

[Description]

[Title of Invention] CONTROL DEVICE, TEMPERATURE ADJUSTMENT SYSTEM, TEMPERATURE ADJUSTMENT DEVICE CONTROL METHOD, AND PROGRAM

5 [Technical Field]

[0001] The present invention relates to a control device for controlling a temperature adjustment device, a temperature adjustment system including such a control device and the temperature adjustment device, a temperature adjustment device control method, and a computer program for causing a
10 processor to execute processes for controlling the temperature adjustment device.

[Background Art]

[0002] Conventionally, as temperature adjustment devices for adjusting the temperature of a predetermined area, air conditioners having both cooling
15 and heating functions, as well as cooling devices such as refrigerators and freezers, have been widely used. In such temperature adjustment devices, a refrigerant sealed in a pipe is compressed by a compressor and decompressed by an expansion valve, and heat exchange is performed through two heat exchangers respectively disposed on a heat-absorbing side and a heat-
20 exhausting side. Heat on the heat-absorbing side is carried by the refrigerant, and the heat of the refrigerant is released on the heat-exhausting side, thereby transferring heat from the heat-absorbing side to the heat-exhausting side. When the heat-absorbing side is located indoors or inside a storage compartment, the temperature adjustment device functions as a room cooling
25 device, refrigerating device, or freezing device; whereas when the heat-exhausting side is located indoors or inside a storage compartment, the temperature adjustment device functions as a room heating device, temperature-retaining device, or heating device.

[0003] In such temperature adjustment devices, major energy consumption occurs when driving the compressor, and the amount of energy consumption is large.

PTL 1 discloses a technique for reducing energy consumption by
5 improving on/off control of the compressor in refrigerant systems, refrigeration systems, and heating systems.

[Citation List]

[Patent Literature]

[0004] [PTL 1] Japanese Patent No. 6434910

10 [Summary of Invention]

[Technical Problem]

[0005] However, in the technique disclosed in PTL 1, the rate of reduction in energy consumption has not necessarily been sufficient.

The present invention has been made in view of such circumstances,
15 and an object of the invention is to appropriately control operation of the compressor in a temperature adjustment device so as to reduce energy consumption while suppressing an influence on the temperature adjustment function. Another object is to enable such a control function to be easily added even to existing temperature adjustment devices.

20 [Solution to Problem]

[0006] In order to achieve the above object, a control device according to the invention is a control device for controlling a temperature adjustment device including a compressor, a heat exchanger, an intake section, an exhaust section, a temperature sensor, and a control section, wherein the temperature
25 adjustment device is configured to perform heat exchange on gas taken in from the intake section by the heat exchanger and to discharge the gas from the exhaust section, and the control section is configured to control operation of the compressor based on a signal supplied from the temperature sensor, the

control device comprising: an intake temperature sensor configured to be disposed at the intake section to detect a temperature of gas taken in; an exhaust temperature sensor configured to be disposed at the exhaust section to detect a temperature of gas discharged; an operation detecting part configured to detect whether the temperature adjustment device is operating; and a control signal output part configured to perform first control. The first control comprises: outputting a first control signal to the control section so as to cause the control section to perform control for stopping or driving at low speed the compressor, when a detected temperature by the intake temperature sensor has become equal to or lower than a predetermined first target temperature after at least a predetermined time has elapsed since start of operation of the temperature adjustment device; and thereafter stopping output of the first control signal to the control section when a detected temperature by the exhaust temperature sensor has become equal to or higher than a second target temperature determined based on the first target temperature.

[0007] Such a control device may be provided with a heat-exchanger temperature sensor configured to be disposed at the heat exchanger to detect a temperature of the heat exchanger, and in the first control, the control signal output part may store a detected temperature by the heat-exchanger temperature sensor when a detected temperature by the intake temperature sensor has become equal to or lower than the first target temperature after at least the predetermined time has elapsed since the start of operation of the temperature adjustment device, and thereafter the control signal output part may stop output of the first control signal to the control section when a detected temperature by the exhaust temperature sensor has become equal to or higher than the second target temperature after a detected temperature by the heat-exchanger temperature sensor has increased by a predetermined first threshold or more compared with the stored detected temperature.

[0008] Alternatively, the control signal output part may be configured to: switch between a cooling mode and a heating mode according to whether a detected temperature by the exhaust temperature sensor at a time point when the predetermined time has elapsed since the start of operation of the temperature adjustment device is equal to or higher than a predetermined second threshold; perform the first control in the cooling mode; and in the heating mode, perform second control. The second control may comprise: outputting the first control signal to the control section, when a detected temperature by the intake temperature sensor has become equal to or higher than a predetermined third target temperature after at least the predetermined time has elapsed since the start of operation of the temperature adjustment device; and thereafter stopping output of the first control signal to the control section when a detected temperature by the exhaust temperature sensor has become equal to or lower than a fourth target temperature determined based on the third target temperature.

[0009] Alternatively, the control signal output part may be configured to: switch between a cooling mode and a heating mode according to whether a detected temperature by the exhaust temperature sensor at a time point when the predetermined time has elapsed since the start of operation of the temperature adjustment device is equal to or higher than a predetermined second threshold; perform the first control in the cooling mode; and in the heating mode, perform second control. The second control may comprise: outputting the first control signal to the control section and storing a detected temperature by the heat-exchanger temperature sensor, when a detected temperature by the intake temperature sensor has become equal to or higher than a predetermined third target temperature after at least the predetermined time has elapsed since the start of operation of the temperature adjustment device; and thereafter stopping output of the first control signal to the control

section when a detected temperature by the exhaust temperature sensor has become equal to or lower than a fourth target temperature determined based on the third target temperature after a detected temperature by the heat-exchanger temperature sensor has decreased by a predetermined second threshold or more
5 compared with the stored detected temperature.

[0010] In any of the above control devices, operation in the heating mode may be switchable between a normal heating mode and a ceiling-mounted heating mode in which the third target temperature is higher than that in the normal heating mode and the fourth target temperature is the same as that in
10 the normal heating mode.

Further, in any of the above control devices, the temperature adjustment device may be configured to be driven by an AC power supply and may comprise a power supply circuit configured to supply a DC power to a remote controller of the temperature adjustment device via a terminal, and the
15 control device may be driven by the DC power supply and may comprise a connecting part configured to be electrically connected to the terminal of the temperature adjustment device.

[0011] Further, a temperature adjustment system according to the present invention comprises: any of the above control devices; and the temperature
20 adjustment device, wherein the temperature adjustment device is configured to be driven by an AC power supply and comprises a power supply circuit configured to supply a DC power to a remote controller of the temperature adjustment device via a terminal, and wherein the control device is driven by the DC power supply and is supplied with power from the terminal of the
25 temperature adjustment device.

[0012] Further, in any of the above control devices, the control signal output part may be configured to output, when stopping output of the first control signal to the control section, a second control signal to the control

section so as to cause the control section to perform control for operating the compressor at a rated operation.

Further, the control signal output part may be configured to stop output of the second control signal to the control section during a period after the
5 second control signal has been output to the control section and before the first control signal is next output to the control section.

[0013] The present invention described above can be implemented not only as the above-described control device or temperature adjustment system, but also in any form such as a system in which functions of each device are
10 distributed among a plurality of devices to operate cooperatively, a method, a computer program, a recording medium on which the computer program is recorded, or the like.

[Effect of the Invention]

[0014] According to the present invention above, operation of the
15 compressor in a temperature adjustment device can be appropriately controlled so as to reduce energy consumption while suppressing an influence on the temperature adjustment function. Further, such a control function can be easily added even to existing temperature adjustment devices.

[Brief Description of Drawings]

20 [0015] [Fig. 1] Fig. 1 is a schematic diagram illustrating a configuration of a control device 100 according to a first embodiment of the present invention, and an air conditioning device 400 which is an example of a temperature adjustment device controlled by the control device 100.

[Fig. 2] Fig. 2 is a diagram illustrating a hardware configuration of the
25 control device 100 in more detail.

[Fig. 3] Fig. 3 is a diagram illustrating an example of a screen displayed on an operation panel 120.

[Fig. 4] Fig. 4 is a flowchart illustrating processing executed by a CPU

101 of the control device 100.

[Fig. 5] Fig. 5 is a flowchart illustrating processing subsequent to that shown in Fig. 4.

[Fig. 6] Fig. 6 is a flowchart illustrating a modification example of the
5 processing shown in Fig. 4.

[Fig. 7] Fig. 7 is a diagram corresponding to Fig. 1, schematically illustrating a configuration of a control device 100 according to a second embodiment of the present invention, and an air conditioning device 400 which is an example of a temperature adjustment device controlled by the control
10 device 100.

[Fig. 8] Fig. 8 is a diagram corresponding to Fig. 2, illustrating a hardware configuration of the control device 100 of the second embodiment in more detail.

[Fig. 9] Fig. 9 is a diagram corresponding to Fig. 3, illustrating an
15 example of a screen displayed on an operation panel 120 of the second embodiment.

[Fig. 10] Fig. 10 is a diagram corresponding to Fig. 9, illustrating an example of a screen displayed on an operation panel 120 in a modification example.

20 [Description of Embodiments]

[0016] [First Embodiment: Fig. 1 to Fig. 5]

Hereinafter, embodiments of the present invention will be described with reference to the drawings.

First, Fig. 1 schematically illustrates a configuration of a control device
25 100 according to a first embodiment of the present invention, and an air conditioning device 400 which is an example of a temperature adjustment device controlled by the control device 100.

The air conditioning device 400 (hereinafter referred to as “air

conditioner”) shown in Fig. 1 includes an indoor unit 200 and an outdoor unit 300. The indoor unit 200 is normally installed in an indoor location in a space within a building wall 500 where room temperature (i.e., the temperature of air as a gas) is to be adjusted. The outdoor unit 300 is installed in an outdoor location. Fig. 1 mainly illustrates components of the air conditioner 400 that are related to temperature adjustment.

[0017] The control device 100 is an apparatus installed in addition to the air conditioner 400, and provided with a function of controlling operation of a compressor 311 of the air conditioner 400 according to an algorithm different from that of a control section 220 on the side of the air conditioner 400.

The air conditioner 400 includes a refrigerant circuit 410 extending across the indoor unit 200 and the outdoor unit 300. The refrigerant circuit 410 is a closed circuit filled with a refrigerant and can be configured, for example, so that the refrigerant circulates to perform a vapor-compression refrigeration cycle.

[0018] The refrigerant circuit 410 includes, on the side of the outdoor unit 300, a compressor 311, a four-way valve (four-port switching valve) 312, an outdoor heat exchanger 313, and an expansion valve (pressure-reducing valve) 314, and includes, on the side of the indoor unit 200, an indoor heat exchanger 211. These components are connected by a refrigerant pipe 310, and a refrigerant is sealed inside the pipe.

The discharge side of the compressor 311 is connected to a first port P1 of the four-way valve 312, and the suction side thereof is connected to a third port P3 of the same valve.

[0019] During cooling operation, as indicated by the solid lines in the figure, the four-way valve 312 connects the first port P1 to a second port P2 and also connects the third port P3 to a fourth port P4. As a result, a circulation path is formed such that a refrigerant discharged from the compressor 311

passes sequentially through the outdoor heat exchanger 313, the expansion valve 314, and the indoor heat exchanger 211, and then returns to the suction side of the compressor 311.

During heating operation, as indicated by the phantom lines in the figure, the four-way valve 312 connects the first port P1 to the fourth port P4 and also connects the second port P2 to the third port P3. As a result, a circulation path is formed such that a refrigerant discharged from the compressor 311 passes sequentially through the indoor heat exchanger 211, the expansion valve 314, and the outdoor heat exchanger 313, and then returns to the suction side of the compressor 311.

[0020] Of these components, the compressor 311 compresses the refrigerant taken in and discharges it. Any type, such as a fixed displacement type or a variable displacement type, may be used.

In the outdoor heat exchanger 313, the refrigerant exchanges heat with outdoor air that is taken in through a ventilation port 316, as indicated by arrow A, by an outdoor fan 321. The air after the heat exchange is discharged from the ventilation port 316, as indicated by arrow B.

The expansion valve 314 decompresses a high-pressure liquid refrigerant to a state suitable for evaporation, thereby converting it into a low-pressure refrigerant liquid. Any type, such as a capillary tube, a thermostatic expansion valve, or an electronic expansion valve, may be used.

[0021] In the indoor heat exchanger 211 on the side of the indoor unit 200, the refrigerant exchanges heat with indoor air taken in through an intake port 214 by an indoor fan 212. The indoor fan 212, for example, by rotating an impeller having blades forwardly curved in the direction of rotation, draws air through the intake port 214 as indicated by arrow C and discharges air having undergone heat exchange from the exhaust port 215 as indicated by arrow D. As a result, indoor air is taken into the indoor unit 200, and air whose

temperature and the like have been adjusted is discharged into the room.

[0022] With the above components, during cooling operation, when the compressor 311 is driven, the outdoor heat exchanger 313 functions as a condenser (heat radiator), and the indoor heat exchanger 211 functions as an evaporator, thereby performing a refrigeration cycle. In this case, a refrigerant discharged from the compressor 311 flows to the outdoor heat exchanger 313 to release heat to the outdoor air. The refrigerant that has released heat is expanded (decompressed) while passing through the expansion valve 314 and then flows to the indoor heat exchanger 211. In the indoor heat exchanger 211, the refrigerant absorbs heat from the indoor air and evaporates, and the cooled indoor air is supplied into the room. The evaporated refrigerant is then drawn into the compressor 311 and compressed.

[0023] During heating operation, when the compressor 311 is driven, the indoor heat exchanger 211 functions as a condenser (heat radiator), and the outdoor heat exchanger 313 functions as an evaporator, thereby performing a refrigeration cycle. In this case, a refrigerant discharged from the compressor 311 flows to the indoor heat exchanger 211 and releases heat to the indoor air. As a result, heated indoor air is supplied into the room. The refrigerant that has released heat expands (is decompressed) while passing through the expansion valve 314. The refrigerant expanded by the expansion valve 314 flows to the outdoor heat exchanger 313, absorbs heat from the outdoor air, and evaporates. The evaporated refrigerant is then drawn into the compressor 311 and compressed.

[0024] The operations of the above components are controlled by a control section 220 provided on the side of the indoor unit 200. The control section 220 may be a computer including a processor and a memory, a dedicated control circuit, or a combination thereof.

The control section 220 controls operations of the respective

components of the air conditioner 400, including both the indoor unit 200 side and the outdoor unit 300 side, by transmitting control signals C1 to Cn to the respective components based on detection signals from sensors provided in the components of the air conditioner 400. Between the indoor unit 200 and the outdoor unit 300, signal lines (not shown) are wired to transmit these control signals.

[0025] In Fig. 1, representative examples of control signals are illustrated, including a control signal C1 for the compressor 311, a control signal C2 for the outdoor fan 321, a control signal C3 for the four-way valve 312, a control signal C4 for the expansion valve 314, and a control signal C5 for the indoor fan 212. However, the control signals are not limited to these examples. As for the sensors, a temperature sensor 213 provided near the intake port 214 and configured to detect the temperature of intake air C is shown as a sensor relevant to the characteristics of this embodiment, but the sensors are not limited thereto.

[0026] When only the air conditioner 400 is installed, wiring is made so that a detection signal Tin from the temperature sensor 213 is input to a Tin terminal of the control section 220. However, in this embodiment, when the control device 100 is installed, wiring is made so that the detection signal Tin from the temperature sensor 213 is input to the control device 100, and a control signal Tinx output from the control device 100 is input to the Tin terminal of the control section 220. The significance of this wiring will be described later in detail.

[0027] The air conditioner 400 is configured to be driven by power supplied from an AC power supply 510 provided in a building to a power supply circuit 230 provided in the indoor unit 200. The power supply circuit 230 appropriately adjusts the voltage and current of electric power supplied from the AC power supply 510, and converts the power into DC as necessary,

to supply required electric power to respective components of the indoor unit 200. The indoor unit 200 and the outdoor unit 300 are connected by power lines (not shown), and the power supply circuit 230 also supplies necessary electric power to respective components on the side of the outdoor unit 300.

- 5 [0028] The air conditioner 400 is provided also with a remote controller 240, which is connected to the control section 220 via a signal line 222. A user can operate the air conditioner 400 by manipulating the remote controller 240 to issue various operation commands to the control section 220, such as turning the power on or off, switching between cooling and heating, and setting a target
10 temperature for cooling or heating.

Here, the remote controller 240 is driven by DC power. The power supply circuit 230 supplies DC power to a DC power terminal 231 of the indoor unit 200. By connecting a power line 241 of the remote controller 240 to the DC power terminal 231, the remote controller 240 can receive power from the
15 indoor unit 200 and operate.

[0029] Next, the configuration of the control device 100 and its peripheral components will be described.

The control device 100 receives detection signals T1 to T3 respectively from an intake temperature sensor 111, an exhaust temperature sensor 112, and
20 a heat-exchanger temperature sensor 113, and receives a detection signal E1 indicating an operating state of the power supply circuit 230. The control device 100 has a function of controlling operation of the compressor 311 provided in the air conditioner 400 in accordance with these signals.

[0030] The intake temperature sensor 111 is a sensor configured to be
25 disposed at an intake section through which intake air C passes, near the intake port 214 of the indoor unit 200, to detect a temperature of the intake air C.

The exhaust temperature sensor 112 is a sensor configured to be disposed at an exhaust section through which exhaust air D passes, near the

exhaust port 215 of the indoor unit 200, to detect a temperature of the exhaust air D.

The heat-exchanger temperature sensor 113 is a sensor configured to be disposed in contact with, or near or inside, the indoor heat exchanger 211 to detect a temperature of the indoor heat exchanger 211.

As these temperature sensors, any type may be used, whether contact-type or non-contact-type, such as a thermistor, a thermocouple, or an infrared sensor.

[0031] Regarding the operating state of the power supply circuit 230, it can be detected, for example, by installing a current sensor 114 in a circuit of the power supply circuit 230 that supplies power to respective components of the refrigerant circuit 410, so as to detect whether the power supply circuit 230 is in a state of supplying power for cooling or heating operation, that is, whether cooling or heating is being performed. In other words, the current sensor 114 is installed at a position in the power supply circuit 230 where such detection can be performed. The current sensor 114 may be, for example, of a magnetic type, but any other type may also be used.

[0032] As described above, the control device 100 is connected via a signal line to the control section 220 of the indoor unit 200 so that a control signal T_{inx} can be input to the control section 220.

An operation panel 120 is an operation unit for operating the control device 100 and is connected to the control device 100 via an appropriate communication path, which may be wired or wireless.

[0033] The control device 100 described above itself constitutes an embodiment of the control device according to the present invention. Alternatively, any configuration that includes any of the intake temperature sensor 111, the exhaust temperature sensor 112, the heat-exchanger temperature sensor 113, and the current sensor 114, or that includes signal lines

or a wireless communication unit for connecting to these sensors, also constitutes an embodiment of the control device according to the present invention. Of course, the control device 100 may further include the operation panel 120.

5 Furthermore, an air conditioning system including the control device 100 and the air conditioner 400 constitutes an embodiment of the temperature adjustment system according to the present invention.

[0034] Next, the hardware configuration of the control device 100 will be described in more detail.

10 Fig. 2 is a diagram illustrating a hardware configuration of the control device 100.

 As shown in Fig. 2, the control device 100 is a computer including a CPU 101, a memory 102, a communication interface 103, a notifying unit 104, an input/output (I/O) interface 105, a switch (SW) control unit 106, and a DIP
15 switch 107, which are connected to each other via a system bus 108. The control device 100 also includes a relay switch 109.

[0035] The CPU 101 is a processor that realizes various functions, including a function of controlling the operation panel 120 and a function of controlling operation of the compressor 311, by executing computer programs
20 stored in the memory 102.

 The memory 102 is a storage unit that stores computer programs executed by the CPU 101 and various parameters used by the CPU 101, and also functions as a work memory.

[0036] The communication interface 103 is an interface for
25 communicating with the operation panel 120, and may be either wired or wireless. The communication interface 103 may also have a function of communicating with other devices.

 The notifying unit 104 has a function of providing various notifications

to a user by means such as light or sound, and includes, for example, an LED (light-emitting diode) and a speaker. When the notification function provided by the operation panel 120 is sufficient, the notifying unit 104 may be omitted.

[0037] The input/output interface 105 has a function of receiving detection
5 signals T1 to T3, E1, and Tin from various sensors shown in Fig. 1, and outputting a control signal Tinx to the control section 220. The signal lines corresponding to these signals include not only signal lines for signal transmission in the directions indicated by the arrows in the drawings, but also, as necessary, signal lines for signal transmission in the opposite directions
10 (such as control signals to sensors) and power supply lines for supplying power.

[0038] The SW control unit 106 has a function of controlling operation of the relay switch 109.

The DIP switch 107 is a switch for receiving a setting related to operation of the control device 100 that are not frequently changed and that are
15 not intended to be changed by the user. In this example, the DIP switch 107 is used to set on/off of a ceiling installation mode described later.

[0039] The relay switch 109 is a switch that is configured to connect the terminal-a side to an output line for the control signal Tinx when no control signal is supplied (including a case in which the control device 100 itself is not
20 operating), as indicated by a solid line, and connects the terminal-b side to the output line for the control signal Tinx while a switching signal is supplied from the SW control unit 106, as indicated by a phantom line. A switch other than a relay type may also be used.

[0040] While the relay switch 109 selects the terminal-a side, a detection
25 signal Tin from the temperature sensor 213 provided in the air conditioner 400 is directly supplied to the output line for the control signal Tinx. As described above, this output line is connected to the Tin terminal of the control section 220 to which the detection signal Tin is normally supplied. Accordingly, in this

state, the control section 220 controls operation of the compressor 311 based on the detection signal T_{in} from the temperature sensor 213 in exactly the same manner as when the control device 100 is not present, and the control device 100 has no influence on the operation of the compressor 311. Since this state is established when the control device 100 itself is not operating, even if the control device 100 becomes inoperative due to a failure or the like, the air conditioner 400 simply performs its original operation, and there is no particular problem other than that the effect of the control device 100 cannot be obtained.

10 [0041] On the other hand, while the relay switch 109 selects the terminal-b side, a control signal output from the T_{inx} terminal of the input/output interface 105 is supplied to the output line for the control signal T_{inx} . In this state, the control device 100 can affect the operation of the compressor 311. However, in the example described here, the control algorithm executed by the control section 220 is not changed. Instead, the control device 100 indirectly controls the operation of the compressor 311 by inputting to the control section 220 a signal that simulates the detection signal T_{in} from the temperature sensor 213 and indicates a temperature different from the actual detected temperature.

15 [0042] For example, during a cooling operation, it can be expected that, in almost all models of the air conditioner 400, when the detected temperature by the temperature sensor 213 is extremely low (to the extent that no error occurs), the control section 220 determines that further cooling is unnecessary and thus stops the compressor 311 or drives it at a low speed. Accordingly, by outputting from the T_{inx} terminal a signal indicating such a temperature

20 detection result, the control section 220 can be caused to perform control to stop the compressor 311 or drive it at a low speed, regardless of the detected temperature indicated by the detection signal T_{in} from the temperature sensor 213, thereby stopping the compressor 311 or driving the compressor 311 at a

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low speed. The control signal for this purpose is referred to as a first control signal (compressor stop signal).

In the following description, explanation will be made only for the control in which the compressor 311 is stopped. However, similar energy savings can also be achieved in cases where the compressor 311 is driven at a low speed instead of being stopped.

[0043] Conversely, by outputting from the Tinx terminal a signal indicating that the detected temperature by the temperature sensor 213 is extremely high, the control section 220 can be caused to perform control to operate the compressor 311 at a rated operation, thereby operating the compressor 311 at the rated operation. The control signal for this purpose is referred to as a second control signal (compressor run signal). Here, the term “rated operation” refers to operation of the compressor 311 at an output level defined in the air conditioner 400 as sufficient to continuously drive the refrigeration cycle.

However, regarding the control on the running side, the control section 220 may adopt an algorithm in which the compressor 311 is not immediately started at the rated operation even when the detected temperature by the temperature sensor 213 becomes high. This is because, for example, if the temperature of the refrigerant is sufficiently low, cooling may be continued without operating the compressor 311 at the rated operation.

[0044] Accordingly, in this embodiment, as will be described later with reference to Fig. 4 and Fig. 5, when it is desired to operate the compressor 311, the relay switch 109 is switched to the terminal-a side so that the compressor 311 is operated in accordance with the original control algorithm of the control section 220. This is because, among the control functions of the control device 100, it is important to reduce the energy consumption of the air conditioner 400 by stopping the compressor 311 for certain periods during which a specific

condition is satisfied, whereas the timing of operating the compressor 311 outside such periods is relatively less important.

However, as will be described later with reference to Fig. 6, an algorithm may alternatively be adopted in which the compressor 311 is
5 operated at the rated operation using the second control signal.

[0045] Further, during the heating operation as well, control of the compressor 311 can be performed in the opposite manner to that during the cooling operation.

In the case of the heating operation, it can be expected that, in almost
10 all models of the air conditioner 400, when the detected temperature by the temperature sensor 213 is extremely high (to the extent that no error occurs), the control section 220 determines that further heating is unnecessary and thus stops the compressor 311. Accordingly, by outputting from the Tinx terminal a signal indicating such a temperature detection result, the control section 220
15 can be caused to perform control to stop the compressor 311, thereby stopping the compressor 311. The control signal for this purpose is also the first control signal.

[0046] Conversely, by outputting from the Tinx terminal a signal indicating that the detected temperature by the temperature sensor 213 is
20 extremely low, the control section 220 can be caused to perform control to operate the compressor 311, thereby operating the compressor 311. The control signal for this purpose is also the second control signal. The policy regarding whether to adopt the second control signal is the same as in the case of the cooling operation.

25 [0047] It should be noted that the current, voltage, waveform, and the like of the first and second control signals may be determined based on the characteristics measured from the temperature sensor 213 when the control device 100 is installed, and the determined characteristics may be stored in the

memory 102 in accordance so that the input/output interface 105 can output signals with those characteristics.

Alternatively, the resistance value of a thermistor constituting the temperature sensor 213 provided in the indoor unit may be measured, and a resistor having a resistance value close to the measured value may be installed in the output path to adjust the characteristics of the first and second control signals. A variable resistance function capable of setting such a resistance value may be incorporated into the input/output interface 105. However, since the resistance values of thermistors incorporated in the air conditioners 400 manufactured by different manufacturers vary, when resistors are used in this manner, it is necessary, at the time of installing the control device 100, to measure the resistance value of each thermistor and install a resistor having a resistance value close to the measured value.

[0048] It should be noted that the control device 100 may be configured to operate by being supplied with power from an AC power source provided near its installation site. However, in such a configuration, a power supply circuit would be required inside the control device 100 in order to obtain a stable DC current for driving the CPU 101 and the like, which would result in an increase in the size and cost of the control device 100.

[0049] On the other hand, in many cases, the control device 100 is disposed near the indoor unit 200, and the indoor unit 200 is provided with a DC power supply terminal 231 for supplying power to the remote controller 240. Accordingly, as shown by a broken line in Fig. 1, if the control device 100 is configured to receive power supply from the DC power supply terminal 231, the internal configuration of the control device 100 can be simplified, and downsizing and cost reduction thereof can be achieved. If an unused DC power supply terminal 231 is available in the indoor unit 200, a power line can be directly connected thereto. Even if no spare terminal is available, the power

line may be branched and connected to both the control device 100 and the remote controller 240.

[0050] Next, operations performed by an operator through the operation panel 120 will be described.

5 Fig. 3 is a diagram illustrating an example of an operation screen 150 displayed on the operation panel 120.

The operation screen 150 is displayed on a touch panel provided in the operation panel 120 in accordance with instructions transmitted from the CPU 101. Fig. 3 shows a screen for setting target temperatures for cooling and heating, which is displayed in response to an operation of a setting button 181.

10 [0051] The operation screen 150 is provided with a cooling temperature setting section 160 and a heating temperature setting section 170. An operator can input a desired temperature into input fields 161 and 171 by using keys or the like displayed as a pop-up, and can set target temperatures for cooling and heating by operating change buttons 162 and 172.

The target temperatures are referenced by the control device 100, but they do not necessarily have to coincide with the set temperatures set via the remote controller 240 and referenced by the control section 220 of the air conditioner 400.

20 [0052] A bypass mode button 182 is a button for toggling on and off a bypass mode in which the relay switch 109 is kept constantly connected to the terminal-a side. During the bypass mode, the control device 100 does not affect the operation of the air conditioner 400 in any way.

[0053] A data storage button 183 is a button for toggling on and off the storage of operation logs of the control device 100. When the storage is turned on, for example, operation time, the time period during which the relay switch 109 is connected to the terminal-b side, and timings at which each determination in Fig. 4 and Fig. 5 results in a “Yes” decision, and so on are

stored in the memory 102 as operation logs. The operation logs can be read out to an external PC or the like via the communication interface 103. Further, the current sensor 114 may be configured to detect the total amount of current supplied from the power supply circuit 230 to the respective parts of the air conditioner 400, or the amount of current supplied to the compressor 311, and such detected current amounts may also be stored as operation logs. Based on the above information, the amount of energy reduction achieved by the control device 100 can be estimated by analyzing changes in energy consumption depending on whether the bypass mode is on or off.

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10 [0054] Next, processing executed by the CPU 101 of the control device 100 will be described.

Fig. 4 and Fig. 5 are flowcharts illustrating this processing. The processing shown herein is an embodiment of the temperature adjustment device control method according to the present invention. For convenience of explanation, each step of the processing is described as being executed by the control device 100.

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When the control device 100 is activated or restored from a sleep state, it starts the processing shown in the flowchart of Fig. 4.

[0055] In the processing of Fig. 4, the control device 100 first connects the relay switch 109 to the terminal-a side (S11). It should be noted that, as described above, the relay switch 109 is configured to be connected to the terminal-a side in a state where no control signal is supplied. Therefore, at the time of startup, the relay switch 109 should already be connected to the terminal-a side, and thus step S11 may be omitted.

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[0056] The control device 100 next determines whether the state of the detection signal E1, which indicates the operating state of the power supply circuit 230, is ON (operating) (S12). If the signal does not indicate that the power supply circuit 230 is operating, there is no need for the control device

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100 to control the air conditioner 400. Therefore, the control device 100 transitions to a sleep mode (S24) and terminates the processing. Even during the sleep mode, the detection signal E1 is monitored, and when it turns ON, the processing of Fig. 4 may be executed again. In the processing of step S12,
5 the CPU 101 functions as an operation detecting part.

[0057] On the other hand, if the determination in step S12 results in a “Yes” decision, the control device 100 activates the temperature sensors 111 to 113 and starts monitoring the detection signals T1 to T3 (S13). Thereafter, the control device 100 waits for a predetermined time (S14). The predetermined
10 time is set to a period during which, after the air conditioner 400 is powered ON from a state where it has not been used for a while, the compressor 311 operates for a sufficient time and the indoor unit 200 starts discharging cooled air (in the case of cooling) or heated air (in the case of heating) from the exhaust port 215. This period may be, for example, two minutes. However, if the
15 predetermined time is set longer, the time until the control of the compressor 311 by the control device 100 actually starts becomes longer, resulting in a decrease in energy-saving effect, but no other disadvantage occurs. Therefore, the predetermined time may be set to a longer period.

[0058] After waiting for the predetermined time, the control device 100
20 determines whether the detection signal T2 from the exhaust temperature sensor 112 indicates a temperature of 25°C or lower (S15). If this results in a “Yes” decision, the control device 100 determines that the indoor unit 200 is discharging cooled air, and therefore the air conditioner 400 is performing a cooling operation. In this case, the control device 100 shifts to cooling mode
25 control (first control) (S16) and proceeds to the processing of step S17 and subsequent steps.

If the determination in step S15 results in a “No” decision, the control device 100 determines that the indoor unit 200 is discharging heated air, and

therefore the air conditioner 400 is performing a heating operation. In this case, the control device 100 shifts to heating mode control (second control) (S31 in Fig. 5) and proceeds to the processing of step S32 and subsequent steps.

[0059] The temperature of 25°C used as the determination reference in step S15 is selected as a temperature that is higher than the temperature of cooled air discharged during cooling operation and lower than the temperature of heated air discharged during heating operation in most air conditioners 400 regardless of model. However, the value of the determination reference is not limited thereto. In the air conditioner 400, regardless of the set room temperature for cooling or heating and the actual room temperature, it is generally the case that the temperatures of cooled air and heated air discharged in a state where the room temperature has become relatively stable fall within limited ranges, respectively. Therefore, assuming that the state after the predetermined time of step S14 has elapsed is reached, it is normally possible to set a reference temperature such as the above-mentioned 25°C. In addition, in the determination of step S15, it is not necessary to take into account the temperature of the intake air C.

[0060] Next, in the case of the cooling mode, the control device 100 determines whether, within a predetermined upper-limit time, the temperature indicated by the detection signal T1 from the intake temperature sensor 111 (that is, the indoor temperature of the room where the indoor unit 200 is installed) has become equal to or lower than the cooling target temperature (first target temperature) set on the screen shown in Fig. 3 (S17, S18).

The predetermined upper-limit time used in step S17 is set to a period of time that is considered sufficient for the indoor temperature to reach the cooling target temperature, even when the air conditioner 400 is turned on after having been unused for a while, taking into account the predetermined time in step S14. For example, this period may be set to three minutes.

[0061] If the determination in step S18 does not result in a “Yes” decision within the upper-limit time, the determination in step S17 results in “Yes” decision, and error processing starting from step S25 is executed. Specifically, the control device 100 connects the relay switch 109 to the terminal-a side (S25), and if the number of consecutive resets is equal to or less than a predetermined number, the recontrol device 100 resets and restarts the CPU 101 (S26, S27), thereby performing a retry in consideration of cases where the detection signals from the sensors are not normally input. If the number of consecutive resets exceeds the predetermined number, the control device 100 notifies the operator of an abnormality by means of light, sound, or the like through the notification section 104, and the processing is terminated (S28). In such a case, since it is possible that the air-conditioning function of the air conditioner 400 is not operating properly or that there is a malfunction in the sensors on the control device 100 side, the control device 100 is stopped.

15 [0062] On the other hand, when the determination in step S18 results in a “Yes” decision, the control device 100 stores, as a temperature $T3m$, the temperature indicated by the detection signal T3 from the heat exchanger temperature sensor 113 at that point in time (S19), and switches the relay switch 109 to the terminal-b side (S20). As a result, the above-described first control signal (compressor stop signal) is output from the Tinx terminal of the input/output interface 105 to the control section 220. It is expected that, when the first control signal is input, the control section 220 stops the compressor 311.

20 [0063] Thereafter, the control device 100 continues outputting the compressor stop signal until the temperature indicated by the detection signal T3 from the heat exchanger temperature sensor 113 becomes equal to or higher than $T3m + 0.5^{\circ}\text{C}$ (i.e., the temperature T3 increases by at least a first threshold value), and subsequently the temperature indicated by the detection signal T2

from the exhaust temperature sensor 112 becomes equal to or higher than the cooling target temperature + 0.5°C (second target temperature) (S21, S22). During this period, the compressor 311 remains stopped.

[0064] When the determination in step S22 results in a “Yes” decision, the control device 100 connects the relay switch 109 to the terminal-a side (S23). As a result, the detection signal T_{in} from the temperature sensor 213 provided in the air conditioner 400 is directly input to the control section 220, and the control section 220 is brought into a state in which it controls the start and stop of the compressor 311 in accordance with the original control function of the air conditioner 400.

At this point in time, since the indoor unit 200 is in a state in which it cannot discharge cooled air below the cooling target temperature, it is expected that the control section 220 will soon or immediately start the compressor 311, and it is expected that discharge of cooled air from the indoor unit 200 will be resumed.

Thereafter, the processing returns to step S17 and is repeated.

[0065] Among the above series of processes, steps S18 and S20 are for forcibly stopping the compressor 311 when the indoor temperature has reached the cooling target temperature, since no further cooling is required at that point, thereby reducing energy consumption. According to the inventors' investigation, in many models, the control algorithm originally provided in the control section 220 of the air conditioner 400 does not necessarily stop the compressor 311 at this timing for some reason, which results in higher energy consumption. However, by the control device 100 intervening in this control to stop the compressor 311, the energy consumption can be reduced.

[0066] Even when the compressor 311 is stopped, if the air conditioner 400 continues to operate, the indoor fan 212 keeps running, so the heat of the intake air C continues to be supplied to the indoor heat exchanger 211, thereby

continuously transferring heat to the refrigerant inside the refrigerant pipe 310. Accordingly, the temperature of the refrigerant gradually increases, and the heat absorption efficiency decreases. The determination in step S21 is, in effect, to determine whether the heat absorption efficiency has been maintained since
5 the time when the compressor 311 was stopped, i.e., when the room temperature reached the cooling target temperature, and to output “Yes” when the heat absorption efficiency has decreased by a certain extent. The “+0.5°C” portion may be set according to how much decrease in heat absorption efficiency is allowable.

10 [0067] Even if the heat absorption efficiency has decreased, the indoor unit 200 can still discharge exhaust air D at a temperature lower than that of the intake air C, and thus it is not necessary to immediately start the compressor 311. Here, in step S22, when the temperature of the exhaust air D actually exceeds the cooling target temperature ($+\alpha$) and it is no longer expected that
15 the room temperature can be maintained at the cooling target temperature without operating the compressor 311, the stop of the compressor 311 is released.

In this manner, the operating time of the compressor 311 can be minimized, thereby reducing the energy consumption of the air conditioner 400.

20 [0068] Note that, in the example of Fig. 4, the value of $+\alpha$ is set to +0.5°C, but this value is not limited thereto. If α is large, it is assumed that it will take a longer time for the temperature of the exhaust air D to decrease after the relay switch 109 is switched, resulting in large fluctuations in the room temperature. On the other hand, if α is small, the period during which the compressor 311 is
25 stopped becomes shorter, and the energy-saving effect is considered to be smaller. Therefore, α may be set to an appropriate value in consideration of these factors. A negative value may also be adopted.

[0069] In many cases, the determination in step S21 comes to be “Yes”

earlier than the determination in step S22. However, since the temperature of the exhaust air generally fluctuates more easily than that of the heat exchanger, by performing the determination in step S21 as well and releasing the stopping control of the compressor 311 after the determination in step S21 comes to be

5 “Yes,” it is possible to determine the release timing more accurately and thereby achieve greater energy savings. Nevertheless, it is also possible to omit the determination in step S21 and perform only the determination in step S22. In this case, the stopping control of the compressor 311 may be released at an earlier timing than in the process of Fig. 4 in some cases, but this only slightly

10 reduces the degree of energy saving and does not cause any other problem.

[0070] Even if the compressor 311 is stopped in step S20, the indoor heat exchanger 211 still retains a heat absorption capability for a while. Considering this, if the compressor 311 is stopped when the cooling target temperature is reached, the remaining cooling capacity thereafter may cause the actual room

15 temperature to temporarily become lower than the cooling target temperature. This results in a temperature drop that does not meet the user’s needs, and the energy consumed for this purpose can be regarded as wasteful.

[0071] Accordingly, in step S18, by comparing T1 with a value higher than the actual cooling target temperature, it is possible to set the room

20 temperature to a temperature that matches the user’s intention while further reducing energy consumption. The degree to which the comparison temperature should be higher than the cooling target temperature varies depending on factors such as the installation environment of the indoor unit 200 and the outdoor temperature. However, it is preferable to set the

25 temperature difference such that the room temperature (T1) reaches the cooling target temperature at or slightly before the time when the determination in step S22 comes to be “Yes.” It is expected that, in many environments, this can be achieved by setting the temperature difference to approximately 0.5°C to 2°C.

[0072] Next, the operation in the heating mode will be described. In this case, the control device 100 first determines whether a ceiling-mounted mode is set (S32). The ceiling-mounted mode is a mode in which, in consideration that warm air tends to accumulate in the upper part of the room, when the indoor unit 200 is installed on the ceiling of a room, the intake air temperature is compared with a temperature higher than the heating target temperature in step S36, in order to appropriately recognize whether the room temperature has reached the heating target temperature. That is, when the ceiling-mounted mode is set, a third target temperature is set higher than in the case where this mode is not set. Since the installation position of the indoor unit 200 is normally fixed, the setting of the ceiling-mounted mode may be made by the installer when installing the control device 100, and there is no need to change it thereafter.

[0073] In a normal heating mode that is not the ceiling-mounted mode, the control device 100 determines whether, within a predetermined upper-limit time, the temperature indicated by the detection signal T1 from the intake temperature sensor 111 (i.e., the temperature of the room where the indoor unit 200 is installed) has become equal to or higher than the heating target temperature (third target temperature) set on the screen shown in Fig. 3 (S33, S34). When the ceiling-mounted mode is set, the control device 100 similarly determines whether the temperature indicated by T1 has become equal to or higher than the heating target temperature + 3°C (third target temperature) (S35, S36). The value of “+3°C” is merely an example, and an appropriate value may be set based on factors such as the temperature difference between the vicinity of the ceiling where the indoor unit 200 is installed and an appropriate position within the room.

[0074] The predetermined upper-limit time used in steps S33 and S35 is set to a period of time that is considered sufficient for the indoor temperature

to reach the heating target temperature, even when the air conditioner 400 is turned on after having been unused for a while, taking into account the predetermined time in step S14. For example, this period may be set to three minutes. However, it is not essential that this period be identical to that used
5 in the cooling mode.

In any case, if the determination in step S34 or S36 does not result in a “Yes” decision within the upper-limit time, the determination in step S33 or S35 results in “Yes” decision, and error processing starting from step S25 is executed, as in the cooling mode.

10 [0075] On the other hand, when the determination in step S34 or S36 results in a “Yes” decision, the control device 100 stores, as a temperature $T3m$, the temperature indicated by the detection signal T3 from the heat exchanger temperature sensor 113 at that point in time (S37), and switches the relay switch 109 to the terminal-b side (S38). This operation is the same as that of
15 steps S19 and S20 in the cooling mode, and as a result, the control section 220 is expected to stop the compressor 311.

[0076] Thereafter, the control device 100 continues outputting the first control signal (compressor stop signal) until the temperature indicated by the detection signal T3 from the heat exchanger temperature sensor 113 decreases
20 below the temperature $T3m$ stored in step S37 (i.e., the temperature indicated by T3 decreases by at least a second threshold value (≈ 0)), and subsequently the temperature indicated by the detection signal T2 from the exhaust temperature sensor 112 becomes equal to or lower than the heating target temperature (fourth target temperature) (S39, S40). During this period, the
25 compressor 311 remains stopped.

[0077] When the determination in step S40 results in a “Yes” decision, the control device 100 connects the relay switch 109 to the terminal-a side (S41). As a result, as in the case of step S23 in the cooling mode, the control section

220 is brought into a state in which it controls the start and stop of the compressor 311 in accordance with the original control function of the air conditioner 400.

At this point in time, since the indoor unit 200 is in a state in which it cannot discharge warmed air above the heating target temperature, it is expected that the control section 220 will soon or immediately start the compressor 311, and it is expected that the discharge of warmed air from the indoor unit 200 will be resumed.

Thereafter, the processing returns to step S32 and is repeated.

[0078] Among the above series of controls, steps S34, S36, and S38 are for forcibly stopping the compressor 311 when the indoor temperature has reached the heating target temperature, since no further heating is required at that point, thereby reducing energy consumption. According to the inventors' investigation, in many models, the control algorithm originally provided in the control section 220 of the air conditioner 400 does not necessarily stop the compressor 311 at this timing also in its heating mode for some reason, which results in higher energy consumption. However, by the control device 100 intervening in this control to stop the compressor 311, the energy consumption can be reduced.

[0079] Even when the compressor 311 is stopped, if the air conditioner 400 continues to operate, the indoor fan 212 keeps running, so the heat of the indoor heat exchanger 211 continues to be supplied to the intake air C, thereby continuously transferring heat from the refrigerant inside the refrigerant pipe 310 to the intake air C. Accordingly, the temperature of the refrigerant gradually decreases, and the heating efficiency decreases. The determination in step S39 is, in effect, to determine whether the heating efficiency has been maintained since the time when the compressor 311 was stopped, i.e., when the room temperature reached the heating target temperature, and to output

“Yes” when the heating efficiency has decreased by a certain extent. Depending on the allowable degree of decrease in heating efficiency, a value slightly lower than $T3m$ may be used as a comparison value.

[0080] Even if the heating efficiency has decreased, the indoor unit 200
5 can still discharge exhaust air D at a temperature higher than that of the intake air C, and thus it is not necessary to immediately start the compressor 311. Here, in step S40, when the temperature of the exhaust air D actually becomes equal to or lower than the heating target temperature and it is no longer expected that the room temperature can be maintained at the heating target
10 temperature without operating the compressor 311, the stop of the compressor 311 is released.

In this manner, the operating time of the compressor 311 can be minimized, thereby reducing the energy consumption of the air conditioner 400.

[0081] Note that, in the example of Fig. 5, the comparison target for T2 in
15 step S40 is the heating target temperature itself, but this value is not limited thereto. For example, the comparison target may be the heating target temperature - β . If β is large, it is assumed that it will take a longer time for the temperature of the exhaust air D to increase after the relay switch 109 is switched, resulting in large fluctuations in the room temperature. On the other
20 hand, if β is small, the period during which the compressor 311 is stopped becomes shorter, and the energy-saving effect is considered to be smaller. Therefore, β may be set to an appropriate value in consideration of these factors. A negative value of β may also be adopted.

[0082] In many cases, the determination in step S39 comes to be “Yes”
25 earlier than the determination in step S40. The reasons why the determination in step S39 is nevertheless provided and why it may be omitted are the same as those described for the determination in step S21 in the cooling-mode operation.

[0083] Even when the compressor 311 is stopped in step S38, the indoor heat exchanger 211 still retains a heat releasing capability for a while. Considering this, if the compressor 311 is stopped when the heating target temperature is reached, a temperature rise that does not meet the user's needs
5 will occur, as in the case of cooling mode.

Accordingly, in the heating mode as well, by comparing T1 with a value lower than the actual heating target temperature in step S34, it is possible to set the room temperature to a temperature that matches the user's intention while further reducing energy consumption. The appropriate temperature
10 difference may be determined in the same manner as in the cooling mode. In the case of the ceiling-mounted mode, the comparison target in step S36 may be set to a temperature higher than that in step S34 of the normal mode.

[0084] The control device 100 described above substantially forces the compressor 311 to stop by temporarily interrupting the control of the
15 compressor 311 performed by the control section 220 of the air conditioner 400, through the processes shown in Fig. 4 and Fig. 5. Thus, by reducing the operating time of the compressor 311 compared with a case without the control device 100, the energy consumption of the air conditioner 400 can be reduced.

[0085] When installing the control device 100, it is only necessary to
20 dispose the three temperature sensors at respective positions of the indoor unit 200 and to connect the input/output interface 105 so as to intercept the signal line from the temperature sensor 213 to the control section 220. It is not necessary to modify other parts of the air conditioner 400. Therefore, installation of the control device 100 is easy, and the possibility that the
25 installation of the control device 100 causes any malfunction in the air conditioner 400 is extremely low.

[0086] Depending on the algorithm for controlling the operation of the compressor 311 originally provided in the air conditioner 400, the energy-

saving effect may be small or may not be obtained even when the control device 100 is installed. However, the possibility of such a case does not affect the usefulness of the control device 100 at all. By conducting repeated tests, it is sufficiently possible to identify, based on model numbers or manufacturing
5 years, air conditioners 400 with which the control device 100 can provide a large energy-saving effect. Therefore, by installing the control device 100 only for air conditioners 400 with such model numbers or manufacturing years, the energy-saving effect can be obtained.

[0087] [Modification Example of the First Embodiment: Fig. 6]

10 Next, a modification example of the first embodiment will be described. In this modification, when the determination in step S22 of Fig. 4 results in “Yes” decision, the control device 100 executes steps S51 to S53 of Fig. 6 instead of step S23.

 That is, when it becomes a timing at which the compressor 311 should
15 be operated, instead of causing the control section 220 to control the compressor 311 in accordance with its original control function, the control device 100 outputs a compressor run signal for causing the control section 220 to perform control to operate the compressor 311 at the rated operation (S51). At this time, the relay switch 109 remains connected to the terminal-b side, and
20 the compressor run signal is output from the Tinx terminal of the input/output interface 105.

[0088] As a result, when it becomes the timing at which the compressor 311 should be operated, the compressor 311 can be promptly operated at the rated operation, thereby enabling cooled air to be discharged before the room
25 temperature rises excessively.

 Thereafter, it is expected that operation of the compressor 311 will cause cooled air to be discharged and thereby decreasing the room temperature. In this case, after step S51, the process may proceed to step S17 in Fig. 4, and

the compressor 311 may continue the rated operation until the room temperature becomes equal to or lower than the cooling target temperature in step S18.

[0089] However, if the rated operation of the compressor 311 is forcibly
5 continued until this point in time, it may result in excessive operation of the compressor 311. Therefore it is preferable that, as shown in step S52, when the room temperature indicated by the detection signal T1 from the intake temperature sensor 111 reaches a temperature slightly higher (by a positive value X) than the cooling target temperature, the control device connects the
10 relay switch 109 to the terminal-a side (S53), thereby returning the air conditioner 400 to a state in which the control section 220 controls the compressor 311 in accordance with its original control function, and thereafter the process may proceed to step S17 in Fig. 4.

[0090] In this manner, even during the period until the determination in
15 step S18 next results in a “Yes” decision and the compressor 311 is stopped, after the room temperature has decreased to some extent, it becomes possible for the control section 220 to stop the compressor 311 as needed under its own control.

The same configuration may also be applied in the heating mode such
20 that, when the determination in step S40 results in a “Yes” decision, the control device 100 similarly outputs a compressor run signal. In this case, the corresponding determination to step S52 may be defined as “ $T1 \geq (\text{heating target temperature} - X)$?”.

[0091] [Second Embodiment: Fig. 7 to Fig. 9]

25 Next, a second embodiment of the present invention will be described. The second embodiment illustrates an example in which the control device 100 for controlling the compressor 311 is installed for an air conditioner 400 of the type in which a plurality of indoor units share a single outdoor unit. In the

description of the second embodiment, components that are common to or correspond to those in the first embodiment are designated by the same reference numerals as in the first embodiment, and explanations of the common portions will be omitted as appropriate.

5 [0092] Fig. 7 schematically illustrates a configuration of the control device 100 according to the second embodiment, and the air conditioner 400 which is an example of a temperature adjustment device controlled by the control device 100. In Fig. 7, for simplicity of illustration, only a refrigerant pipe 310, a compressor 311, an outdoor heat exchanger 313, and indoor heat exchangers
10 211a to 211c are shown as components of the refrigerant circuit 410, while illustration of the outdoor fan 321, the indoor fans 212, power supply components, and the wall 500 is omitted. The refrigerant pipe 310 is illustrated in a connection state during cooling operation. However, as in the case of Fig. 1, switching between cooling and heating operations is possible.

15 [0093] As shown in Fig. 7, the air conditioner 400 according to the second embodiment includes three indoor units 200a to 200c and one outdoor unit 300. A refrigerant circuit 410 is configured such that a refrigerant sequentially passes through the outdoor heat exchanger 313 of the outdoor unit 300 and the indoor heat exchangers 211a to 211c of the respective indoor units 200a to
20 200c. The refrigerant discharged from the compressor 311 releases heat in the outdoor heat exchanger 313, is decompressed, and then flows to the indoor heat exchangers 211a to 211c, thereby cooling the intake air C of the indoor units 200a to 200c.

[0094] Each of the indoor units 200a to 200c includes a control section
25 220a to 220c, respectively. However, among these, only the control section 220a of the indoor unit 200a is involved in controlling the outdoor unit 300. The indoor unit 200a that performs control of the outdoor unit 300 is often referred to as a “master unit,” while the other indoor units 200b and 200c are

referred to as “slave units.”

[0095] Similarly to the control section 220 of the indoor unit 200 in the first embodiment, the control section 220a of the indoor unit 200a serving as a master unit outputs control signals C1a to Cna to respective parts of the air conditioner 400, based on detection signals from sensors provided in various parts of the air conditioner 400 including both the indoor unit 200a side and the outdoor unit 300 side, thereby controlling operations of those parts. Among these control signals, those having the second subscript from 1 to $(i - 1)$ are control signals for controlling the outdoor unit 300, while those having the subscript from i to n are control signals for controlling the indoor unit 200a. The third subscript “a” indicates that the signal is an output signal from the control section 220a. Between the indoor unit 200a and the outdoor unit 300, unillustrated signal lines are wired to transmit the control signals C1a to C($i - 1$)a.

15 In addition, a remote controller 240 for operating the air conditioner 400 is connected to the control section 220a of the master unit.

[0096] On the other hand, the control sections 220b and 220c of the slave units respectively output control signals C1b to Cnb and C1c to Cnc to respective parts of the indoor units 200b and 200c, based on detection signals from sensors provided in various parts on the sides of the indoor units 200b and 200c, thereby controlling operations of those parts. Control signals C1b to C($i - 1$)b or C1c to C($i - 1$)c are not provided. The meanings of the subscripts are the same as those described for the control section 220a.

[0097] The indoor unit 200a is provided also with a temperature sensor 213a corresponding to the temperature sensor 213 in the first embodiment. When only the air conditioner 400 is installed, wiring is made such that the detection signal Tina from the temperature sensor 213a is input to the Tin terminal of the control section 220a. However, in this embodiment, when the

control device 100 is installed, the wiring is arranged such that the detection signal Tina from the temperature sensor 213a is input to the control device 100, and the control signal Tinx output from the control device 100 is input to the Tin terminal of the control section 220a. The meaning of this wiring is the same
5 as in the first embodiment.

That is, the control device 100 of the second embodiment is installed so as to supply a control signal to the control section 220a of the master unit. This corresponds to the fact that the control section 220a of the master unit controls the start and stop of the compressor 311.

10 [0098] The slave units are respectively provided with temperature sensors 213b and 213c corresponding to the temperature sensor 213, and the detection signals Tinb and Tinc from these sensors are input to the Tin terminals of the control sections 220b and 220c, respectively. However, since the control sections 220b and 220c do not participate in the control of the compressor 311,
15 these detection signals Tinb and Tinc do not affect the operation of the compressor 311.

[0099] On the other hand, as temperature sensors connected to the control device 100, an intake temperature sensor 111a, an exhaust temperature sensor 112a, and a heat exchanger temperature sensor 113a, similar to the temperature
20 sensors 111 to 113 in the first embodiment, are disposed in the indoor unit 200a which is the master unit, and detection signals T1a to T3a from these sensors are input to the control device 100. In addition, corresponding intake temperature sensors 111b and 111c, exhaust temperature sensors 112b and 112c, and heat exchanger temperature sensors 113b and 113c are respectively
25 provided in the indoor units 200b and 200c that are slave units, and the detection signals T1b to T3b and T1c to T3c from these sensors are input to the control device 100.

[0100] This configuration is to enable switching of which indoor unit 200

is used as a basis for controlling the operation of the compressor 311 based on the temperatures detected by that indoor unit. If such switching is unnecessary, it is sufficient to provide the temperature sensors only in one indoor unit (for example, the master unit).

5 Further, a human detecting sensor 130, such as an infrared or ultrasonic sensor configured to detect which of the indoor units a person is near, is also connected to the control device 100, and its detection signal H1 is input to the control device 100. However, this human detecting sensor 130 is not essential.

[0101] Fig. 8 illustrates a hardware configuration of the control device 100
10 according to the second embodiment.

As shown in Fig. 8, the input/output interface 105 has a function of receiving detection signals T1a to T3c, E1 (see Fig. 1), H1, and Tina from various sensors shown in Fig. 7, and outputting a control signal Tinx to the control section 220a.

15 [0102] The input/output interface 105 is also provided with a selector for selecting which of the detection signals from the temperature sensors, i.e., T1a to T3a, T1b to T3b, or T1c to T3c, are to be used when the control device 100 executes the process shown in Fig. 4 and Fig. 5, that is, for selecting which indoor unit's detection temperatures obtained from its temperature sensors are
20 to be used.

Other hardware components are the same as those described with reference to Fig. 2 in the first embodiment.

[0103] Next, an operation performed by an operator through the operation panel 120 will be described.

25 Fig. 9 is a diagram illustrating an example of an operation screen 150 displayed on the operation panel 120.

This operation screen 150 differs from the example shown in Fig. 3 only in that a temperature reference setting section 190 is additionally provided.

The temperature reference setting section 190 includes a window-side button 191, a center button 192, a wall-side button 193, and an automatic button 194, and only one of these buttons can be turned on at a time.

[0104] The window-side button 191, the center button 192, and the wall-side button 193 are buttons for manually selecting which of the three indoor units 200a to 200c is to be used by the control device 100 to control operation of the compressor based on the temperatures detected by the temperature sensors installed in that unit.

For example, when the indoor unit 200a is installed on the window side of the room, the indoor unit 200b in the center, and the indoor unit 200c on the wall side, it is considered that the wall-side area tends to be cooled more easily during the daytime by air conditioning, and therefore, the temperature sensor installed in the indoor unit 200c tends to output a lower temperature than that installed in the indoor unit 200a.

[0105] Accordingly, for example, when the process shown in Fig. 4 is executed based on the detection temperatures of the temperature sensors disposed in the indoor unit 200c, it is considered that the compressor 311 may be stopped even though the room temperature at the window side is still high, or that the compressor 311 may fail to resume operation even though the room temperature at the window side has risen.

Conversely, when the control is performed based on the detection temperatures of the temperature sensors disposed in the indoor unit 200a, it is considered that the compressor 311 may operate for a longer period, resulting in reduced energy-saving efficiency.

[0106] Which location should be used as a reference in order to achieve both energy-saving efficiency and a comfortable room temperature varies depending on the user's preference, the structure of the room, and the like. Therefore, in this embodiment, the user is allowed to arbitrarily select the

reference location.

[0107] The automatic button 194 is a button for setting the control to be performed based on the detection temperatures of the temperature sensors of the indoor unit that is located in the area where the largest number of people
5 are present, as determined from the detection signal of the human detecting sensor 130. By using this control, air conditioning can be performed to provide a comfortable environment for most people in the room while achieving energy saving to the extent possible without impairing the comfort of that environment.

[0108] Thus, in the control device 100 according to the second
10 embodiment, by executing the process shown in Fig. 4 and Fig. 5 based on the detection temperatures of the temperature sensors disposed in one indoor unit selected from among the three indoor units 200a to 200c, it is possible, even in an air conditioner 400 of a type in which a plurality of indoor units 200a to 200c share one outdoor unit 300, to maintain the room temperature at the set
15 temperature while reducing the operating time of the compressor 311 to achieve energy saving.

It is also considered that the process shown in Fig. 4 and Fig. 5 may be executed using an average value of the detection temperatures of all the indoor units or of a plurality of indoor units arbitrarily selected, instead of using those
20 of a specific single indoor unit. In such a case, the control can be performed based on an average condition of the room.

[0109] [Other Modification Examples: Fig. 10]

The description of the embodiments has been completed above. However, in the present invention, the specific configurations of the devices
25 or systems, the specific processing procedures, parameter values, sensor arrangements, and the applications or configurations of the temperature adjustment devices are not limited to those described in the embodiments.

[0110] For example, in the above-described embodiments, an example in

which the air conditioner 400 performs both cooling and heating operations was described, but the air conditioner 400 may perform only one of them. In this case, the control device 100 does not need to perform both cooling and heating control, and may be configured to perform only one of the cooling
5 mode control and the heating mode control corresponding to the air conditioner 400 to be controlled. That is, the determination at step S15 in Fig. 4 becomes unnecessary.

[0111] It is also not essential that switching between the heating mode and the cooling mode in the control device 100 be performed automatically, and it
10 may instead be switched manually. In this case as well, the determination at step S15 in Fig. 4 becomes unnecessary.

Furthermore, it is not essential to provide a ceiling mounted mode. In the heating mode, the temperature to be compared with T1 in steps S34 and S36 in Fig. 5 may be only one temperature. In this case, it is considered that an
15 intermediate temperature between those in steps S34 and S36 may be adopted, but the invention is not limited thereto.

[0112] When the processes at step S21 in Fig. 4 and step S39 in Fig. 5 are not performed, it is not necessary to provide the heat exchanger temperature sensor 113.

20 The numerical values such as the determination reference temperatures shown in Fig. 4 and Fig. 5 are merely examples, and the values are not limited to those used in the description.

[0113] In the above-described embodiments, an example was described in which the setting of the target temperature for heating or cooling in the control
25 device 100 through the operation panel 120 is performed independently of the setting of the heating or cooling temperature in the air conditioner 400 through the remote controller 240. However, it is also considered that the control device 100 may detect a temperature setting signal from the remote controller 240 and

automatically track the target temperature in the control device 100 to the set temperature indicated by the temperature setting signal (that is, the set temperature on the side of the air conditioner 400). This makes it possible to prevent a large difference from occurring between the set temperature on the
5 air conditioner 400 side and that on the control device 100 side, and to prevent a situation in which the control by the control device 100 fails to function properly due to a difference in set temperatures.

[0114] In this case, as shown for example in Fig. 10, automatic buttons 163 and 173 may be additionally provided in the cooling temperature setting
10 section 160 and the heating temperature setting section 170, respectively, on the operation screen 150, so that the automatic tracking of the target temperature for cooling and heating can be respectively switched on and off by toggling these buttons.

[0115] In the above-described embodiments, an example was described in
15 which the control device 100 is configured as a device to be retrofitted to the air conditioner 400. However, a control section that performs the same control as the control device 100 may be incorporated in the air conditioner 400 from the beginning. For example, this corresponds to a case where the control section 220 controls the start and stop of the compressor 311 according to the
20 same algorithm as that described with reference to Fig. 4 and Fig. 5. In this case, the output of the compressor stop signal in Fig. 4 and Fig. 5 can be regarded as a forced stop of the compressor 311, and the connection of the relay switch 109 to the terminal-a side can be regarded as the execution of switching between start and stop of the compressor 311 based on the detection
25 temperature of the temperature sensor 213.

[0116] In the above-described embodiments, an example was described in which the control device 100 refers, in the process shown in Fig. 4 and Fig. 5, to temperature sensors provided separately from the temperature sensors that

are standardly equipped in the indoor unit 200. However, for example, the temperature sensor 213 and the intake temperature sensor 111 are identical in both installation position and measurement target. Accordingly, if the control device 100 is capable of controlling the temperature sensor 213 and can
5 appropriately grasp the correspondence between its detection signal and detection temperature, it is conceivable that the control device 100 performs the process shown in Fig. 4 and Fig. 5 with reference to the detection signal from the temperature sensor 213 that is standardly provided in the indoor unit 200. The same replacement can be made for other sensors in the indoor unit
10 200 that can be similarly utilized.

[0117] In the above-described embodiments, an example was described in which the control target of the control device 100 is an air conditioner. However, the present invention is not limited thereto. The control of the operation of a compressor in a temperature adjustment device that performs
15 cooling or heating of a gas using a compressor and a heat exchanger, such as a refrigerator, a freezer, a temperature-retaining apparatus, a heating device, or the like can also be performed by a similar control device 100. Of course, the temperature adjustment device may be an apparatus that performs only one of cooling or heating. In these cases, the gas serving as the temperature
20 adjustment target is not necessarily required to be in a closed space such as a room, and an open-type refrigerator or the like can also naturally be a control target.

[0118] An embodiment of the computer program according to the present invention is a computer program for causing a computer to control required
25 hardware so as to realize the functions of the control device 100 in the above-described embodiments.

Such a computer program may be stored in advance in a ROM or another nonvolatile storage medium (such as a flash memory or an EEPROM)

provided in the computer. Alternatively, the computer program may be recorded on any nonvolatile recording medium, such as a memory card, CD, DVD, or Blu-ray disc, and supplied in that form. By installing and executing the program recorded on such a recording medium in the computer, the above-
5 described functions can be realized.

[0119] Furthermore, it is also possible to download the program to the computer from an external device connected to a network and having a recording medium in which the program is recorded or from an external device that stores the program in a storage means, and then install and execute the
10 program.

It is needless to say that the configurations of the respective embodiments and modifications described above can be combined arbitrarily as long as they are not inconsistent with each other.

[Reference Signs List]

15 [0120] 100: control device; 109: relay switch; 111, 111a to 111c: intake temperature sensors; 112, 112a to 112c: exhaust temperature sensors; 113, 113a to 113c: heat exchanger temperature sensors; 114: current sensor; 120: operation panel; 130: human detecting sensor; 150: operation screen; 160: cooling temperature setting section; 170: heating temperature setting section;
20 161, 171: input fields; 200, 200a to 200c: indoor units; 211, 211a to 211c: indoor heat exchangers; 212: indoor fan; 213: temperature sensor; 214: intake port; 215: exhaust port; 220: control section; 222: signal line; 230: power supply circuit; 231: DC power terminal; 240: remote controller; 241: power line; 300: outdoor unit; 310: refrigerant pipe; 311: compressor; 312: four-way
25 valve; 313: outdoor heat exchanger; 314: expansion valve; 316: ventilation port; 321: outdoor fan; 400: air conditioner; 410: refrigerant circuit; 500: wall; 510: AC power supply; A, C: intake air; B, D: exhaust air; C1 to Cn: control signals; E1: detection signal indicating operation state of power supply circuit;

H1: detection signal from human detecting sensor; T1 to T3, Tin: detection signals from temperature sensors

[Claims]

[Claim 1] A control device for controlling a temperature adjustment device including a compressor, a heat exchanger, an intake section, an exhaust section, a temperature sensor, and a control section, wherein the temperature
5 adjustment device is configured to perform heat exchange on gas taken in from the intake section by the heat exchanger and to discharge the gas from the exhaust section, and the control section is configured to control operation of the compressor based on a signal supplied from the temperature sensor,

the control device comprising:

10 an intake temperature sensor configured to be disposed at the intake section to detect a temperature of gas taken in;

an exhaust temperature sensor configured to be disposed at the exhaust section to detect a temperature of gas discharged;

an operation detecting part configured to detect whether the
15 temperature adjustment device is operating; and

a control signal output part configured to perform first control comprising:

outputting a first control signal to the control section so as to
cause the control section to perform control for stopping or driving at low
20 speed the compressor, when a detected temperature by the intake temperature sensor has become equal to or lower than a predetermined first target temperature after at least a predetermined time has elapsed since start of operation of the temperature adjustment device; and

thereafter stopping output of the first control signal to the
25 control section when a detected temperature by the exhaust temperature sensor has become equal to or higher than a second target temperature determined based on the first target temperature.

[Claim 2] The control device according to claim 1,

further comprising a heat-exchanger temperature sensor configured to be disposed at the heat exchanger to detect a temperature of the heat exchanger,

wherein, in the first control, the control signal output part stores a detected temperature by the heat-exchanger temperature sensor when a
5 detected temperature by the intake temperature sensor has become equal to or lower than the first target temperature after at least the predetermined time has elapsed since the start of operation of the temperature adjustment device; and

thereafter stops output of the first control signal to the control section when a detected temperature by the exhaust temperature sensor has
10 become equal to or higher than the second target temperature after a detected temperature by the heat-exchanger temperature sensor has increased by a predetermined first threshold or more compared with the stored detected temperature.

[Claim 3] The control device according to claim 1,

15 wherein the control signal output part is configured to:

switch between a cooling mode and a heating mode according to whether a detected temperature by the exhaust temperature sensor at a time point when the predetermined time has elapsed since the start of operation of the temperature adjustment device is equal to or higher than a predetermined
20 second threshold;

perform the first control in the cooling mode; and

in the heating mode, perform second control comprising:

outputting the first control signal to the control section, when a detected temperature by the intake temperature sensor has become
25 equal to or higher than a predetermined third target temperature after at least the predetermined time has elapsed since the start of operation of the temperature adjustment device; and

thereafter stopping output of the first control signal to

the control section when a detected temperature by the exhaust temperature sensor has become equal to or lower than a fourth target temperature determined based on the third target temperature.

[Claim 4] The control device according to claim 2,

5 wherein the control signal output part is configured to:

 switch between a cooling mode and a heating mode according to whether a detected temperature by the exhaust temperature sensor at a time point when the predetermined time has elapsed since the start of operation of the temperature adjustment device is equal to or higher than a predetermined

10 second threshold;

 perform the first control in the cooling mode; and

 in the heating mode, perform second control comprising:

 outputting the first control signal to the control section and storing a detected temperature by the heat-exchanger temperature sensor, 15 when a detected temperature by the intake temperature sensor has become equal to or higher than a predetermined third target temperature after at least the predetermined time has elapsed since the start of operation of the temperature adjustment device; and

 thereafter stopping output of the first control signal to 20 the control section when a detected temperature by the exhaust temperature sensor has become equal to or lower than a fourth target temperature determined based on the third target temperature after a detected temperature by the heat-exchanger temperature sensor has decreased by a predetermined second threshold or more compared with the stored detected temperature.

25 [Claim 5] The control device according to claim 3 or 4,

 wherein operation in the heating mode is switchable between a normal heating mode and a ceiling-mounted heating mode in which the third target temperature is higher than that in the normal heating mode and the fourth target

temperature is the same as that in the normal heating mode.

[Claim 6] The control device according to any one of claims 1 to 4,

wherein the temperature adjustment device is configured to be driven by an AC power supply and comprises a power supply circuit configured to supply a DC power to a remote controller of the temperature adjustment device via a terminal, and

wherein the control device is driven by the DC power supply and comprises a connecting part configured to be electrically connected to the terminal of the temperature adjustment device.

10 [Claim 7] A temperature adjustment system comprising: the control device according to any one of claims 1 to 4; and the temperature adjustment device,

wherein the temperature adjustment device is configured to be driven by an AC power supply and comprises a power supply circuit configured to supply a DC power to a remote controller of the temperature adjustment device

15 via a terminal, and

wherein the control device is driven by the DC power supply and is supplied with power from the terminal of the temperature adjustment device.

[Claim 8] The control device according to any one of claims 1 to 4,

wherein the control signal output part is configured to output, when stopping output of the first control signal to the control section, a second control signal to the control section so as to cause the control section to perform control for operating the compressor at a rated operation.

[Claim 9] The control device according to claim 8,

wherein the control signal output part is configured to stop output of the second control signal to the control section during a period after the second control signal has been output to the control section and before the first control signal is next output to the control section.

[Claim 10] A temperature adjustment device control method for controlling a

temperature adjustment device including a compressor, a heat exchanger, an intake section, an exhaust section, a temperature sensor, and a control section, wherein the temperature adjustment device is configured to perform heat exchange on gas taken in from the intake section by the heat exchanger and to
5 discharge the gas from the exhaust section, and the control section is configured to control operation of the compressor based on a signal supplied from the temperature sensor,

the method comprising performing first control

based on detection results obtained by: an intake temperature sensor
10 disposed at the intake section and configured to detect a temperature of gas taken in; an exhaust temperature sensor disposed at the exhaust section and configured to detect a temperature of gas discharged; and an operation detecting part configured to detect whether the temperature adjustment device is operating,

15 the first control comprising:

outputting a first control signal to the control section so as to cause the control section to perform control for stopping or driving at low speed the compressor, when a detected temperature by the intake temperature sensor has become equal to or lower than a predetermined first target
20 temperature after at least a predetermined time has elapsed since start of operation of the temperature adjustment device; and

thereafter stopping output of the first control signal to the control section when a detected temperature by the exhaust temperature sensor has become equal to or higher than a second target temperature determined
25 based on the first target temperature.

[Claim 11] The temperature adjustment device control method according to claim 10,

wherein in the first control, when stopping output of the first control

signal to the control section, a second control signal is outputted to the control section so as to cause the control section to perform control for operating the compressor at a rated operation.

[Claim 12] A computer program for causing a processor to control a
5 temperature adjustment device including a compressor, a heat exchanger, an intake section, an exhaust section, a temperature sensor, and a control section, wherein the temperature adjustment device is configured to perform heat exchange on gas taken in from the intake section by the heat exchanger and to discharge the gas from the exhaust section, and the control section is
10 configured to control operation of the compressor based on a signal supplied from the temperature sensor,

the program being configured to cause the processor to perform first control

based on detection results obtained by: an intake temperature sensor
15 disposed at the intake section and configured to detect a temperature of gas taken in; an exhaust temperature sensor disposed at the exhaust section and configured to detect a temperature of gas discharged; and an operation detecting part configured to detect whether the temperature adjustment device is operating,

20 the first control comprising:

outputting a first control signal to the control section so as to cause the control section to perform control for stopping or driving at low speed the compressor, when a detected temperature by the intake temperature sensor has become equal to or lower than a predetermined first target
25 temperature after at least a predetermined time has elapsed since start of operation of the temperature adjustment device; and

thereafter stopping output of the first control signal to the control section when a detected temperature by the exhaust temperature sensor

has become equal to or higher than a second target temperature determined based on the first target temperature.

[Claim 13] The computer program according to claim 12,

5 wherein in the first control, when stopping output of the first control
signal to the control section, a second control signal is outputted to the control
section so as to cause the control section to perform control for operating the
compressor at a rated operation.