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(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

(72) Inventors:
- **AKAGI, Satoshi**
  Tokyo 100-8310 (JP)
- **HIKONE, Takahito**
  Tokyo 100-8310 (JP)
- **MUKAITANI, Naoya**
  Tokyo 100-8310 (JP)

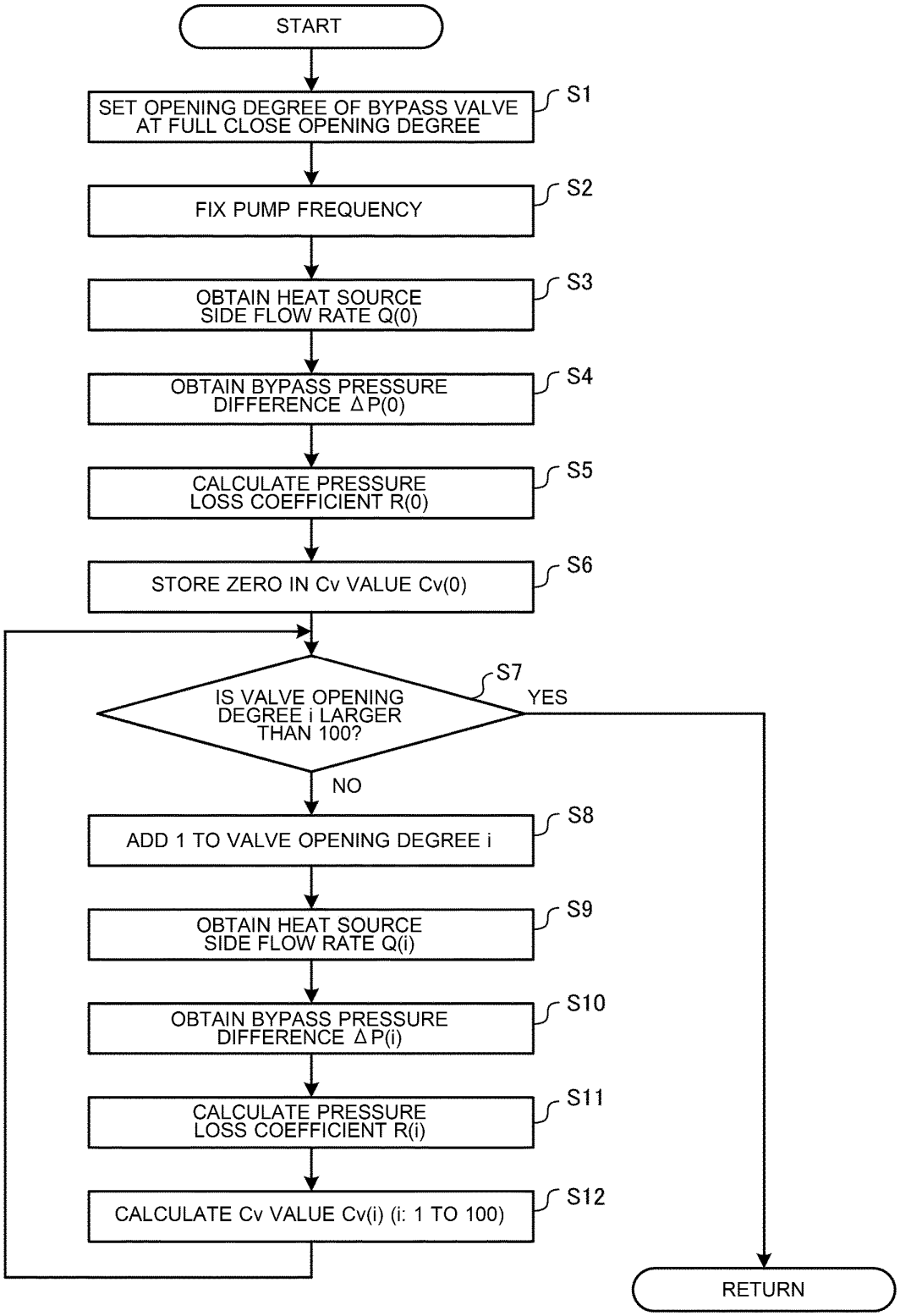
(74) Representative: **Studio Torta S.p.A.**
Via Viotti, 9
10121 Torino (IT)

(54) AIR-CONDITIONING SYSTEM

(57) An air-conditioning system is configured to circulate a heat medium through a heat medium circuit to exchange heat between the heat medium and air in an air-conditioning target space to condition air in the air-conditioning target space, and includes: a load device configured to exchange heat between air in the air-conditioning target space and the heat medium flowing through the heat medium circuit; a heat source device configured to exchange heat between refrigerant flowing through a refrigerant circuit and the heat medium flowing through the heat medium circuit, and deliver the heat medium cooled or heated through the heat medium circuit to the load device; a first pipe that connects the heat source device and the load device and through which the heat medium flows from the heat source device to the load device; a second pipe that connects the load device and the heat source device and through which the heat medium flows from the load device to the heat source device; a bypass pipe connecting the first pipe with the second pipe; a pressure difference gauge provided at the bypass pipe and configured to measure a bypass pressure difference being a pressure difference between the heat medium flowing through the first pipe and the heat medium flowing through the second pipe; a bypass valve provided at the bypass pipe and configured to control a flow rate of the heat medium flowing through the bypass pipe; and a controller configured to control operation of the heat source device and the bypass valve, the controller being configured to fix the opening degree of the bypass valve at a full close opening degree and acquire a heat source side flow rate indicating a flow rate of the heat medium flowing through the heat source device and the bypass pressure difference being measured by the pressure difference gauge, the heat source side flow rate and the bypass pressure difference being measured when the bypass valve is set at the full close opening degree, fix the opening degree of the bypass valve at a full open opening degree, acquire the heat source side flow rate and the bypass pressure difference, the heat source side flow rate and the bypass pressure difference being measured when the opening degree of the bypass valve is at the full open opening degree, and calculate a Cv value of the bypass valve when the opening degree of the bypass valve is at the full open opening degree based on the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full close opening degree and the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full open opening degree.

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FIG. 4


START
SET OPENING DEGREE OF BYPASS VALVE AT FULL CLOSE OPENING DEGREE
S1
FIX PUMP FREQUENCY
S2
OBTAIN HEAT SOURCE SIDE FLOW RATE Q(0)
S3
OBTAIN BYPASS PRESSURE DIFFERENCE ΔP(0)
S4
CALCULATE PRESSURE LOSS COEFFICIENT R(0)
S5
STORE ZERO IN Cv VALUE Cv(0)
S6
IS VALVE OPENING DEGREE i LARGER THAN 100?
S7
YES
NO
ADD 1 TO VALVE OPENING DEGREE i
S8
OBTAIN HEAT SOURCE SIDE FLOW RATE Q(i)
S9
OBTAIN BYPASS PRESSURE DIFFERENCE ΔP(i)
S10
CALCULATE PRESSURE LOSS COEFFICIENT R(i)
S11
CALCULATE Cv VALUE Cv(i) (i: 1 TO 100)
S12
RETURN

Description

Technical Field

[0001] The present disclosure relates to an air-conditioning system having a bypass valve.

Background Art

[0002] A conventional air-conditioning system has been known in which a heat source device and a load device are connected by an outgoing-side pipe toward the load device and a return-side pipe from the load device. In this air-conditioning system, a bypass pipe is provided between the outgoing-side pipe and the return-side pipe, and a bypass valve is attached to the bypass pipe. Patent Literature 1 discloses such an air-conditioning system as described above, that is configured to control a pump or a bypass valve provided at a bypass pipe such that a pressure difference between an outgoing pipe and a return pipe falls within a target range.

Citation List

Patent Literature

[0003] Patent Literature 1: International Publication No. WO 2018/225221

Summary of Invention

Technical Problem

[0004] In general, such an air-conditioning system as disclosed in Patent Literature 1 controls the bypass valve based on specifications of the bypass valve. Accordingly, an air-conditioning system having a bypass valve is required to load specification values of the bypass valve into a controller configured to control the bypass valve. Therefore, installation of the air-conditioning system is burdensome. In the current market, although the controller is provided in a heat source device, specifications of the bypass valve may be selected by an instrumentation provider separate from a manufacturer of the heat source device. In this case, the specification values of the bypass valve need to be manually loaded into the controller at the installation site of the air-conditioning system. This particularly makes the installation of the air-conditioning system burdensome.

[0005] The present disclosure has been made to solve the above problems, and it is an object of the present disclosure to provide an air-conditioning system having a bypass valve and making installation of the air-conditioning system efficient.

Solution to Problem

[0006] An air-conditioning system according to an embodiment of the present disclosure is an air-conditioning system configured to circulate a heat medium through a heat medium circuit to exchange heat between the heat medium and air in an air-conditioning target space to condition air in the air-conditioning target space, the air-conditioning system including: a load device configured to exchange heat between air in the air-conditioning target space and the heat medium flowing through the heat medium circuit; a heat source device configured to exchange heat between refrigerant flowing through a refrigerant circuit and the heat medium flowing through the heat medium circuit, and deliver the heat medium cooled or heated through the heat medium circuit to the load device; a first pipe that connects the heat source device and the load device and through which the heat medium flows from the heat source device to the load device; a second pipe that connects the load device and the heat source device and through which the heat medium flows from the load device to the heat source device; a bypass pipe connecting the first pipe with the second pipe; a pressure difference gauge provided at the bypass pipe and configured to measure a bypass pressure difference being a pressure difference between the heat medium flowing through the first pipe and the heat medium flowing through the second pipe; a bypass valve provided at the bypass pipe and configured to control a flow rate of the heat medium flowing through the bypass pipe; and a controller configured to control operation of the heat source device and the bypass valve, the controller being configured to fix the opening degree of the bypass valve at a full close opening degree and acquire the heat source side flow rate and the bypass pressure difference, the heat source side flow rate and the bypass pressure difference being measured when the bypass valve is set at the full close opening degree, fix the opening degree of the bypass valve at a full open opening degree, fix the opening degree of the bypass valve at a full close opening degree and acquire a heat source side flow rate indicating a flow rate of the heat medium flowing through the heat source device and the bypass pressure difference being measured by the pressure difference gauge, the heat source side flow rate

and the bypass pressure difference being measured when the bypass valve is set at the full close opening degree, and calculate a Cv value of the bypass valve when the opening degree of the bypass valve is at the full open opening degree based on the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full close opening degree and the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full open opening degree. Advantageous Effects of Invention

[0007] According to an embodiment of the present disclosure, the integrated controller calculates a Cv value of the bypass valve when the opening degree of the bypass valve is at the full open opening degree based on the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full close opening degree, and the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full open opening degree. As described above, in the air-conditioning system according to an embodiment of the present disclosure, specification values of the bypass valve are automatically loaded into the controller. This can make installation of the air-conditioning system efficient.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a schematic configuration diagram illustrating an air-conditioning system according to Embodiment 1.
[Fig. 2] Fig. 2 is a functional block diagram illustrating a heat source side controller according to Embodiment 1.
[Fig. 3] Fig. 3 is a functional block diagram illustrating an integrated controller according to Embodiment 1.
[Fig. 4] Fig. 4 is a flowchart illustrating operation of the integrated controller according to Embodiment 1.
[Fig. 5] Fig. 5 is a schematic configuration diagram illustrating an air-conditioning system according to Embodiment 2.
[Fig. 6] Fig. 6 is a functional block diagram illustrating the integrated controller according to Embodiment 2.
[Fig. 7] Fig. 7 is a flowchart illustrating operation of the integrated controller according to Embodiment 2.

Description of Embodiments

Embodiment 1

[0009] Fig. 1 is a schematic configuration diagram illustrating an air-conditioning system 100 according to Embodiment 1. As illustrated in Fig. 1, the air-conditioning system 100 has heat source devices 1a, 1b, and 1c, load devices 2a and 2b, an integrated controller 3, and a heat medium pipe 31. The heat source devices 1a, 1b, and 1c cool a heat medium such as water or brine. The load devices 2a and 2b cool an air-conditioning target space by using the heat medium cooled by the heat source devices 1a, 1b, and 1c. The load devices 2a and 2b are, for example, a fan coil unit or an air handling unit (AHU). The heat source devices 1a, 1b, and 1c all have an identical configuration, and thus may be collectively referred to as "heat source device 1" with the suffixes "a," "b," and "c" omitted from their reference numerals when the heat source devices 1a, 1b, and 1c are not distinguished from each other. Likewise, the load devices 2a and 2b both have an identical configuration, and thus may be collectively referred to as "load device 2" with the suffixes "a" and "b" omitted from their reference numerals when the load devices 2a and 2b are not distinguished from each other. Note that the configurations of the heat source device 1 and the load device 2 will be described later. It suffices that one or more heat source devices 1 and one or more load devices 2 are provided.

[0010] The integrated controller 3 controls the heat source devices 1 and the load devices 2. The heat medium pipe 31 connects in parallel to the heat source devices 1 and the load devices 2. The heat source devices 1 and the load devices 2 are connected by the heat medium pipe 31, thereby forming a heat medium circuit 34 through which a heat medium circulates. Hereinafter, one side of the heat medium circuit 34 near the heat source device 1 may be described as "heat source side." In addition, the other side of the heat medium circuit 34 near the load device 2 may be described as "load side."

[0011] The heat medium pipe 31 has a first pipe 32 and a second pipe 33. The first pipe 32 is an outgoing-water header pipe that connects the heat source devices 1 and the load devices 2, and through which a heat medium flows from the heat source devices 1 to the load devices 2. The second pipe 33 is a return-water header pipe that connects the load devices 2 and the heat source devices 1, and through which a heat medium flows from the load devices 2 to the heat source devices 1.

[0012] The air-conditioning system 100 has a bypass pipe 41, a pressure difference gauge 42, and a bypass valve 43. The bypass pipe 41 is connected to the first pipe 32 and the second pipe 33. The bypass pipe 41 is provided between the heat source devices 1 and the load devices 2 in parallel to the heat source devices 1 and the load devices 2. A heat medium having flowed through the heat source side of the first pipe 32 partially flows through the bypass pipe 41. The heat medium having flowed through the bypass pipe 41 flows out to the heat source side of the second pipe 33. The pressure difference gauge 42 is provided at the bypass pipe 41. The pressure difference gauge 42 measures a bypass

pressure difference. The bypass pressure difference refers to a pressure difference between a heat medium flowing through the first pipe 32 from the heat source side into the load side, and a heat medium flowing out through the second pipe 33 from the load side to the heat source side. An opening degree of the bypass valve 43 is controlled by the integrated controller 3, so that the bypass valve 43 controls the flow rate of a heat medium flowing through the bypass pipe 41.

[0013] The air-conditioning system 100 has a flow meter 51 and a delivery-water temperature sensor 52. The flow meter 51 is provided at the first pipe 32 upstream of its connection location with the bypass pipe 41, that is, on the heat source side. The flow meter 51 measures a heat source side flow rate. The heat source side flow rate indicates a total flow rate of a heat medium flowing through the heat source devices 1. In a case where only a single heat source device 1 is provided, the heat source side flow rate indicates a flow rate of a heat medium flowing through the single heat source device 1. The delivery-water temperature sensor 52 is provided at the first pipe 32 on the heat source side relative to its connection location with the bypass pipe 41. The delivery-water temperature sensor 52 measures a temperature of a heat medium to be delivered from the heat source side to the load side. Hereinafter, the temperature of a heat medium to be delivered from the heat source side to the load side may be described as "delivery-water temperature."

[0014] The pressure difference gauge 42, the flow meter 51, and the delivery-water temperature sensor 52 are connected to the integrated controller 3 with a wire or wirelessly to communicate with the integrated controller 3. The pressure difference gauge 42 transmits information indicating a bypass pressure difference to the integrated controller 3. The flow meter 51 transmits information indicating the heat source side flow rate to the integrated controller 3. The delivery-water temperature sensor 52 transmits information on a delivery-water temperature to the integrated controller 3.

[0015] Next, the heat source devices 1 are described. The heat source device 1a includes, in a housing illustrated by the dotted line, a compressor 10a, a heat source side heat exchanger 11a, a heat source side air-sending device 12a, an expansion valve 13a, a heat medium heat exchanger 14a, a refrigerant pipe 15a, a pump 16a, and a heat source side controller 17a. The compressor 10a, the heat source side heat exchanger 11a, the expansion valve 13a, and the heat medium heat exchanger 14a are connected sequentially by the refrigerant pipe 15a, forming a refrigerant circuit 18a through which refrigerant circulates. The heat medium heat exchanger 14a and the pump 16a are connected by the heat medium pipe 31.

[0016] Similarly to the above, the heat source device 1b includes, in a housing illustrated by the dotted line, a compressor 10b, a heat source side heat exchanger 11b, a heat source side air-sending device 12b, an expansion valve 13b, a heat medium heat exchanger 14b, a refrigerant pipe 15b, a pump 16b, and a heat source side controller 17b. The compressor 10b, the heat source side heat exchanger 11b, the expansion valve 13b, and the heat medium heat exchanger 14b are connected sequentially by the refrigerant pipe 15b, forming a refrigerant circuit 18b through which refrigerant circulates. The heat medium heat exchanger 14b and the pump 16b are connected by the heat medium pipe 31.

[0017] Similarly to the above, the heat source device 1c includes, in a housing illustrated by the dotted line, a compressor 10c, a heat source side heat exchanger 11c, a heat source side air-sending device 12c, an expansion valve 13c, a heat medium heat exchanger 14c, a refrigerant pipe 15c, a pump 16c, and a heat source side controller 17c. The compressor 10c, the heat source side heat exchanger 11c, the expansion valve 13c, and the heat medium heat exchanger 14c are connected sequentially by the refrigerant pipe 15c, forming a refrigerant circuit 18c through which refrigerant circulates. The heat medium heat exchanger 14c and the pump 16c are connected by the heat medium pipe 31. As described above, the heat source devices 1 all have an identical configuration, and thus constituent components included in the heat source devices 1 may also be described with the suffixes "a," "b," and "c" omitted from their reference numerals.

[0018] The compressor 10 suctions refrigerant from the refrigerant pipe 15, compresses the suctioned refrigerant, and discharges the compressed refrigerant to the refrigerant pipe 15. The compressor 10 is an inverter compressor whose capacity is controllable by an inverter. Through the heat source side heat exchanger 11, heat is exchanged between refrigerant and air delivered by the heat source side air-sending device 12. Examples of the heat source side air-sending device 12 include a propeller fan, a turbo fan, and a sirocco fan. The heat source side air-sending device 12 guides air in a space, other than an air-conditioning target space where the load device 2 is provided, to the heat source side heat exchanger 11.

[0019] The expansion valve 13 reduces a pressure of refrigerant flowing from the heat source side heat exchanger 11, and expands the refrigerant. The expansion valve 13 is, for example, an electric expansion valve capable of controlling the flow rate of refrigerant. The heat medium heat exchanger 14 is, for example, a plate heat exchanger through which heat is exchanged between refrigerant flowing through the refrigerant circuit 18 and a heat medium flowing through the heat medium circuit 34. In the heat medium heat exchanger 14, a heat medium is cooled by exchanging heat with refrigerant.

[0020] The pump 16 is configured to circulate a heat medium through the heat medium circuit 34. The pump 16 is configured to adjust the flow rate of a heat medium by varying the operating frequency through the inverter.

[0021] The heat source side controller 17 is made up of dedicated hardware, or a storage device (not illustrated) and a central processing unit (CPU) configured to execute programs stored in the storage device. The heat source side controller 17 controls the compressor 10, the heat source side air-sending device 12, the expansion valve 13, and the

pump 16. The heat source side controller 17 is connected to the compressor 10, the heat source side air-sending device 12, the expansion valve 13, and the pump 16 with a wire or wirelessly. The heat source side controller 17 outputs a control signal for controlling the compressor 10, the heat source side air-sending device 12, the expansion valve 13, and the pump 16 to the target devices through wired communication or wireless communication. The heat source side controller 17 is connected to the integrated controller 3 with a wire or wirelessly and communicates with the integrated controller 3.

[0022] Fig. 2 is a functional block diagram illustrating the heat source side controller 17 according to Embodiment 1. As illustrated in Fig. 2, the heat source side controller 17 has a refrigerant circuit control unit 61 and a pump control unit 62. The refrigerant circuit control unit 61 and the pump control unit 62 are implemented by, for example, software, firmware, or a combination of the software and the firmware. The refrigerant circuit control unit 61 receives, from the integrated controller 3, an instruction signal including information that indicates an operating frequency of the compressor 10, an operating frequency of the heat source side air-sending device 12, and an opening degree of the expansion valve 13. Based on the instruction signal received from the integrated controller 3, the refrigerant circuit control unit 61 controls the compressor 10, the heat source side air-sending device 12, and the expansion valve 13. Specifically, when the instruction signal includes information on an operating frequency of the compressor 10, the refrigerant circuit control unit 61 transmits a control signal to the compressor 10 such that the compressor 10 operates at the operating frequency. When the instruction signal includes information on an operating frequency of the heat source side air-sending device 12, the refrigerant circuit control unit 61 transmits a control signal to the heat source side air-sending device 12 such that the heat source side air-sending device 12 operates at the operating frequency. When the instruction signal includes information on an opening degree of the expansion valve 13, the refrigerant circuit control unit 61 transmits a control signal to the expansion valve 13 such that its opening degree is fixed at the indicated opening degree.

[0023] The pump control unit 62 receives an instruction signal indicating an operating frequency of the pump 16 from the integrated controller 3. The pump control unit 62 controls the pump 16 based on the instruction signal received from the integrated controller 3. Specifically, when receiving the instruction signal, the pump control unit 62 transmits a control signal to the pump 16 such that the pump 16 operates at the operating frequency indicated by the instruction signal.

[0024] Next, referring back to Fig. 1, the load devices 2 are described. The load device 2 includes a load side heat exchanger 21a, a load side air-sending device 22a, a load side controller 23a, and a return-air temperature sensor 24a. Likewise, the load device 2b includes a load side heat exchanger 21b, a load side air-sending device 22b, a load side controller 23b, and a return-air temperature sensor 24b. As described above, the load devices 2 both have an identical configuration, and thus constituent components included in the load devices 2 may also be described with the suffixes "a" and "b" omitted from their reference numerals.

[0025] Through the load side heat exchanger 21, heat is exchanged between air delivered by the load side air-sending device 22 and a heat medium flowing through the heat medium circuit 34. Examples of the load side air-sending device 22 include a propeller fan, a turbo fan, and a sirocco fan. The load side air-sending device 22 guides air in an air-conditioning target space to the load side heat exchanger 21.

[0026] The load side controller 23 is made up of dedicated hardware, or a storage device (not illustrated) and a central processing unit (CPU) configured to execute programs stored in the storage device. The load side controller 23 controls the load side air-sending device 22. The load side controller 23 is connected to the load side air-sending device 22 with a wire or wirelessly, and transmits a control signal for controlling the load side air-sending device 22 to the load side air-sending device 22. The load side controller 23 is connected to the integrated controller 3 with a wire or wirelessly and communicates with the integrated controller 3.

[0027] The load side controller 23 receives, from the integrated controller 3, an instruction signal including information that indicates an operating frequency of the load side air-sending device 22. Based on the received instruction signal, the load side controller 23 controls the load side air-sending device 22. Specifically, when receiving the instruction signal, the load side controller 23 transmits a control signal to the load side air-sending device 22 such that the load side air-sending device 22 operates at the operating frequency indicated by the instruction signal.

[0028] The return-air temperature sensor 24 measures a temperature of air to be guided from an air-conditioning target space to the load device 2. Hereinafter, the temperature of air to be guided from the air-conditioning target space to the load device 2 may be described as "return-air temperature." The return-air temperature sensor 24 is connected to the integrated controller 3 with a wire or wirelessly to communicate with the integrated controller 3. The return-air temperature sensor 24 transmits information indicating a return-air temperature to the integrated controller 3. Note that the return-air temperature sensor 24 may communicate with the integrated controller 3 through the load side controller 23.

[0029] Next, the integrated controller 3 is described. Fig. 3 is a functional block diagram illustrating the integrated controller 3 according to Embodiment 1. As illustrated in Fig. 3, the integrated controller 3 has a calculation unit 71, a pressure difference regulation unit 72, a refrigerant circuit instruction unit 73, a load side instruction unit 74, and a storage unit 75.

[0030] The calculation unit 71 creates a Cv value table in which each opening degree of the bypass valve 43 is associated with a Cv value of the bypass valve 43 fixed at each opening degree when the air-conditioning system 100

performs trial operation. Note that the Cv value indicates how easily fluid flows through a valve. A larger Cv value indicates a smaller pressure loss and indicates that fluid flows through the valve more easily.

[0031] The calculation unit 71 creates the Cv value table in the following manner. First, the calculation unit 71 calculates a heat source side flow rate Q(0) [m^3/h] from a measurement result of the flow meter 51 when the opening degree of the bypass valve 43 is 0%, that is, set at a full close opening degree with each pump 16 operating at a fixed frequency. Similarly to the above, the calculation unit 71 calculates a bypass pressure difference $\Delta P(0)$ [kPa] from a measurement result of the pressure difference gauge 42. Further, zero is stored in a Cv value Cv(0). Note that a figure in parentheses indicates an opening degree of the bypass valve 43. That is, when the opening degree is i%, the heat source side flow rate is represented as Q(i), the bypass pressure difference is represented as $\Delta P(i)$, and the Cv value is represented as Cv(i).

[0032] Next, the calculation unit 71 calculates a total pressure loss in the bypass pipe 41 and the load devices 2a and 2b as a pressure loss coefficient R(0) based on the heat source side flow rate Q(0) and the bypass pressure difference $\Delta P(0)$. Specifically, the pressure loss coefficient R(i) is expressed as Expression (1). The calculation unit 71 substitutes the heat source side flow rate Q(0) and the bypass pressure difference $\Delta P(0)$ in Expression (1) to calculate the pressure loss coefficient R(0).

$$R(i)=\Delta P(i)/(Q(i)\text{^}2) \cdots (1)$$

[0033] Subsequently, the calculation unit 71 obtains the heat source side flow rate Q(1) and the bypass pressure difference $\Delta P(1)$ respectively from the flow meter 51 and the pressure difference gauge 42 when the opening degree of the bypass valve 43 is fixed at 1%. The calculation unit 71 substitutes the heat source side flow rate Q(1) and the bypass pressure difference $\Delta P(1)$ in the above Expression (1) to calculate a pressure loss coefficient R(1).

[0034] The calculation unit 71 calculates a Cv value Cv(1) when the valve opening degree is 1%. When the valve opening degree is i%, the bypass flow rate Q1(i) at which fluid flows through the bypass pipe 41 is expressed as the following Expression (2). When the valve opening degree is i%, a load side flow rate Q2(i) that indicates a total flow rate of a heat medium flowing through the load side is expressed as Expression (3).

$$Q1(i)=Cv(i)/0.7\times(\Delta P(i)\text{^}0.5)\times 60/1000 \cdots (2)$$

$$Q2(i)=(\Delta P(i)/R(0))\text{^}0.5 \cdots (3)$$

[0035] Since the heat source side flow rate Q(i) is equal to the sum of Q1(i) and Q2(i), the following Expression (4) can be derived from Expressions (1) to (3).

$$Cv(i)=\{(1/R(i))\text{^}0.5-(1/R(0))\text{^}0.5\}\times 0.7/60\times 1000 \cdots (4)$$

[0036] The calculation unit 71 substitutes the pressure loss coefficient R(0) obtained when the valve opening degree is a full close opening degree, and the pressure loss coefficient R(1) obtained when the valve opening degree is 1% in Expression (4) to calculate a Cv value Cv(1). The calculation unit 71 calculates a Cv value each time the valve opening degree varies in increments of 1% from 1% to 100%. The calculation unit 71 stores a Cv value table in the storage unit 75. In the Cv value table, Cv(0) with the value "zero" stored therein and calculated Cv(i) are associated with respective valve opening degrees "i." Note that the pressure loss coefficient R(i) is a value derived from measurement values measured by the flow meter 51 and the pressure difference gauge 42 as expressed by Expression (1). Accordingly, in Expression (4), Cv(i) may be calculated by using the heat source side flow rate Q(0) and the bypass pressure difference $\Delta P(0)$ instead of the pressure loss coefficient R(0), and using the heat source side flow rate Q(i) and the bypass pressure difference $\Delta P(i)$ instead of the pressure loss coefficient R(i).

[0037] The pressure difference regulation unit 72 controls the bypass valve 43 and the pump 16 when the air-conditioning system 100 performs trial operation, and also when the air-conditioning system 100 performs actual operation. First, operation of the pressure difference regulation unit 72 when the air-conditioning system 100 performs trial operation is described. When the Cv value table is created during trial operation, the pressure difference regulation unit 72 transmits an instruction signal to the pump control unit 62 in each heat source side controller 17 such that each pump 16 operate at a fixed frequency. The fixed frequency is, for example, a rated frequency that satisfies a rated flow rate of the load device 2 requested by an administrator or other user of the air-conditioning system 100. When receiving the instruction signal, the pump control unit 62 in each heat source side controller 17 transmits a control signal to each pump 16 such

that the pump 16 operates at an operating frequency indicated by the instruction signal. When the Cv value table is created during trial operation, the pressure difference regulation unit 72 transmits a control signal to the bypass valve 43 to increase the valve opening degree in increments of 1%.

[0038] Next, operation of the pressure difference regulation unit 72 when the air-conditioning system 100 performs actual operation is described. The pressure difference regulation unit 72 controls the pump 16 and the bypass valve 43 in conjunction with each other such that the bypass pressure difference becomes a target value. For example, when the bypass pressure difference is below the target value at the control time point, the pressure difference regulation unit 72 gives higher priority to controlling the bypass valve 43 to be throttled than controlling the pump 16 to increase its speed. For another example, when the bypass pressure difference exceeds the target value at the control time point, the pressure difference regulation unit 72 gives higher priority to controlling the pump 16 to decrease its speed than controlling the bypass valve 43 to be opened. In this manner, based on a comparison result between the value of bypass pressure difference at the control time point and a target value, the pressure difference regulation unit 72 transmits an instruction signal to the pump control unit 62 in each heat source side controller 17 or transmits a control signal to the bypass valve 43. The pump 16 and the bypass valve 43 are exclusively controlled in the manner as described above, so that the air-conditioning system 100 improves its energy efficiency.

[0039] Control of the bypass valve 43 is described below in detail. The pressure difference regulation unit 72 executes, for example, a commonly-called I-control, PI-control, or PID control to control the bypass valve 43 such that the bypass pressure difference ΔP becomes a target value. In these controls, the pressure difference regulation unit 72 determines an amount of change [%] in the opening degree of the bypass valve 43 according to a deviation $\Delta\Delta P$ of the bypass pressure difference ΔP from a control target value (=current value of the bypass pressure difference ΔP - target value of the bypass pressure difference ΔP). The amount of change in the opening degree of the bypass valve 43 is determined using a control coefficient that is inversely proportional to a process gain. The process gain is a value obtained by dividing a controlled amount by a manipulated amount when the opening degree of the bypass valve 43 is varied in steps. The controlled amount is equivalent to an amount of change in the bypass pressure difference ΔP, while the manipulated amount is equivalent to the amount of change in the opening degree of the bypass valve 43.

[0040] In a case where a predetermined number of heat source devices 1 are used, it is possible to determine the amount of change in the bypass pressure difference ΔP associated with a Cv value gradient during the design phase based on the characteristics of the pump 16 determined by the flow rate per pump 16 and the bypass pressure difference ΔP. The Cv value gradient indicates a degree of variation in the Cv value when the opening degree of the bypass valve 43 is varied. The amount of change in the bypass pressure difference ΔP is varied according to the value of the Cv value gradient. Accordingly, the amount of change in the bypass pressure difference ΔP associated with the Cv value gradient, and stored in the storage unit 75 as a design value, is multiplied by the value of Cv value gradient, thereby to acquire the amount of change in the bypass pressure difference ΔP corresponding to the amount of change in the opening degree of the bypass valve 43. As described above, the amount of change in the bypass pressure difference ΔP corresponding to the amount of change in the opening degree of the bypass valve 43 is equivalent to the process gain. Based on the calculated process gain, a control coefficient that determines an amount of change in the opening degree of the bypass valve 43, and the amount of change in the opening degree of the bypass valve 43 are acquired.

[0041] In Embodiment 1, the Cv value gradient is calculated based on the Cv value table calculated during trial operation. Specifically, the pressure difference regulation unit 72 acquires the process gain by using a maximum value of Cv value gradient among the Cv value gradients calculated for respective opening degrees in the Cv value table, that is, Cv(i) - Cv(i-1) (i: 0 to 100).

[0042] The refrigerant circuit instruction unit 73 operates in the following manner when the air-conditioning system 100 performs actual operation. That is, the refrigerant circuit instruction unit 73 obtains a delivery-water temperature from the delivery-water temperature sensor 52. The refrigerant circuit instruction unit 73 determines an operating frequency of the compressor 10 such that the delivery-water temperature becomes a target temperature. The refrigerant circuit instruction unit 73 transmits an instruction signal indicating the operating frequency of the compressor 10 to the refrigerant circuit control unit 61 in the heat source side controller 17 of the heat source device 1 to be controlled. The heat source side controller 17 in the heat source device 1, having received the instruction signal, transmits a control signal to the compressor 10 such that the compressor 10 operates at the operating frequency indicated by the instruction signal. The compressor 10 having received the control signal operates at the frequency indicated by the control signal.

[0043] The load side instruction unit 74 operates in the following manner when the air-conditioning system 100 performs actual operation. That is, the load side instruction unit 74 obtains a return-air temperature from the return-air temperature sensor 24. The load side instruction unit 74 determines an operating frequency of the load side air-sending device 22 based on a difference between the obtained return-air temperature and a set temperature. The load side instruction unit 74 transmits an instruction signal indicating the determined operating frequency of the load side air-sending device 22 to the load side controller 23. The load side controller 23 in the load device 2, having received the instruction signal, transmits a control signal to the load side air-sending device 22 such that the load side air-sending device 22 operates at the operating frequency indicated by the instruction signal. The load side air-sending device 22 having received the

control signal operates at the operating frequency indicated by the control signal.

[0044] The storage unit 75 has various types of design values stored therein to be used for controlling the air-conditioning system 100, such as the amount of change in the bypass pressure difference ΔP associated with the Cv value gradient. During trial operation of the air-conditioning system 100, the storage unit 75 stores therein the Cv value table created by the calculation unit 71.

[0045] The integrated controller 3 is made up of dedicated hardware, or the storage unit 75 and a central processing unit (CPU) configured to execute programs stored in the storage unit 75. When the integrated controller 3 is dedicated hardware, the integrated controller 3 is equivalent to, for example, a single circuit, a combined circuit, an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or a combination thereof. The functional units of the integrated controller 3 may be individually implemented by separate units of hardware, or the functional units of the integrated controller 3 may be implemented together by a single unit of hardware.

[0046] When the integrated controller 3 is a CPU, the functional units to be executed by the integrated controller 3 are implemented by software, firmware, or a combination of the software and the firmware. The software and the firmware are described as programs and stored in the storage unit 75. The CPU reads and executes the programs stored in the storage unit 75, and thereby implements the functional units of the integrated controller 3. For example, the storage unit 75 is a nonvolatile or volatile semiconductor memory such as a RAM, a ROM, a flash memory, an EPROM, or an EEPROM. Note that the functions of the integrated controller 3 may be partially implemented by dedicated hardware, while being partially implemented by software or firmware.

[0047] Fig. 4 is a flowchart illustrating operation of the integrated controller 3 according to Embodiment 1. With reference to Fig. 4, the procedure for creating the Cv value table during trial operation is described below. First, the pressure difference regulation unit 72 fixes the opening degree of the bypass valve 43 at a full close opening degree (step S1). The pressure difference regulation unit 72 fixes the frequency of each pump 16 (step S2). With the frequency of each pump 16 fixed at a predetermined frequency, and the opening degree of the bypass valve 43 fixed at a full close opening degree, the calculation unit 71 obtains the heat source side flow rate Q(0) from the flow meter 51 (step S3). The calculation unit 71 obtains the bypass pressure difference ΔP(0) from the pressure difference gauge 42 (step S4). The calculation unit 71 calculates the pressure loss coefficient R(0) (step S5), and stores zero in the Cv value Cv(0) (step S6).

[0048] Subsequently, the pressure difference regulation unit 72 determines whether the valve opening degree "i" of the bypass valve 43 exceeds 100 (step S7). Note that zero is stored as an initial value of the valve opening degree "i." When the valve opening degree "i" of the bypass valve 43 is equal to or smaller than 100 (step S7: NO), the pressure difference regulation unit 72 adds 1 to the valve opening degree "i," that is, increases the opening degree of the bypass valve 43 by 1% (step S8). With the valve opening degree increased by 1% and fixed, the calculation unit 71 obtains the heat source side flow rate Q(i) from the flow meter 51 (step S9). The calculation unit 71 obtains the bypass pressure difference ΔP(i) from the pressure difference gauge 42 (step S10). The calculation unit 71 calculates the pressure loss coefficient R(i) (step S11).

[0049] The calculation unit 71 calculates the Cv value Cv(i), using the pressure loss coefficient R(0) and the pressure loss coefficient R(i) (step S12). The integrated controller 3 repeats the processes in steps S8 to S12 until the valve opening degree "i" exceeds 100 (step S7: YES). With this processing, the integrated controller 3 completes the calculation of an opening degree of the bypass valve 43 and the Cv value of the bypass valve 43 fixed at each opening degree, where the opening degree of the bypass valve 43 is 1% to 100%.

[0050] In the manner as described above, the integrated controller 3 creates the Cv value table by storing the value "zero" corresponding to the Cv value Cv(0) and having been stored in step S6, as well as an opening degree and each Cv value of the bypass valve 43 fixed at each opening degree in association with each valve opening degree "i." Note that in the above procedure for creating the Cv value table, the order of the steps may be changed appropriately to the extent not affecting the calculated Cv values.

[0051] According to Embodiment 1, the integrated controller 3 calculates a Cv value of the bypass valve 43 when the opening degree of the bypass valve 43 is at the full open opening degree based on the bypass pressure difference and the heat source side flow rate measured when the bypass valve 43 is set at the full close opening degree, and the bypass pressure difference and the heat source side flow rate measured when the bypass valve 43 is set at the full open opening degree. As described above, in the air-conditioning system 100 in Embodiment 1, specification values of the bypass valve 43 are automatically loaded into the integrated controller 3. This can make installation of the air-conditioning system 100 efficient.

[0052] In Embodiment 1, the integrated controller 3 creates the Cv value table. As described above, in the air-conditioning system 100 in Embodiment 1, detailed specification values of the bypass valve 43 are automatically loaded into the integrated controller 3. This makes installation of the air-conditioning system 100 even more efficient. In addition, it is possible to determine the control coefficient of the bypass valve 43 based on the characteristics of variations in the Cv value relative to variations in the opening degree of the bypass valve 43, so that the air-conditioning system 100 can improve its stability during actual operation. Note that examples of the characteristics described herein include linear characteristics, quick open characteristics, and equal percentage characteristics. The linear characteristics show that

the Cv value varies linearly relative to variations in the opening degree of the bypass valve 43. The quick open characteristics show that the Cv value varies significantly when the opening degree of the bypass valve 43 varies within a range of low opening degree. The equal percentage characteristics show that the Cv value varies significantly when the opening degree of the bypass valve 43 varies within a range of high opening degree.

[0053] In Embodiment 1, during actual operation, the process gain is acquired by using the maximum value of Cv value gradient among the Cv value gradients calculated for respective opening degrees in the Cv value table. As described above, the amount of change in the opening degree of the bypass valve 43 is determined using a coefficient that is inversely proportional to the process gain. The process gain is acquired by using the maximum value of Cv value gradient, and accordingly the amount of change in the opening degree is reduced. Consequently, even when the variations in the Cv value relative to the variations in the opening degree of the bypass valve 43 exhibit quick open characteristics or equal percentage characteristics, rather than linear characteristics, the opening degree of the bypass valve 43 can still be controlled in a stable manner.

(Modification 1 of Embodiment 1)

[0054] In Modification 1 of Embodiment 1, during actual operation, the process gain is acquired by using a value of Cv value gradient corresponding to an opening degree of the bypass valve 43 at the control time point among the values of Cv value gradient calculated for respective opening degrees in the Cv value table, that is, Cv(i) - Cv(i-1) (i: 0 to 100). For example, where an opening degree of the bypass valve 43 at the control time point is represented as j%, the Cv value gradient corresponding to the opening degree of the bypass valve 43 at the control time point is given as a Cv value gradient within a range of predetermined plus or minus k% of the median j%, that is, Cv(j+k) - Cv(j-k).

[0055] Also in Modification 1 of Embodiment 1, specification values of the bypass valve 43 are automatically loaded into the integrated controller 3. This can make installation of the air-conditioning system 100 efficient. It is also possible to control the bypass valve 43 with an optimal control coefficient according to the valve opening degree at the control time point. This helps the bypass pressure difference ΔP to follow the target value at the earliest possible time, while ensuring the stability of the air-conditioning system 100.

(Modification 2 of Embodiment 1)

[0056] In Modification 2 of Embodiment 1, only a Cv(100) is calculated during trial operation, instead of creating the Cv value table. During actual operation, based on the assumed type of characteristics of variations in the Cv value relative to variations in the opening degree of the bypass valve 43, the Cv value gradient is calculated to acquire the process gain. Specifically, when variations in the Cv value relative to variations in the opening degree of the bypass valve 43 are assumed to exhibit, for example, linear characteristics, the Cv value gradient is equivalent to Cv(100)/100.

[0057] Also in Modification 2 of Embodiment 1, specification values of the bypass valve 43 are automatically loaded into the integrated controller 3. This can make installation of the air-conditioning system 100 efficient. Only Cv(100) is calculated, so that the time required for trial operation can be reduced, compared to the case when the Cv value table is created. It is also possible for the storage unit 75 to omit a storage area for storing the Cv value table. It is also allowable to control the bypass valve 43 in the manner as described above using the Cv value table created during trial operation.

Embodiment 2

[0058] Fig. 5 is a schematic configuration diagram illustrating an air-conditioning system 100A according to Embodiment 2. As illustrated in Fig. 5, Embodiment 2 is different from Embodiment 1 in that the load device 2 has a supply-air temperature sensor 25 and a flow control valve 26. In Embodiment 2, the same components as those in Embodiment 1 are denoted by the same reference signs, and therefore descriptions thereof are omitted. The different points from Embodiment 1 are mainly described below.

[0059] The load device 2a has a supply-air temperature sensor 25a and a flow control valve 26a. The load device 2b has a supply-air temperature sensor 25b and a flow control valve 26b. The supply-air temperature sensor 25 measures a temperature of air to be sent from the load device 2 to an air-conditioning target space. Hereinafter, the temperature of air to be sent from the load device 2 to the air-conditioning target space may be described as "supply-air temperature".

[0060] The flow control valve 26 is, for example, a two-way valve. An opening degree of the flow control valve 26 is controlled by the load side controller 23, so that the flow control valve 26 controls the flow rate of a heat medium flowing through the load device 2. In a case where the flow control valves 26 are provided, the bypass pipe 41 has a function of avoiding the heat medium circuit 34 from being closed when both the flow control valves 26 are set at a full close opening degree.

[0061] The load side controller 23 controls the flow control valve 26 in addition to the load side air-sending device 22. The load side controller 23 is connected to the flow control valve 26 with a wire or wirelessly. The load side controller

23 outputs a control signal for controlling the flow control valve 26 to the flow control valve 26.

[0062] Fig. 6 is a functional block diagram illustrating the integrated controller 3 according to Embodiment 2. As illustrated in Fig. 6, the load side instruction unit 74 in the integrated controller 3 indirectly controls the flow control valve 26 when an air-conditioning system 100A performs trial operation, and also when the air-conditioning system 100A performs actual operation. First, operation of the load side instruction unit 74 when the air-conditioning system 100A performs trial operation is described. When the Cv value table is created during trial operation, the load side instruction unit 74 transmits an instruction signal to the load side controller 23 such that the opening degree of the flow control valve 26 is fixed. The opening degree is fixed at, for example, a full open opening degree. The load side controller 23 in the load device 2, having received the instruction signal, transmits a control signal to the flow control valve 26 such that the flow control valve 26 is fixed at the opening degree indicated by the instruction signal. The flow control valve 26 having received the control signal is fixed at the opening degree indicated by the control signal.

[0063] Next, operation of the load side instruction unit 74 when the air-conditioning system 100A performs actual operation is described. The load side instruction unit 74 in the integrated controller 3 obtains a supply-air temperature from the supply-air temperature sensor 25. The load side instruction unit 74 determines an opening degree of the flow control valve 26 based on the obtained supply-air temperature. The flow control valve 26 is set at such an opening degree that the supply-air temperature becomes close to the set temperature. The load side instruction unit 74 transmits an instruction signal indicating the determined opening degree of the flow control valve 26 to the load side controller 23. The load side controller 23 in the load device 2, having received the instruction signal, transmits a control signal to the flow control valve 26 such that the flow control valve 26 operates at the opening degree indicated by the instruction signal. The flow control valve 26 having received the control signal is fixed at the opening degree indicated by the control signal.

[0064] Fig. 7 is a flowchart illustrating operation of the integrated controller 3 according to Embodiment 2. As illustrated in Fig. 7, the procedure for creating the Cv value table during trial operation in Embodiment 2 is different from the procedure for creating the Cv value table during trial operation in Embodiment 1 only in that the opening degree of the flow control valve 26 is fixed (step S21) prior to fixing the opening degree of the bypass valve 43 at a full close opening degree (step S1). The processes in steps S1 to S12 in Embodiment 2 are the same as those in Embodiment 1, and therefore descriptions thereof are omitted.

[0065] While the embodiments and the modifications have been described above, it is possible to appropriately make a change to the air-conditioning systems 100 and 100A of the present disclosure within the scope of the present disclosure. For example, the heat source side flow rate may be measured by a device configured to measure a pressure difference between the pressures upstream and downstream of the heat medium heat exchanger 14 in each heat source device 1, instead of the flow meter 51. For example, assuming that a flow rate of the heat source devices 1 is proportional to the one-half power of the pressure difference between the upstream and downstream pressures, the heat source side flow rate that is a total flow rate of the heat source devices 1 is acquired. A proportionality coefficient is determined by tests or the like during the design phase.

[0066] It is also allowable that the second pipe 33 is provided with the flow meter 51 configured to measure a flow rate of a heat medium flowing out from the load side to the heat source side.

[0067] For example, when the bypass pressure difference exceeds a predetermined value that is set larger than the target value, the pressure difference regulation unit 72 may control the opening degree of the bypass valve 43, giving priority to the control stability as an emergency measure, such that the bypass valve 43 is opened at a highest possible speed.

[0068] The functions of the integrated controller 3, the heat source side controller 17, and the load side controller 23 are not limited to those described in Embodiments 1 and 2. For example, some of the functions of the integrated controller 3, some the functions of the heat source side controllers 17, and some of the functions of the load side controllers 23 may be implemented by other devices. Two or more of the integrated controller 3, the heat source side controllers 17, and the load side controllers 23 may be integrated into a single device. Further, the integrated controller 3, each of the heat source side controllers 17, or each of the load side controllers 23 may be made up of two or more devices. In any of the cases, one or more devices configured to directly or indirectly control the heat source device 1 and the bypass valve 43 are equivalent to "controller" of the present disclosure. Note that during trial operation, the load side controller 23 in each load device 2 may operate each device to be controlled by the load side controller 23 by being directly manipulated by an installation worker, instead of operating each device to be controlled by the load side controller 23 based on an instruction signal from the integrated controller 3. For example, the flow control valves 26 in Embodiment 2 are fixed at a full open opening degree by an installation worker manipulating the load side controllers 23 during trial operation.

[0069] In Embodiments 1 and 2, an example in which the heat source device 1 cools a heat medium has been described. However, the refrigerant circuit 18 may be provided with a flow switching valve or other device to cause refrigerant to flow through the refrigerant circuit 18 in the reverse direction, thereby to heat the heat medium.

[0070] In Embodiments 1 and 2, an example in which the operating frequency of each pump 16 is fixed at the time of

creating the Cv value table has been described. However, the operating frequency of each pump 16 may be varied to the extent not affecting the heat source side flow rate or the bypass pressure difference. For example, provided that there are no variations in the heat source side flow rate and the bypass pressure difference, the operating frequency of the pump 16a may be increased, while the operating frequency of the pump 16b may be decreased.

[0071] In Modification 2 of Embodiment 1, the case has been described in which the opening degree of the bypass valve 43 is controlled during actual operation, assuming that variations in the Cv value relative to variations in the opening degree of the bypass valve 43 exhibit linear characteristics. However, variations in the Cv value relative to variations in the opening degree of the bypass valve 43 may be assumed to exhibit characteristics other than the linear characteristics. Even when variations in the Cv value relative to variations in the opening degree of the bypass valve 43 exhibit, for example, quick open characteristics or equal percentage characteristics, computation expressions stored in advance in the storage unit 75 may be referenced to complement the Cv value table based on a measured Cv value Cv(100). In this case, based on the complemented Cv value table, the maximum value of Cv value gradient may be referenced to control the opening degree of the bypass valve 43, or the Cv value gradient corresponding to an opening degree of the bypass valve 43 at the control time point may be referenced to control the opening degree of the bypass valve 43. In any of the cases, the time required for trial operation can be reduced, compared to the case when the Cv value table is created based on actual measurement results of the heat source side flow rate and the bypass pressure difference.

Reference Signs List

[0072] 1, 1a, 1b, 1c: heat source device, 2, 2a, 2b: load device, 3: integrated controller, 10, 10a, 10b, 10c: compressor, 11, 11a, 11b, 11 c: heat source side heat exchanger, 12, 12a, 12b, 12c: heat source side air-sending device, 13, 13a, 13b, 13c: expansion valve, 14, 14a, 14b, 14c: heat medium heat exchanger, 15, 15a, 15b, 15c: refrigerant pipe, 16, 16a, 16b, 16c: pump, 17, 17a, 17b, 17c: heat source side controller, 18, 18a, 18b, 18c: refrigerant circuit, 21, 21a, 21b: load side heat exchanger, 22, 22a, 22b: load side air-sending device, 23, 23a, 23b: load side controller, 24, 24a, 24b: return-air temperature sensor, 25, 25a, 25b: supply-air temperature sensor, 26, 26a, 26b: flow control valve, 31: heat medium pipe, 32: first pipe, 33: second pipe, 34: heat medium circuit, 41: bypass pipe, 42: pressure difference gauge, 43: bypass valve, 51: flow meter, 52: delivery-water temperature sensor, 61: refrigerant circuit control unit, 62: pump control unit, 71: calculation unit, 72: pressure difference regulation unit, 73: refrigerant circuit instruction unit, 74: load side instruction unit, 75: storage unit, 100, 100A: air-conditioning system

Claims

1. An air-conditioning system configured to circulate a heat medium through a heat medium circuit to exchange heat between the heat medium and air in an air-conditioning target space to condition air in the air-conditioning target space, the air-conditioning system comprising:

   a load device configured to exchange heat between air in the air-conditioning target space and the heat medium flowing through the heat medium circuit;
   a heat source device configured to exchange heat between refrigerant flowing through a refrigerant circuit and the heat medium flowing through the heat medium circuit, and deliver the heat medium cooled or heated through the heat medium circuit to the load device;
   a first pipe that connects the heat source device and the load device and through which the heat medium flows from the heat source device to the load device;
   a second pipe that connects the load device and the heat source device and through which the heat medium flows from the load device to the heat source device;
   a bypass pipe connecting the first pipe with the second pipe;
   a pressure difference gauge provided at the bypass pipe and configured to measure a bypass pressure difference being a pressure difference between the heat medium flowing through the first pipe and the heat medium flowing through the second pipe;
   a bypass valve provided at the bypass pipe and configured to control a flow rate of the heat medium flowing through the bypass pipe; and
   a controller configured to control operation of the heat source device and the bypass valve,
   the controller being configured to
   fix the opening degree of the bypass valve at a full close opening degree and acquire a heat source side flow rate indicating a flow rate of the heat medium flowing through the heat source device and the bypass pressure difference being measured by the pressure difference gauge, the heat source side flow rate and the bypass pressure difference being measured when the bypass valve is set at the full close opening degree,

fix the opening degree of the bypass valve at a full open opening degree, acquire the heat source side flow rate and the bypass pressure difference, the heat source side flow rate and the bypass pressure difference being measured when the opening degree of the bypass valve is at the full open opening degree, and
calculate a Cv value of the bypass valve when the opening degree of the bypass valve is at the full open opening degree based on the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full close opening degree and the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full open opening degree.

2. The air-conditioning system of claim 1, wherein

the load device has
a flow control valve configured to control a flow rate of the heat medium flowing through the heat medium circuit, and
while the controller calculates a Cv value of the bypass valve, an opening degree of the flow control valve is fixed.

3. The air-conditioning system of claim 1 or 2, wherein

the heat source device has
the refrigerant circuit formed by connecting a compressor, a heat source side heat exchanger, an expansion valve, and a heat medium heat exchanger by a refrigerant pipe, and
a pump configured to circulate the heat medium through the heat medium circuit, the heat medium exchanging heat with the refrigerant in the heat medium heat exchanger, and
the controller is configured to
fix an operating frequency of the pump, while calculating a Cv value of the bypass valve.

4. The air-conditioning system of any one of claims 1 to 3, further comprising a flow meter provided at the first pipe near the heat source device relative to a connection location with the bypass pipe, the flow meter being configured to measure the heat source side flow rate.

5. The air-conditioning system of any one of claims 1 to 4, wherein the controller is configured to

vary an opening degree at which the bypass valve is fixed in increments of 1% from the full close opening degree, acquire the heat source side flow rate and the bypass pressure difference measured when the bypass valve is fixed at each opening degree, and
create a Cv value table in which each opening degree is associated with a Cv value of the bypass valve fixed at each opening degree based on the bypass pressure difference and the heat source side flow rate measured when the bypass valve is set at the full close opening degree and the bypass pressure difference and the heat source side flow rate measured when the bypass valve is fixed at each opening degree.

6. The air-conditioning system of any one of claims 1 to 5, wherein the controller is configured to
calculate a Cv value gradient indicating a degree of variations in the Cv value when the opening degree of the bypass valve is varied, and control the bypass valve based on the Cv value gradient, such that the bypass pressure difference becomes a predetermined target value.

7. The air-conditioning system of claim 6 as dependent on claim 5, wherein the controller is configured to
calculate the Cv value gradient based on the Cv value table.

8. The air-conditioning system of claim 6 or 7, wherein the controller is configured to
control the bypass valve based on the Cv value gradient when the opening degree of the bypass valve is at the full open opening degree.

9. The air-conditioning system of claim 6 or 7, wherein the controller is configured to
control the bypass valve based on a maximum of the Cv value gradient among the Cv value gradients, each of which is calculated from when the opening degree of the bypass valve is at the full close opening degree to when the opening degree of the bypass valve is at the full open opening degree.

10. The air-conditioning system of claim 6 or 7, wherein the controller is configured to
control the bypass valve based on the Cv value gradient corresponding to the opening degree of the bypass valve

at a control time point.

FIG. 1

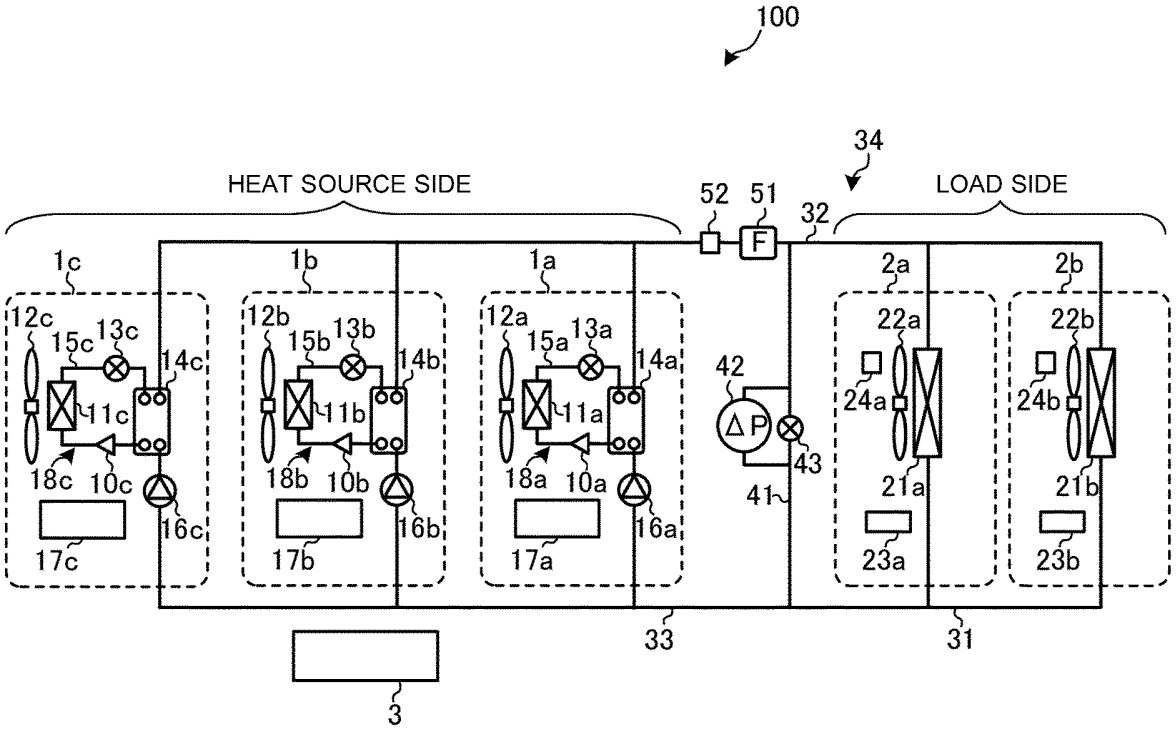

100
34
HEAT SOURCE SIDE
LOAD SIDE
52
51
32
F
1c
1b
1a
2a
2b
12c
15c
13c
14c
11c
18c
10c
16c
17c
12b
15b
13b
14b
11b
18b
10b
16b
17b
12a
15a
13a
14a
11a
18a
10a
16a
17a
42
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23b
33
31
3

FIG. 2

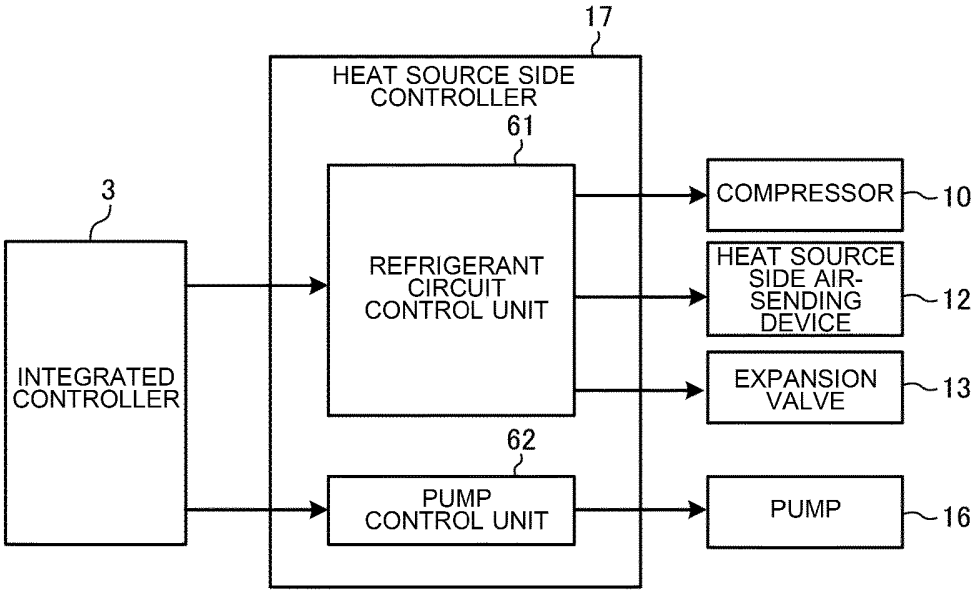

17
HEAT SOURCE SIDE CONTROLLER
61
3
INTEGRATED CONTROLLER
REFRIGERANT CIRCUIT CONTROL UNIT
62
PUMP CONTROL UNIT
COMPRESSOR
10
HEAT SOURCE SIDE AIR-SENDING DEVICE
12
EXPANSION VALVE
13
PUMP
16

FIG. 3

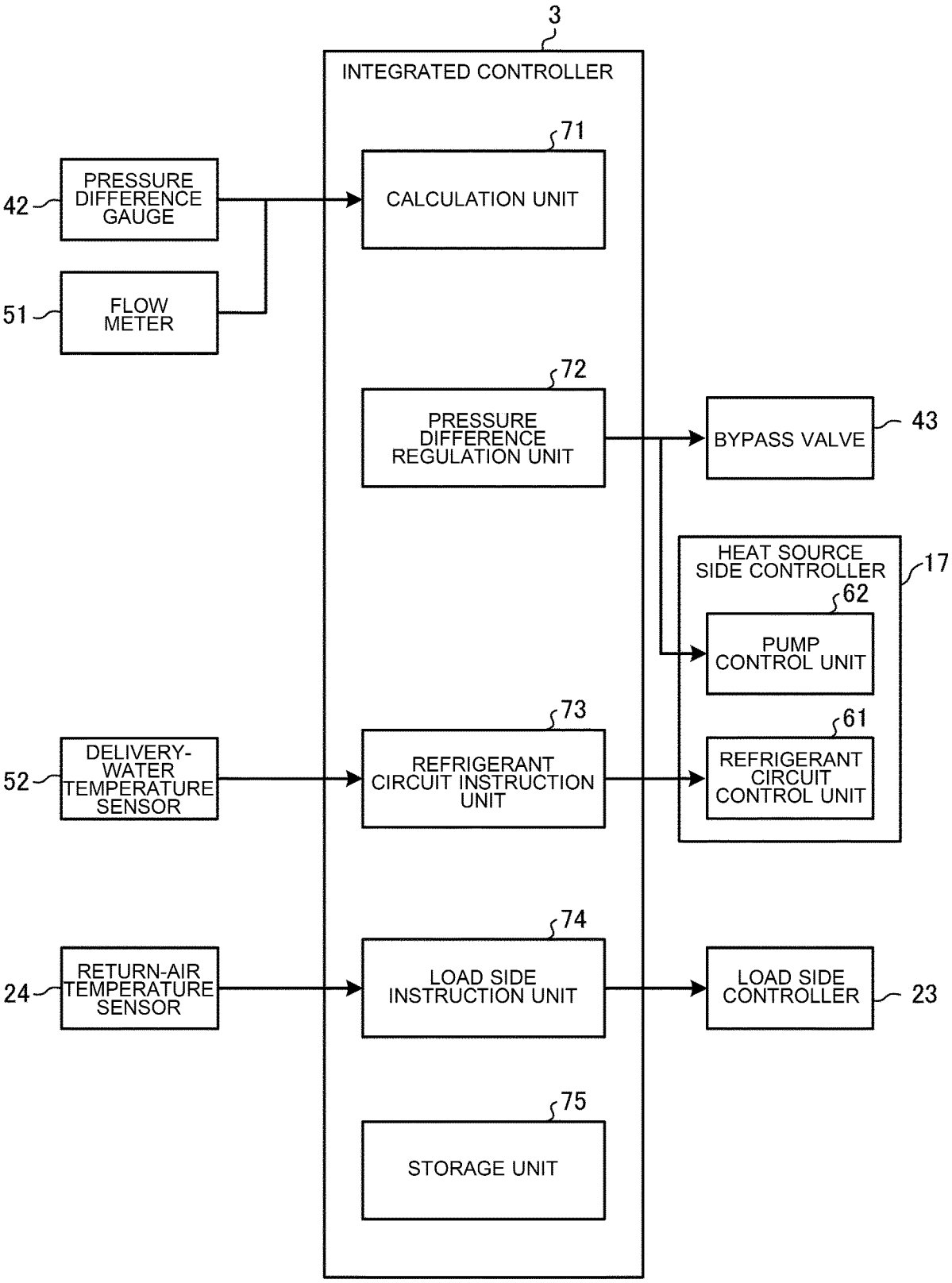

3
INTEGRATED CONTROLLER
71
CALCULATION UNIT
42
PRESSURE DIFFERENCE GAUGE
51
FLOW METER
72
PRESSURE DIFFERENCE REGULATION UNIT
BYPASS VALVE
43
HEAT SOURCE SIDE CONTROLLER
17
62
PUMP CONTROL UNIT
61
REFRIGERANT CIRCUIT CONTROL UNIT
73
REFRIGERANT CIRCUIT INSTRUCTION UNIT
52
DELIVERY-WATER TEMPERATURE SENSOR
74
LOAD SIDE INSTRUCTION UNIT
24
RETURN-AIR TEMPERATURE SENSOR
LOAD SIDE CONTROLLER
23
75
STORAGE UNIT

FIG. 4

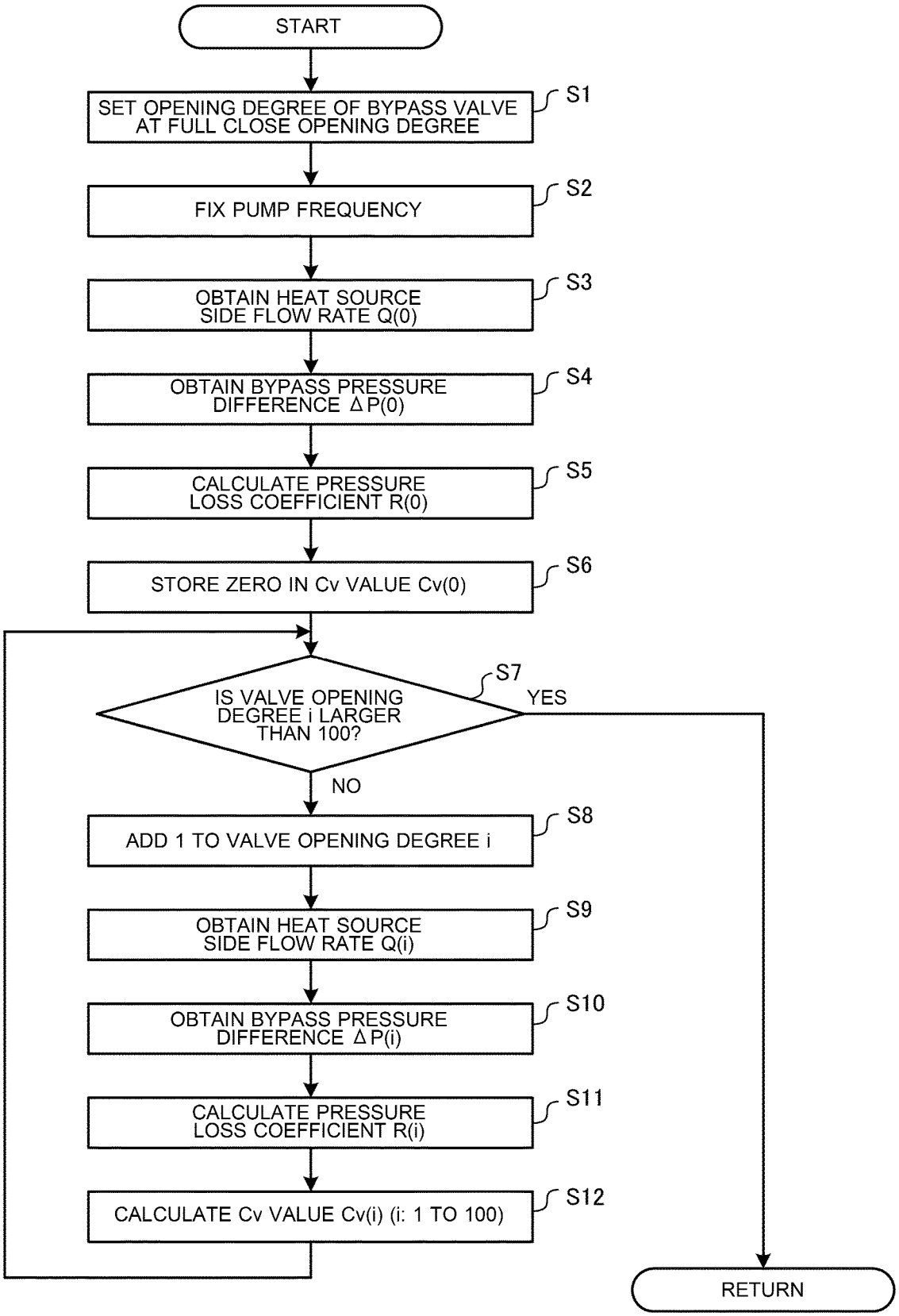

START
SET OPENING DEGREE OF BYPASS VALVE AT FULL CLOSE OPENING DEGREE
S1
FIX PUMP FREQUENCY
S2
OBTAIN HEAT SOURCE SIDE FLOW RATE Q(0)
S3
OBTAIN BYPASS PRESSURE DIFFERENCE ΔP(0)
S4
CALCULATE PRESSURE LOSS COEFFICIENT R(0)
S5
STORE ZERO IN Cv VALUE Cv(0)
S6
IS VALVE OPENING DEGREE i LARGER THAN 100?
S7
YES
NO
ADD 1 TO VALVE OPENING DEGREE i
S8
OBTAIN HEAT SOURCE SIDE FLOW RATE Q(i)
S9
OBTAIN BYPASS PRESSURE DIFFERENCE ΔP(i)
S10
CALCULATE PRESSURE LOSS COEFFICIENT R(i)
S11
CALCULATE Cv VALUE Cv(i) (i: 1 TO 100)
S12
RETURN

FIG. 5

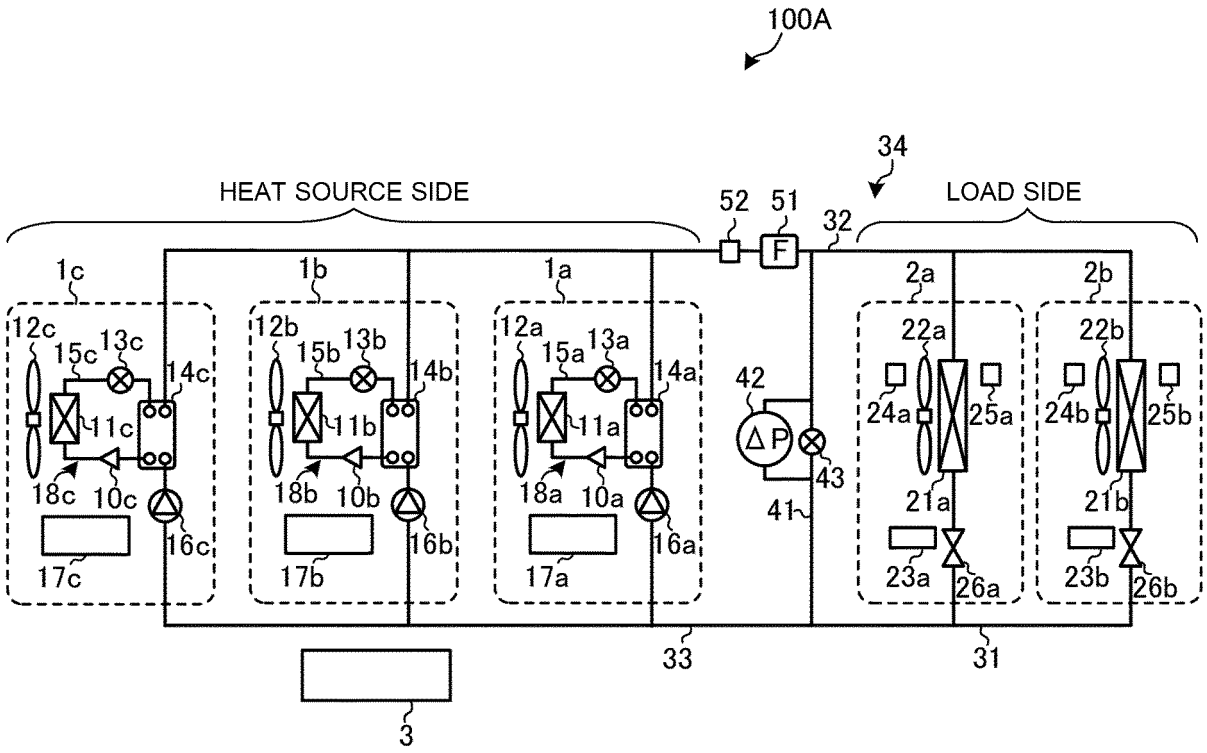

100A
34
HEAT SOURCE SIDE
LOAD SIDE
52
51
F
32
1c
1b
1a
2a
2b
12c
15c
13c
14c
11c
18c
10c
16c
17c
12b
15b
13b
14b
11b
18b
10b
16b
17b
12a
15a
13a
14a
11a
18a
10a
16a
17a
42
ΔP
43
41
22a
24a
25a
21a
23a
26a
22b
24b
25b
21b
23b
26b
33
31
3

FIG. 6

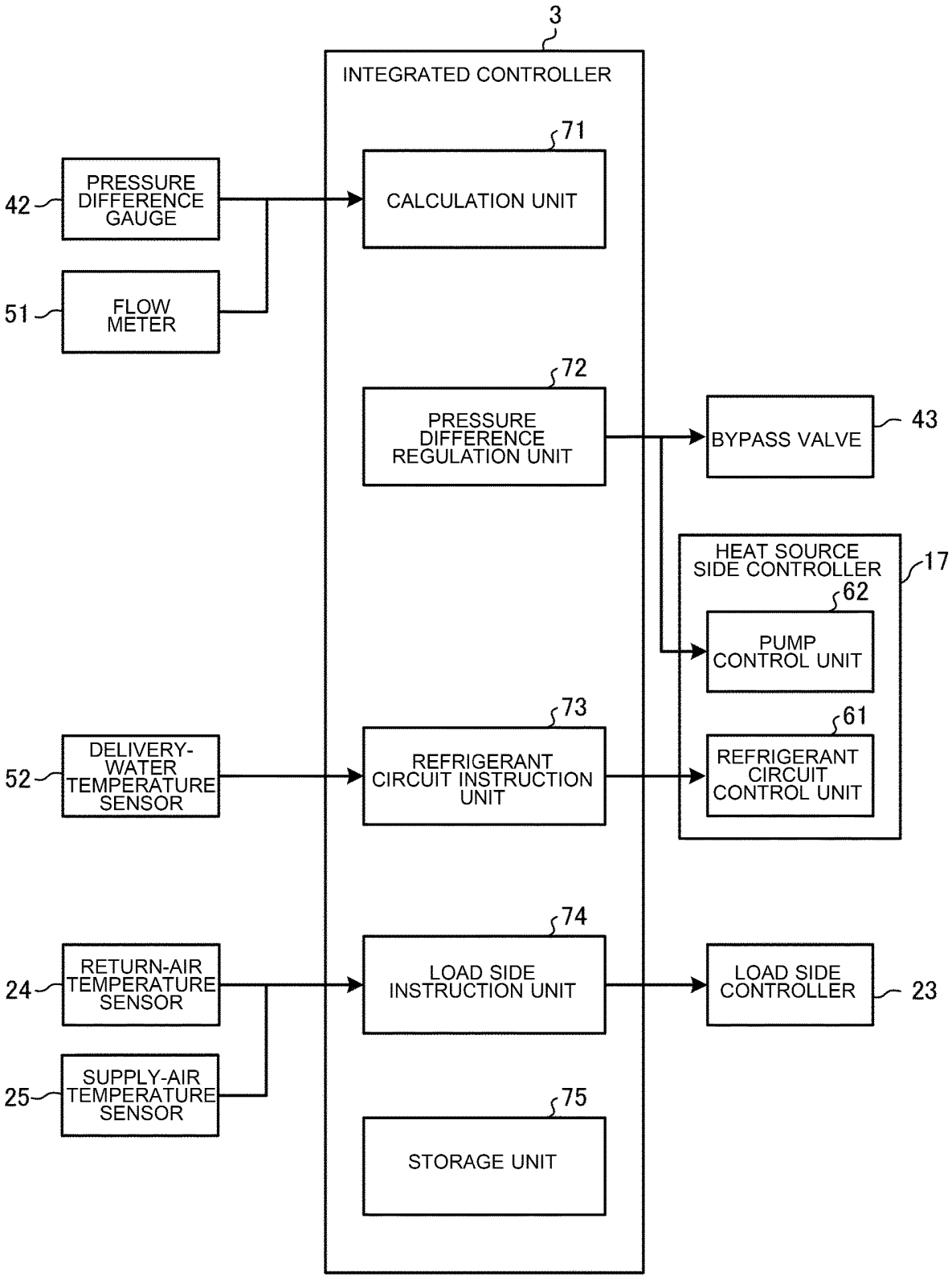
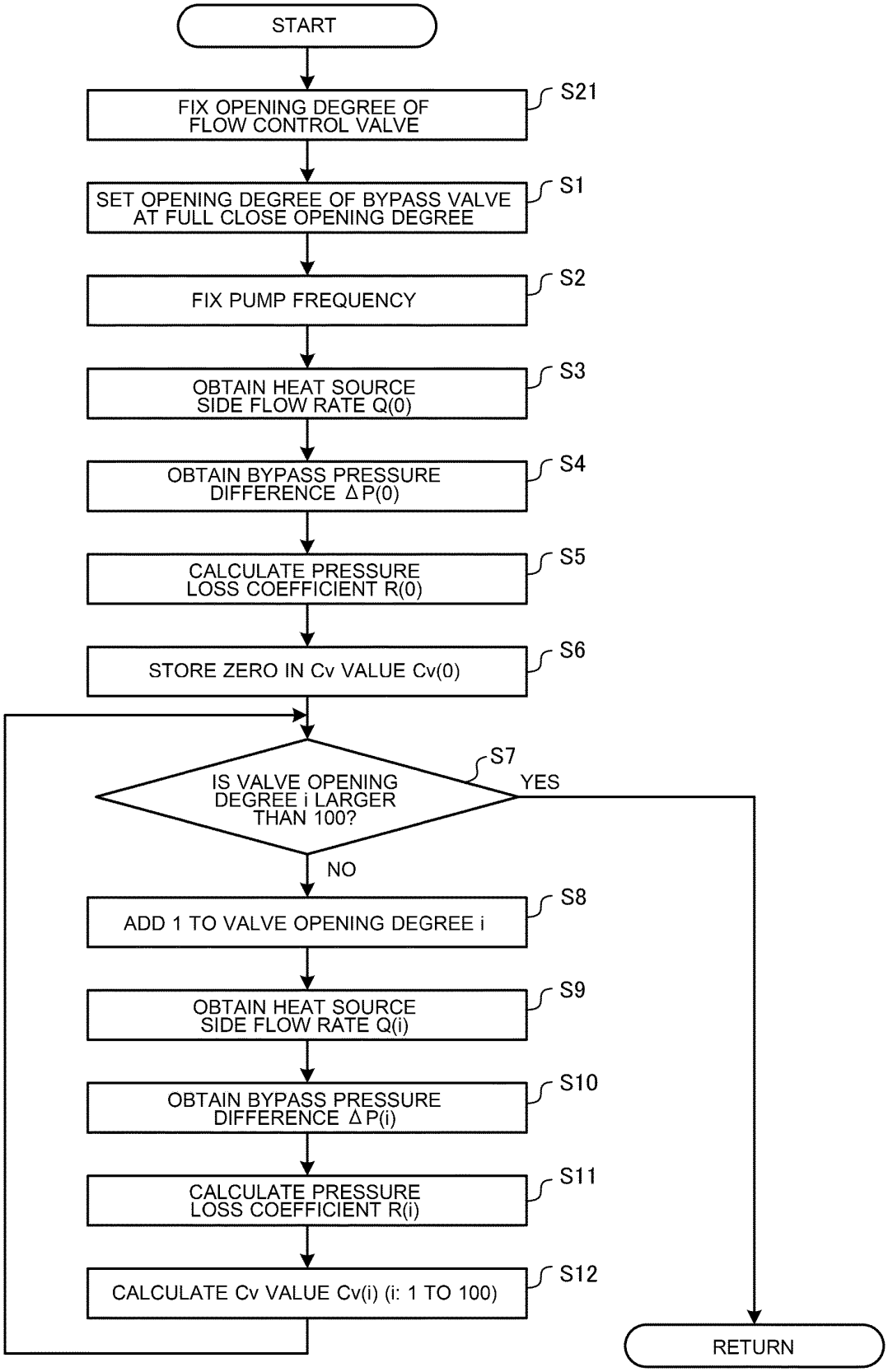

3
INTEGRATED CONTROLLER
71
CALCULATION UNIT
42
PRESSURE DIFFERENCE GAUGE
51
FLOW METER
72
PRESSURE DIFFERENCE REGULATION UNIT
BYPASS VALVE
43
HEAT SOURCE SIDE CONTROLLER
17
62
PUMP CONTROL UNIT
61
REFRIGERANT CIRCUIT CONTROL UNIT
73
REFRIGERANT CIRCUIT INSTRUCTION UNIT
52
DELIVERY-WATER TEMPERATURE SENSOR
74
LOAD SIDE INSTRUCTION UNIT
LOAD SIDE CONTROLLER
23
24
RETURN-AIR TEMPERATURE SENSOR
25
SUPPLY-AIR TEMPERATURE SENSOR
75
STORAGE UNIT

FIG. 7


START
FIX OPENING DEGREE OF FLOW CONTROL VALVE
S21
SET OPENING DEGREE OF BYPASS VALVE AT FULL CLOSE OPENING DEGREE
S1
FIX PUMP FREQUENCY
S2
OBTAIN HEAT SOURCE SIDE FLOW RATE Q(0)
S3
OBTAIN BYPASS PRESSURE DIFFERENCE ΔP(0)
S4
CALCULATE PRESSURE LOSS COEFFICIENT R(0)
S5
STORE ZERO IN Cv VALUE Cv(0)
S6
IS VALVE OPENING DEGREE i LARGER THAN 100?
S7
YES
NO
ADD 1 TO VALVE OPENING DEGREE i
S8
OBTAIN HEAT SOURCE SIDE FLOW RATE Q(i)
S9
OBTAIN BYPASS PRESSURE DIFFERENCE ΔP(i)
S10
CALCULATE PRESSURE LOSS COEFFICIENT R(i)
S11
CALCULATE Cv VALUE Cv(i) (i: 1 TO 100)
S12
RETURN

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/041566

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/49(2018.01)i
FI: F24F11/49

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F11/49

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 5-264072 A (OSAKA GAS CO., LTD.) 12 October 1993 (1993-10-12) paragraphs [0012]-[0037], fig. 1-4	1-10
A	WO 2020/012750 A1 (TOSHIBA CARRIER CORP.) 16 January 2020 (2020-01-16) entire text, all drawings	1-10
A	JP 2006-220363 A (SHIN NIPPON AIR TECHNOL. CO., LTD.) 24 August 2006 (2006-08-24) entire text, all drawings	1-10
A	WO 2013/129349 A1 (MITSUBISHI HEAVY INDUSTRIES, LTD.) 06 September 2013 (2013-09-06) entire text, all drawings	1-10

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

* Special categories of cited documents:
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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
08 December 2021	**21 December 2021**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/041566

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 5-264072 A	12 October 1993	(Family: none)	
WO 2020/012750 A1	16 January 2020	(Family: none)	
JP 2006-220363 A	24 August 2006	(Family: none)	
WO 2013/129349 A1	06 September 2013	US 2014/0360714 A1 entire text, all drawings EP 2821726 A1 CN 103958980 A KR 10-2014-0088900 A	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2018225221 A **[0003]**