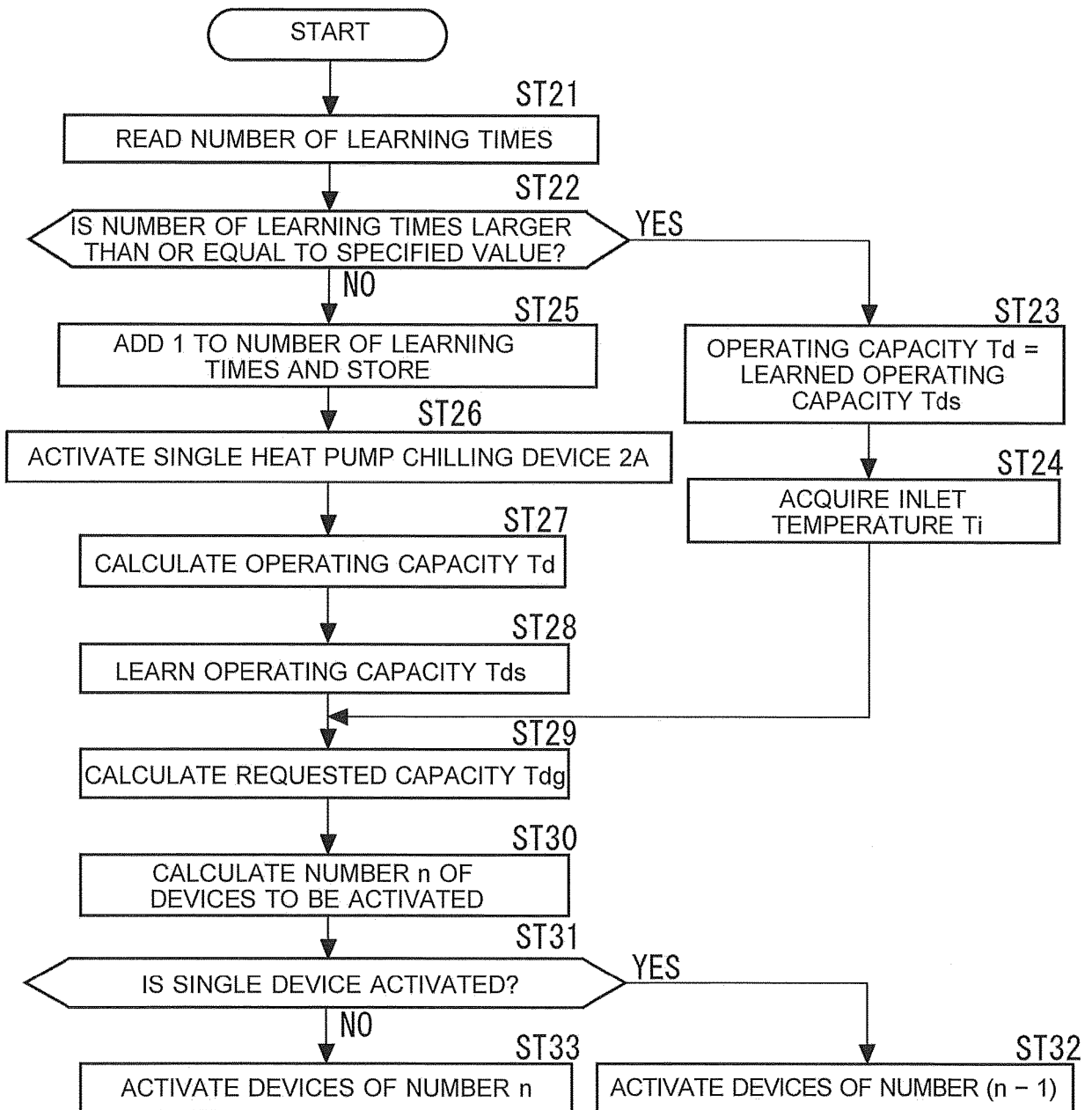


FIG. 10

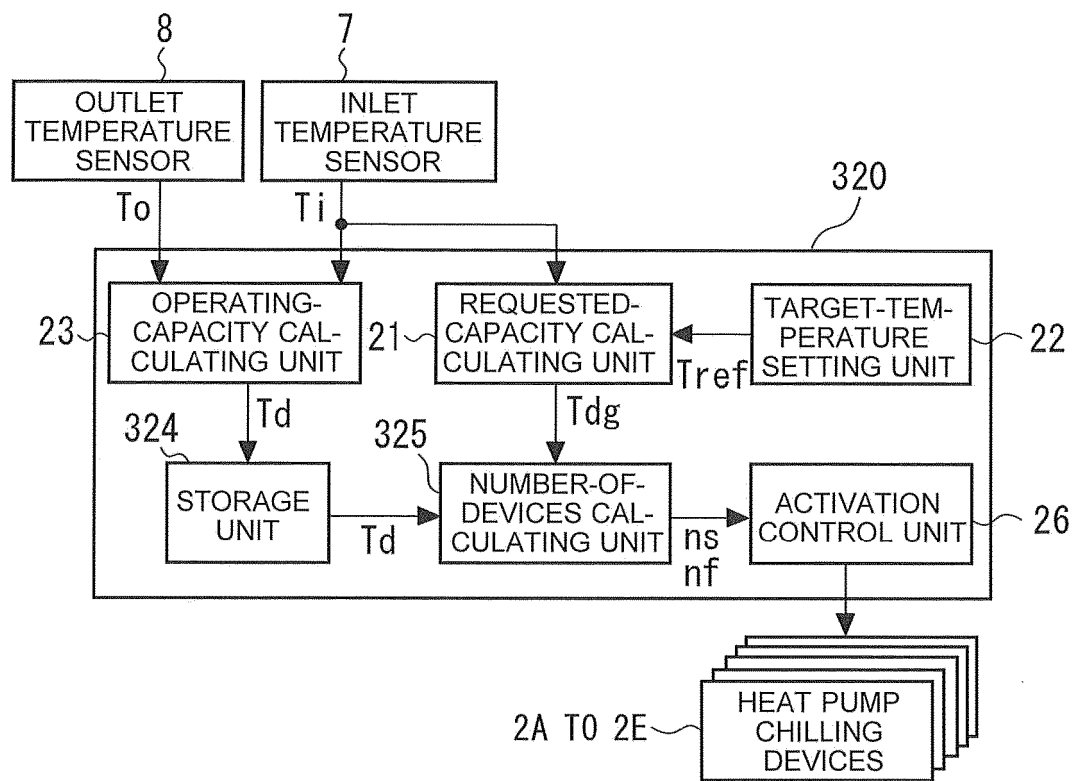
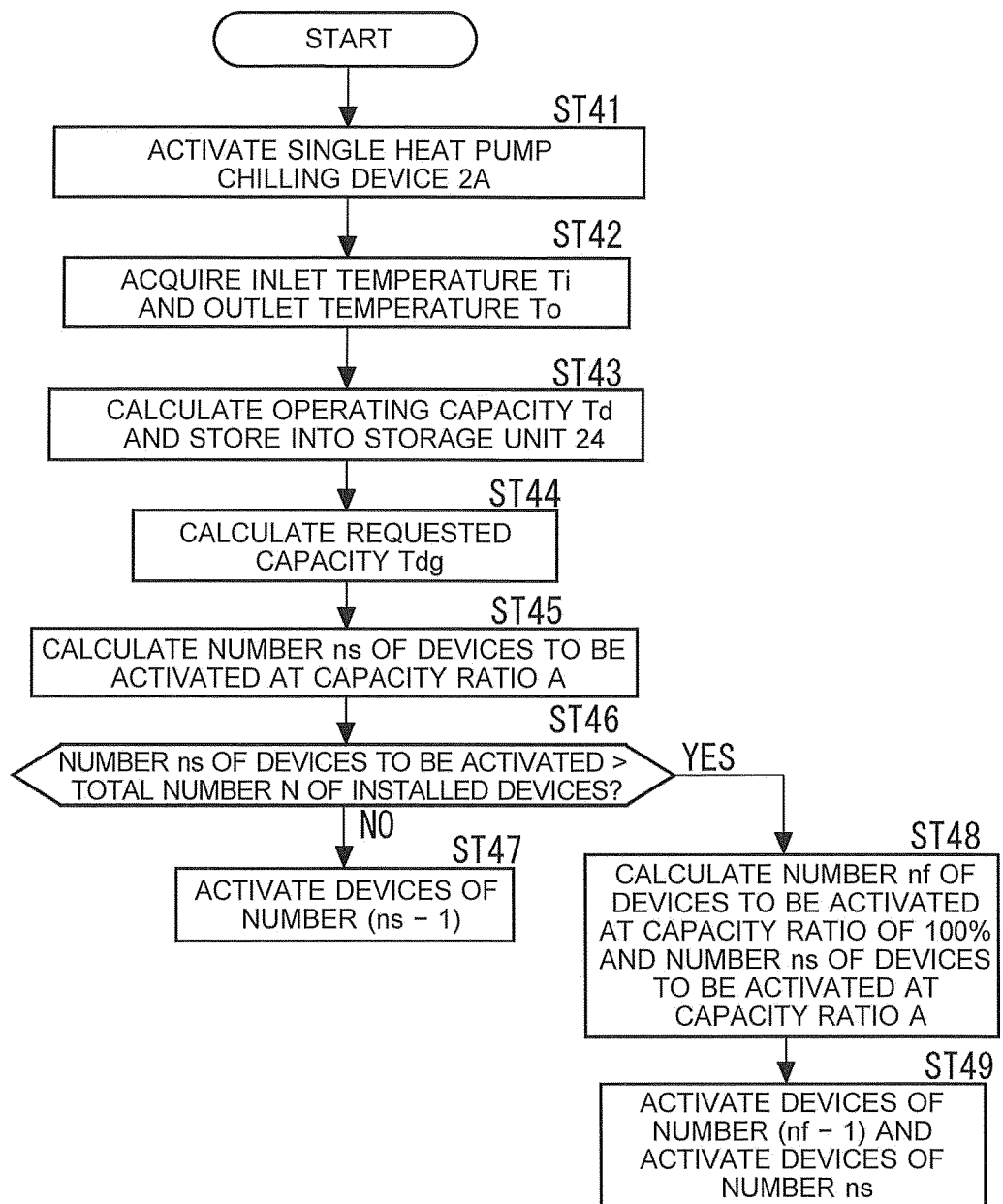


FIG. 11



REFERENCES CITED IN THE DESCRIPTION

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