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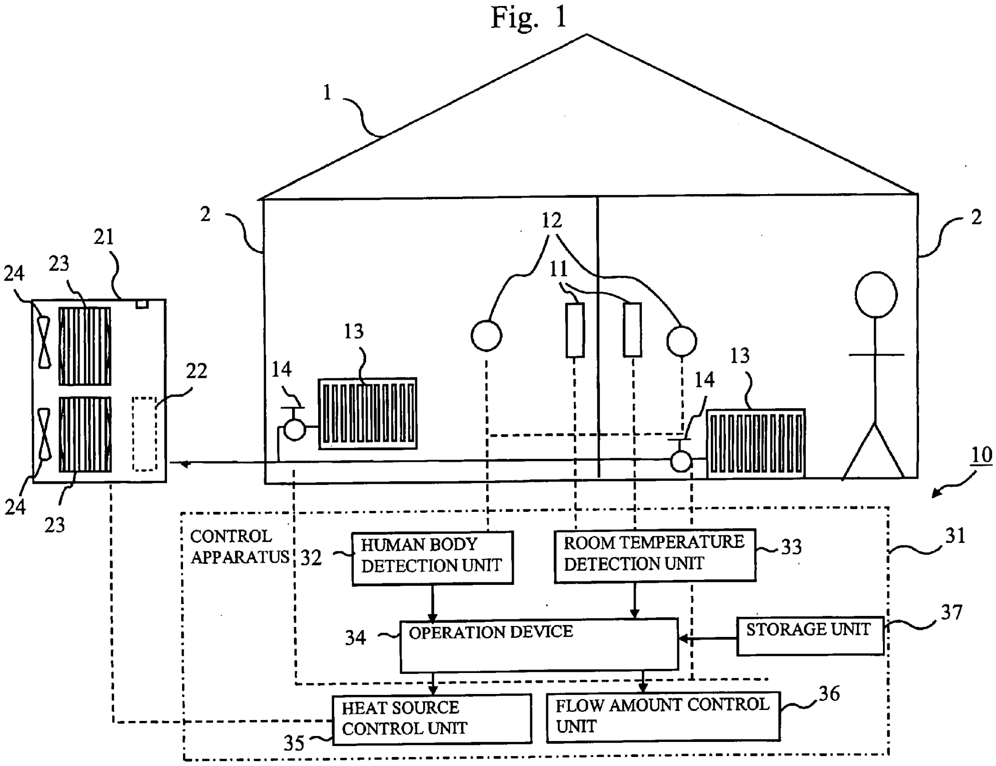
(54) **Air conditioning system and air conditioning method**

(57) A storage unit 37 of a control apparatus 31 stores the first temperature set in advance and the second temperature set to be lower than the first temperature, for each space 2. An operation device 34 of the control apparatus 31 controls at least one of an amount of heating of a fluid by a heat source unit 21 and an amount of flow of the fluid into a radiator 13 so that when a human body is detected by a human detection sensor 12, a temperature to be measured by a room temperature sensor 11 becomes the first temperature, and when no human body is detected by the human detection sensor 12, the temperature to be measured by the room temperature sensor becomes the second temperature.

Fig. 1



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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims the benefit of priority from Japanese Patent Application No. 2011-086959, filed in Japan on April 11, 2011, the content of which is incorporated herein by reference in its entirety.

Technical Field

[0002] The present invention relates to an air conditioning system and an air conditioning method. More specifically, the present invention relates to energy-saving control in a central air conditioning system based on radiation air conditioning.

Background Art

[0003] As compared with convection air conditioning that blows out warm air, radiation air conditioning creates no feeling of air flow and provides higher comfort. For that reason, the radiation air conditioning using a radiator or the like is often employed in a heating facility mainly in a cold region or the like. Conventionally, a heating facility using hot water boiled by a boiler has been generally employed.

[0004] In recent years, it has been pointed out that emission of global warming substances such as CO_2 (carbon dioxide) has caused global warming. A heat pump technology has drawn attention under such a situation. In the heat pump technology, a heat source unit utilizes atmospheric heat, thereby efficiently allowing generation of heat. In a heating system based on radiation air conditioning using a radiator, floor heating, or the like, a demand for a heat pump with a low environmental load has increased.

[0005] A control method using a human detection sensor, which may lead to energy saving, has been widespread in an air conditioning system (refer to Patent Literature 1 to 5, for example).

Citation List

Patent Literature

[0006] Patent Literature 1: JP 9-178216 A
Patent Literature 2: JP 9-184649 A
Patent Literature 3: JP 7-190457 A
Patent Literature 4: JP 3051372 U
Patent Literature 5: JP 2001-235218 A

Summary of Invention

Technical Problem

[0007] Though the radiation air conditioning provides higher comfort than the convection air conditioning, the radiation air conditioning produces no air flow. For that reason, it takes time to warm an entire room. It is a common practice to use the radiation air conditioning in such a manner that air conditioning operation is constantly performed as central air conditioning or the like to keep a room temperature to be constant.

[0008] Assume that an air conditioner is used in an ordinary house, for example. During weekday daytime, very few people are in the house, so that the number of rooms in use is limited. Accordingly, when central air conditioning is performed, excessive heating capacity is used. In a usual life pattern, rooms in use during the weekday daytime are limited spaces, such as a living room and a kitchen. A bedroom, a child room, or the like is a room usually not in use during the weekday daytime. On the other hand, a room-use pattern on a holiday is supposed to differ from that on a weekday. The presence-in-room rate of a room on the holiday is supposed to be higher than that on the weekday. Excessive heating on the holiday is supposed to be reduced from that on the weekday.

[0009] As mentioned above, the radiation air conditioning produces no air flow, so that a comfortable heating operation can be performed. However, an energy loss caused by central air conditioning occurs, and thus excessive energy is consumed.

[0010] The present invention aims at achieving energy saving while maintaining comfort of air conditioning, for example.

Solution to Problem

[0011] An air conditioning system according to one aspect of the present invention may include:

a heat source unit that heats a fluid;
a heat exchanger installed in a room, the fluid heated by the heat source unit flowing through the heat exchanger and the heat exchanger performing heat exchange between the fluid and air in the room;
a room temperature sensor that measures a temperature of the room;
a human detection sensor that detects a human body in the room; and
a control apparatus that, when a human body is detected by the human detection sensor, controls at least one of an amount of heating of the fluid by the heat source unit and an amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room sensor becomes a first temperature set in advance, and, when no human body is detected by the human detection sensor, controls the at least one of the amount of heating of the fluid by the heat source unit and the amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes a second temperature different from the first temperature. Advantageous Effects of

Invention

[0012] According to one aspect of the present invention, energy saving may be achieved while maintaining comfort of air conditioning.

Brief Description of Drawings

[0013] The present invention will become fully understood from the detailed description given hereinafter in conjunction with the accompanying drawings, in which:
[0014]

Fig. 1 is a diagram showing a configuration example of an air conditioning system according to the first embodiment;
Fig. 2 is a diagram showing a configuration example of an air conditioning system according to the second embodiment;
Fig. 3 is a diagram showing a control example of a radiator in the second embodiment; and
Fig. 4 is a diagram showing a setting example of the second temperature in the third embodiment.

Description of Embodiments

[0015] In describing preferred embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of the present invention is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.
[0016] Embodiments of the present invention will be described below using drawings.

First Embodiment

[0017] Fig. 1 is a diagram showing a configuration example of an air conditioning system 10 according to this embodiment.
[0018] Referring to Fig. 1, the air conditioning system 10 is installed in a building 1. The air conditioning system 10 includes at least one room temperature sensor 11, at least one human detection sensor 12, at least one radiator 13, and at least one flow amount adjusting valve 14. The air conditioning system 10 further includes a heat source unit 21 and a control apparatus 31.
[0019] In addition to a radiator 13 which is a load-side device, a room temperature sensor 11 and a human detection sensor 12 are mounted in a same room space 2. There are a plurality of such spaces 2 (i.e., rooms) in the building 1. A radiator 13, a room temperature sensor 11, and a human detection sensor 12 are installed in each of the plurality of spaces 2.
[0020] The radiator 13 is an example of a heat exchanger installed in a room. A fluid (i.e., a heat medium) heated by the heat source unit 21 flows through the radiator 13. The radiator 13 performs heat exchange between this fluid and air in the room, thereby warming an inside of the room. The room temperature sensor 11 measures a temperature of the room. The human detection sensor 12 detects a human body in the room.
[0021] As mentioned before, the heat source unit 21 heats the fluid to be flown into the radiator 13. Though a boiler may be employed as the heat source unit 21, a heat pump is employed as the heat source unit 21 in this embodiment in view of the environment. The heat pump heats the fluid by heat exchange between the fluid and a refrigerant circulating in the heat pump.
[0022] The heat source unit 21 includes a compressor 22 and an air heat exchanger 23 (or air heat exchangers 23). Though not shown, the heat source unit 21 further includes an expansion unit and a fluid heat exchanger. The compressor 22, the fluid heat exchanger, the air heat exchanger 23, and the expansion unit are sequentially connected to form a heat pump cycle.
[0023] The compressor 22 compresses and heats the refrigerant. When a rotational speed of the compressor 22 increases, an amount of heating of the refrigerant increases. The fluid heat exchanger uses the refrigerant heated by the compressor 22 to heat the fluid to be flown into the radiator 13. The expansion unit cools the refrigerant by expansion cooling. The air heat exchanger 23 is an example of a heat exchanger different from the radiator 13. After the refrigerant has been cooled by the expansion unit, the air heat exchanger 23 recovers heat for the refrigerant from outside air. A fan 24 is mounted on the air heat exchanger 23. When a rotational speed of the fan 24 increases, an amount of the outside air blown to the air heat exchanger 23 increases. Accordingly, the recovery amount of the heat (i.e., an amount of heating of the refrigerant) increases.
[0024] Preferably, a refrigerant with a low global warming potential is used as the refrigerant that circulates in the heat pump, in view of the environment. Specifically, it is preferable that the refrigerant with a global warming potential of 1000 or less be used. R32, HFO (Hydro-Fluoro-Olefm)-1234yf, hydrocarbon, or CO_2, for example, may be used as the refrigerant that circulates in the heat pump.
[0025] A liquid (e.g., just water) mainly composed of water is used as the fluid that circulates between the heat source unit 21 and the radiator 13. When the building 1 is located in a region where a pipe may freeze, such as a cold region, it is preferable that an antifreeze solution mainly composed of ethylene glycol be used.
[0026] The control apparatus 31 includes a human body detection unit 32, a room temperature detection unit 33, an operation device 34, a heat source control unit 35, a flow amount control unit 36, and a storage unit 37.
[0027] The human body detection unit 32 receives from the human detection sensor 12 a signal indicating whether or not a human body is detected by the human detection sensor 12, for each space 2.
[0028] The room temperature detection unit 33 re-

ceives from the room temperature sensor 11 a signal indicating a temperature measured by the room temperature sensor 11, for each space 2.

[0029] The heat source control unit 35 controls an amount of heating of the fluid by the heat source unit 21. Specifically, the heat source control unit 35 increases the rotational speed of the compressor 21 in the heat source unit 21 or the rotational speed of the fan 24, thereby increasing the amount of heating of the refrigerant in the heat pump and, as a result, increasing the amount of heating of the fluid by the heat source unit 21. Alternatively, the heat source control unit 35 reduces the rotational speed of the compressor 21 in the heat source unit 21 or the rotational speed of the fan 24, thereby reducing the amount of heating of the refrigerant in the heat pump and, as a result, reducing the amount of heating of the fluid by the heat source unit 21.

[0030] The flow amount control unit 36 controls an amount of flow of the fluid into the radiator 13. Specifically, the flow amount control unit 36 increases an opening degree of the flow amount adjusting valve 14, thereby increasing the amount of flow of the fluid into the radiator 13. Alternatively, the flow amount control unit 36 reduces the opening degree of the flow amount adjusting valve 14, thereby reducing the amount of flow of the fluid into the radiator 13.

[0031] The storage unit 37 is a memory, for example. The storage unit 37 stores a first temperature set in advance for each space 2 and a second temperature set to be lower than the first temperature, for each space 2.

[0032] The operation device 34 is a processor, for example. The operation device 34 controls the amount of heating of the fluid by the heat source unit 21 and the amount of flow of the fluid into the radiator 13, using the heat source control unit 35 and the flow amount control unit 36, based on the signal received by the human body detection unit 32 and the signal received by the room temperature detection unit 33. In this way, the operation device 34 adjusts a temperature of the room, for each space 2.

[0033] Specifically, when a human body is detected by the human detection sensor 12, the operation device 34 controls at least one of the amount of heating of the fluid by the heat source unit 21 and the amount of flow of the fluid into the radiator 13 so that the temperature to be measured by the room temperature sensor 11 becomes the first temperature stored in the storage unit 37. When the amount of heating of the fluid by the heat source unit 21 is adjusted using the heat source control unit 35, a temperature of the building 1 as a whole can be collectively adjusted. When the amount of flow of the fluid into the radiator 13 is adjusted using the flow amount control unit 36, the temperature of each individual space 2 can be finely adjusted.

[0034] Assume that the temperatures of all or most of the spaces 2 are each lower than the corresponding first temperature stored in the storage unit 37, for example. In this case, the operation device 34 first increases the amount of heating of the fluid by the heat source unit 21. Next, the operation device 34 determines whether the most recent temperature of each space 2 measured by the room temperature sensor 11 is higher or lower than the corresponding first temperature. The operation device 34 increases the amount of flow of the fluid into the radiator 13 in the space 2 whose temperature is still lower than the corresponding first temperature. On the other hand, the operation device 34 reduces the amount of flow of the fluid into the radiator 13 in the space 2 whose temperature has become higher than the corresponding first temperature.

[0035] Assume that the temperature of one or some of the spaces 2 is lower than the corresponding first temperature stored in the storage unit 37, for example. In this case, the operation device 34 increases the amount of flow of the fluid into the radiator 13 in the space 2 whose temperature is lower than the corresponding first temperature. At this time, the operation device 34 does not need to increase the amount of heating of the fluid by the heat source unit 21.

[0036] The control operation of the operation device 34 as described above is an example. The temperature of each space 2 may be adjusted by a different operation.

[0037] When no human body is detected by the human detection sensor 12, the operation device 34 controls at least one of the amount of heating of the fluid by the heat source unit 21 and the amount of flow of the fluid into the radiator 13 so that the temperature to be measured by the room temperature sensor 11 becomes the second temperature stored in the storage unit 37.

[0038] The control operation of the operation device 34 when no human body is detected by the human detection sensor 12 is similar to that when a human body is detected by the human detection sensor 12. However, the operation device 34 just adjusts the temperature of each space 2 to be the second temperature lower than the first temperature in this case. Thus, an increase in the amount of heating of the fluid by the heat source unit 21 is relatively low. Accordingly, when there is no person in a space 2, a consumption amount of energy can be kept lower than that when there is a person in the space 2. That is, while maintaining comfort by warming the entire building 1, excessive energy consumption can be avoided in the space 2 where there is no person, and thereby energy saving can be achieved.

[0039] As mentioned above, when presence of a person in a room is confirmed by the human detection sensor 12 installed in the room, information is input to the operation device 34 through the human detection unit 32 in the control apparatus 31, in this embodiment. The operation device 34 compares a room temperature detected by the room temperature sensor 11 with the set temperature, and performs control using the heat source control unit 35 and the flow amount control unit 36 to cause the room temperature to come close to the set temperature.

[0040] When the room temperature detected by the room temperature sensor 11 is lower than the set temperature, the operation device 34 controls the heat source unit 21 so that an amount of a heat source supply is increased. As major methods of increasing the amount of the heat source supply in the heat pump, the number of rotations of the compressor 22 may be increased or the number of rotations of the fan 24 mounted on the air heat exchanger 23 may be increased.

[0041] When the room temperature detected by the room temperature sensor 11 is higher than the set temperature, the operation device 34 controls the flow amount adjusting valve 14 mounted before the radiator 13 to a more closed state, thereby reducing an amount of flow of the heat medium into the radiator 13 to suppress heating capacity. In that case, the operation device 34 also sends a signal instructing to save the amount of the heat source supply, from the heat source control unit 35 to the heat source unit 21, so as to prevent heat source supply capacity of the heat source unit 21 from getting excessive. As major methods of saving the amount of the heat source supply in the heat pump, the number of rotations of the compressor 22 may be reduced or the number of rotations of the fan 24 mounted on the air heat exchanger 23 may be reduced.

[0042] On the other hand, when presence of a person in the room is not confirmed by the human detection sensor 12, the operation device 34 reduces an amount of flow of the heat medium into the radiator 13 using the flow amount adjusting valve 14. Together with that arrangement, the operation device 34 sends a signal indicating to save the amount of the heat source supply, from the heat source control unit 35, in order to maintain balance between the heat source supply capacity and capacity demanded on a load side. Execution of such control makes it possible to reduce an energy loss caused by excessive heating. When presence of a person in the room is thereafter confirmed, the operation device 34 controls the amount of flow by the flow amount adjusting valve 14 and the amount of the heat supplied by the heat source unit 21 to cause the room temperature to come close to the set temperature.

[0043] As described above, the air conditioning system 10 in this embodiment includes in the room spaces a plurality of radiation type heat exchangers (e.g., the radiators 13), adjusting valves (e.g., the flow amount adjusting valves 14) each of which adjusts an amount of flow of the heat medium into a corresponding one of the plurality of radiation type heat exchangers, the room temperature sensors 11, and the human detection sensors 12 each of which can detect a human body in a corresponding space 2 for which a corresponding one of the plurality of radiation type heat exchangers performs air conditioning. The air conditioning system 10 further includes the heat source unit 21 that generates a heat source and the control apparatus 31 that controls each device. When no human body is detected by a human detection sensor 12 in a room, the control apparatus 31 controls the temperature of the room by adjusting the amount of flow of the heat medium into a corresponding one of the plurality of radiated heat exchangers. As the heat source unit 21 that generates heat, the heat pump is employed. The compressor 22 used in the heat pump is of an inverter driven type. By adjusting the number of rotations of the compressor 22, a circulation amount of the refrigerant can be adjusted. The fan 24 with adjustable number of rotations is mounted on the heat exchanger (e.g., the air heat exchanger 23). By adjusting the number of rotations of the fan 24, a temperature of the refrigerant can be adjusted.

[0044] In the radiation air conditioning system in this embodiment, by employing the human detection sensors 12, whether or not a person is present is detected. A normal heating operation is performed for the space 2 where a person continues to be present. Control is performed for the room where no person is present so that the temperature of the room becomes lower than the target temperature of the room for which air conditioning is being performed. In this way, excessive energy consumption can be suppressed. That is, according to this embodiment, the human detection sensors 12 are provided in the radiation type central air conditioning system to detect whether or not a person is present. The temperature of each room can be thereby controlled so that excessive heating is reduced.

[0045] In this embodiment, the heat exchanger (i.e., the radiator 13) installed in each room is a heating appliance. This heat exchanger may be replaced with a cooling appliance. In that case, the second temperature is set to be higher than the first temperature.

Second Embodiment

[0046] This embodiment, mainly a difference from the first embodiment, will be described.

[0047] Fig. 2 is a diagram showing a configuration example of an air conditioning system 10 according to this embodiment.

[0048] Referring to Fig. 2, the air conditioning system 10 is different from the air conditioning system 10 in the first embodiment shown in Fig. 1 in that a forced convection generation unit 15 is provided for the radiator 13. The forced convection generation unit 15 is a fan whose rotational speed is variable, for example, and generates forced convection.

[0049] When a human body is detected by the human detection sensor 12, the operation device 34 of the control apparatus 31 operates the forced convection generation unit 15 of the radiator 13 until a temperature to be measured by a room temperature sensor 11 becomes the first temperature stored in the storage unit 37. This may promptly increase the temperature of each space 2 to the first temperature.

[0050] Assume that the temperature of a certain space 2 is lower than the corresponding first temperature stored in the storage unit 37. In this case, the operation device 34 increases at least one of an amount of heating of the fluid by the heat source unit 21 and an amount of flow of the fluid into the radiator 13 in that space 2. At this time, the operation device 34 starts the operation of the forced convection generation unit 15 of the radiator 13. Then, the operation device 34 monitors the temperature of that space 2 to be measured by the room temperature sensor 11. When the temperature of that space 2 reaches the corresponding first temperature, the operation device 34 stops the operation of the forced convection generation unit 15 of the radiator 13. Namely, after the temperature of the space 2 where a person is present reaches the first temperature, that is at a time of a normal heating operation, the operation device 34 performs only a heating operation by radiation. In this way, a feeling of air flow can be reduced. Accordingly, comfort can be maintained.

[0051] When no human body is detected by the human detection sensor 12, the operation device 34 operates in a similar manner to that in the first embodiment.

[0052] In the first embodiment, when presence of a person in a room is not confirmed by the human detection sensor 12, the operation device 34 performs control to reduce heating supply capacity. However, when presence of a person in the room is newly confirmed and then heating depending on radiation alone is performed, it takes time for the temperature of the room to reach the set temperature. Therefore, in this embodiment, the operation device 34 generates forced convection only when needed, thereby causing the temperature of the room to quickly reach the set temperature. The operation device 34 switches to air conditioning by radiation alone again when the room temperature has reached the set temperature.

[0053] Fig. 3 is a diagram showing a control example of the radiator 13.

[0054] Fig. 3 compares a relationship between whether or not a person is present and a room temperature control pattern between the case of the radiator 13 not including the forced convection generation unit 15 and the case of the radiator 13 including the forced convection generation unit 15.

[0055] Even if it is detected by the human detection sensor 12 that no person is present and then the control apparatus 31 stops supply of a heat medium to the radiator 13 (or reduces an amount of supply of the heat medium to the radiator 13), no air flow is produced. Thus, there will be a slight response delay in a change of the room temperature. In the case of the radiator 13 not including the forced convection generation unit 15, when it is detected by the human detection sensor 12 that a person is present in the room to the contrary and then the control apparatus 31 starts supply of the heat medium to the radiator 13 (or increases the amount of supply of the heat medium to the radiator 13), the same applies, that is, there will be a delay in a rise of the room temperature. However, in the case of the radiator 13 including the forced convection generation unit 15 as in this embodiment, when the control apparatus 31 starts supply of the heat medium to the radiator 13 (or increases the amount of supply of the heat medium to the radiator 13) and also generates forced convection by the forced convection generation unit 15, the room temperature rises sharply.

[0056] As mentioned above, when it is detected by the human detection sensor 12 that a person is present in the room, the heat medium is supplied to the radiator 13, and forced convection is also generated, in this embodiment. In this way, a delay in a rise of the room temperature caused by air conditioning depending on radiation alone can be reduced, and it is possible to make the room temperature quickly come close to the set temperature. After the room temperature has reached the set temperature, generation of forced convection is stopped, and heating by radiation that does not cause a feeling of air flow is continued.

[0057] As described above, when a human body is detected by the human detection sensor 12, the air conditioning system 10 in this embodiment generates forced convection using the forced convection generation unit 15 provided for the radiation type heat exchanger (e.g., the radiator 13). This may reduce a delay in room temperature control (i.e., a delay in room temperature adjustment time).

Third Embodiment

[0058] This embodiment, mainly a difference from the first embodiment, will be described.

[0059] An air conditioning system 10 in this embodiment has the same configuration as the air conditioning system 10 in the first embodiment shown in Fig. 1.

[0060] The storage unit 37 of the control apparatus 31 stores as the second temperature a temperature set in advance according to a rate at which a human body was detected by the human detection sensor 12 in the past, for each combination of each space 2 and each of time periods. The second temperature, for example, is set to be reduced in a stepwise pattern accordingly as the rate in a corresponding one of the time periods is lower (i.e., the lower the rate in the corresponding time period is, the lower the second temperature is set), for example. Alternatively, the second temperature may be set to be reduced in a continuous pattern accordingly as the rate in the corresponding time period is lower. The second temperature may be set to have a value obtained by multiplication of the rate in the corresponding time period by a predetermined factor.

[0061] When no human body is detected by the human detection sensor 12 in a certain space 2, the operation device 34 of the control apparatus 31 controls at least one of an amount of heating of the fluid by the heat source unit 21 and an amount of flow of the fluid into the radiator 13 so that a temperature to be measured by the room temperature sensor 11 becomes the second temperature stored in the storage unit 37 and corresponding to the combination of that space 2 and a current time period.

[0062] In this embodiment, when the above-mentioned rate (i.e., the rate at which a human body was detected in the space 2 by the human detection sensor 12 in the past) in the current time period is 100%, the operation device 34 performs special control. Specifically, the operation device 34 controls at least one of the amount of heating of the fluid by the heat source unit 21 and the amount of flow of the fluid into the radiator 13 so that the temperature to be measured by the room temperature sensor 11 becomes the first temperature corresponding to the combination of the space 2 and the current time period, even if no human body is detected in that space 2 by the human detection sensor 12.

[0063] In this embodiment, when the above-mentioned rate (i.e., the rate at which a human body was detected in the space 2 by the human detection sensor 12 in the past) in the current time period is 0%, the operation device 34 also performs special control. Specifically, the operation device 34 stops flow of the fluid into the radiator 13 in the space 2 if no human body is detected in that space 2 by the human detection sensor 12.

[0064] Fig. 4 is a diagram showing a setting example of the second temperature.

[0065] Generally and mostly, a human behavior pattern changes according to the day of the week. In the example of Fig. 4, the operation device 34 learns the behavior pattern of one week in the building 1, and controls a heating operation based on the behavior pattern.

[0066] The operation device 34 makes a judgment on whether or not a person is present in each room using the human detection sensor 12 mounted in each space 2. The judgment on whether or not a person is present in each room is made by the human detection sensor 12 at given times. In this example, the judgment is made for each time period of six hours for the sake of simplicity, and a result of the judgment ("presence in room" in Fig. 4) is stored in the storage unit 37 for each combination of each space 2 and each time period. Assume that a person exits a room in the middle of a six-hour time period. When duration of his presence in the room is not less than three hours that corresponds to 50% of the six-hour time period, it is judged that a person is present in the room. When duration of his presence in the room is less than the three hours, it is judged that no person is present. The judgment may also be finely made for each minute, as necessary. In that case, a result of the judgment is stored in the storage unit 37 for each minute, for each space 2.

[0067] The first temperature (the temperature set when a person is present in the room) is set to 20°C for each space 2, and is stored in the storage unit 37. The first temperature may be set to be different for each space 2. Also, the first temperature may be set to be different for each time period.

[0068] The operation device 34 evaluates a presence-in-room rate for each time period on both weekdays and weekends. The presence-in-room rate is evaluated into four grades in the ascending order: judgment D (indicating the presence-in-room rate of 0%), judgment C (indicating the presence-in-room rate in the range from 1 to 30%), judgment B (indicating the presence-in-room rate in the range from 31 to 79%), and judgment A (indicating the presence-in-room rate in the range from 80 to 100%). The result of the evaluation ("judgment" in Fig. 4) is stored in the storage unit 37 for each combination of each space 2 and each time period.

[0069] The operation device 34 sets the second temperature (the temperature set when no person is present in the room) according to the result of the evaluation of the presence-in-room rate, for each combination of each space 2 and each time period. Specifically, the second temperature is set to 20°C (i.e., the same temperature as the first temperature) when the result of the evaluation of the presence-in-room rate is the judgment A. The second temperature is set to 18°C when the result of the evaluation of the presence-in-room rate is the judgment B. The second temperature is set to 16°C when the result of the evaluation of the presence-in-room rate is the judgment C. The second temperature is stored in the storage unit 37. The second temperature is not set when the result of the evaluation of the presence-in-room rate is the judgment D.

[0070] In the case of a room X on Monday, for example, a person is in the room X from 0 to 6 o'clock, but no person is in the room X from 6 to 18 o'clock, and a person is in the room X from 18 to 0 o'clock. This cycle is repeated from Monday to Friday, which are weekdays. That is, a state of a person being present in the room and a state of no person being present is cyclically repeated. The presence-in-room rates from 18 o'clock to next day 6 o'clock are 100% from Monday to Friday. Accordingly, the presence-in-room rates in these time periods are evaluated to be the judgment A. The presence-in-room rates from 6 to 18 o'clock are 0% from Monday to Friday. Accordingly, the presence-in-room rates in these time periods are evaluated to be the judgment D. It is highly likely that a person is present in the room X in the time periods corresponding to the judgment A. Accordingly, a heating operation is continued with the set temperature being unchanged from the target temperature and kept at 20°C in these time periods, even if no person is present in the room X temporarily. On the other hand, a probability that a person is in the room X in the time periods corresponding to the judgment D is 0%. Accordingly, basically, the heating operation is not performed in these time periods, when no person is in the room X, and the room temperature is not specifically set.

[0071] A person is always in the room X on Saturday and Sunday, which are weekends. Thus, the presence-in-room rates in all of the time periods on these days are evaluated to be the judgment A. Accordingly, the heating operation is performed, constantly targeting 20°C.

[0072] In the case of a room Y, a person is in the room Y from 0 to 6 o'clock on Monday, Wednesday, and Thursday, but no person is in the room Y on Tuesday and Friday. Accordingly, the presence-in-room rate in this time period on the five weekdays is 60%, so that the presence-in-room rate in this time period on the five weekdays is evaluated to be the judgment B. Similarly, the presence-in-room rate from 6 to 12 o'clock is evaluated to be the judgment C. The presence-in-room rate from 12 to 18 o'clock is evaluated to be the judgment D. The presence-in-room rate from 18 to 0 o'clock is evaluated to be the judgment A. When no person is in the room Y in the time period corresponding to the judgment B, a heating operation is performed at the set temperature of 18°C, which is slightly lower than the normal set temperature. When no person is in the room Y in the time period corresponding to the judgment C, a heating operation is performed at the set temperature of 16°C, which is lower than 18°C.

[0073] Similarly, when no person is in the room Y on Saturday and Sunday, the heating operation is performed at the temperature that is set according to a result of evaluation of the presence-in-room rate. When presence of a person in the room Y is detected by the human detection sensor 12, the heating operation is performed at the normal set temperature of 20°C.

[0074] In this example, the presence-in-room rates are separately evaluated on the weekdays (from Monday to Friday) and the holidays (Saturday and Sunday). Alternatively, the evaluation may be performed for each day of the week.

[0075] In this embodiment, the heating system, in which it takes time to follow a fluctuation of a load such as the radiator 13, performs the heating operation with changing the target set temperature according to the presence-in-room rate of a room as described above when no person is in the room. Therefore, according to this embodiment, quantity of heat that may leak to an outside along a wall or due to ventilation can be reduced, so that an efficient heating operation can be performed. Further, deterioration of comfort that would occur when it takes a long time to follow a fluctuation of a load can be avoided as much as possible.

[0076] Hereinbefore, the embodiments of the present invention are described. Two or more of these embodiments may be combined to be carried out. Alternatively, one of these embodiments may be partially carried out. Alternatively, two or more of these embodiments may be partially combined to be carried out.

Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the disclosure of this patent specification may be practiced otherwise than as specifically described herein.

Reference Signs List

[0077]

1: building
2: space
3: air conditioning system
11: room temperature sensor
12: human detection sensor
13: radiator
14: flow amount adjusting valve
15: forced convection generation unit
21: heat source unit
22: compressor
23: air heat exchanger
24: fan
31: control apparatus
32: human body detection unit
33: room temperature detection unit
34: operation device
35: heat source control unit
36: flow amount control unit
37: storage unit

Claims

1. An air conditioning system (3) comprising:

a heat source unit (21) that heats a fluid;
a heat exchanger (13) installed in a room, the fluid heated by the heat source unit flowing through the heat exchanger and the heat exchanger performing heat exchange between the fluid and air in the room;
a room temperature sensor (11) that measures a temperature of the room;
a human detection sensor (12) that detects a human body in the room; and
a control apparatus (31) that, when a human body is detected by the human detection sensor, controls at least one of an amount of heating of the fluid by the heat source unit and an amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes a first temperature set in advance, and, when no human body is detected by the human detection sensor, controls the at least one of the amount of heating of the fluid by the heat source unit and the amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes a second temperature different from the first temperature.

2. The air conditioning system according to claim 1, wherein
the control apparatus includes a storage unit (37) that stores, as the second temperature, a temperature set in advance according to a rate at which a human body was detected by the human detection sensor in the past, for each of time periods, and, when no human body is detected by the human detection sensor, controls the at least one of the amount of heating of the fluid by the heat source unit and the amount of flow of the fluid into the heat exchanger

so that the temperature to be measured by the room temperature sensor becomes the second temperature stored in the storage unit and corresponding to a current one of the time periods.

3. The air conditioning system according to claim 2, wherein
the storage unit of the control apparatus stores, as the second temperature, a temperature set to be lower than the first temperature and to be reduced accordingly as the rate in a corresponding one of the time periods is lower.

4. The air conditioning system according to claim 3, wherein
the storage unit of the control apparatus stores, as the second temperature, a temperature set to be reduced in a stepwise pattern accordingly as the rate in the corresponding one of the time periods is lower.

5. The air conditioning system according to any one of claims 2 to 4, wherein,
when no human body is detected by the human detection sensor and the rate in the current one of the time periods is 100%, the control apparatus controls the at least one of the amount of heating of the fluid by the heat source unit and the amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes the first temperature.

6. The air conditioning system according to any one of claims 2 to 5, wherein,
when no human body is detected by the human detection sensor and the rate in the current one of the time periods is 0%, the control apparatus stops flow of the fluid into the heat exchanger.

7. The air conditioning system according to any one of claims 2 to 6, wherein
the heat exchanger is installed in each of a plurality of rooms,
the storage unit of the control apparatus stores the temperature set in advance according to the rate at which a human body was detected by the human detection sensor in the past, for each combination of each of the time periods and each of the plurality of rooms, and,
for each of the plurality of rooms, when a human body is detected by the human detection sensor, the control apparatus controls the at least one of the amount of heating of the fluid by the heat source unit and the amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes the first temperature, and, when no human body is detected by the human detection sensor, the control apparatus controls the at least one of the amount of heating of the fluid by the heat source unit and the amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes the second temperature stored in the storage unit and corresponding to the current one of the time periods.

8. The air conditioning system according to one of claims 1 to 7, wherein
the heat exchanger includes a forced convection generation unit (15) that generates forced convection, and,
when a human body is detected by the human detection sensor, the control apparatus operates the forced convection generation unit of the heat exchanger until the temperature to be measured by the room temperature sensor becomes the first temperature.

9. The air conditioning system according to any one of claims 1 to 8, wherein
the fluid is mainly composed of one of water and ethylene glycol.

10. The air conditioning system according to any one of claims 1 to 9, wherein
the heat source unit is a heat pump including a compressor (22) that compresses a refrigerant, the heat pump heating the fluid by heat exchange between the refrigerant and the fluid, and
the control apparatus controls the amount of heating of the fluid by the heat source unit by adjusting a rotational speed of the compressor.

11. The air conditioning system according to any one of claims 1 to 9, wherein
the heat source unit is a heat pump including a different heat exchanger (23) that heats a refrigerant with air blown by a fan (24), the heat pump heating the fluid by heat exchange between the refrigerant and the fluid, and
the control apparatus controls the amount of heating of the fluid by the heat source unit by adjusting a rotational speed of the fan.

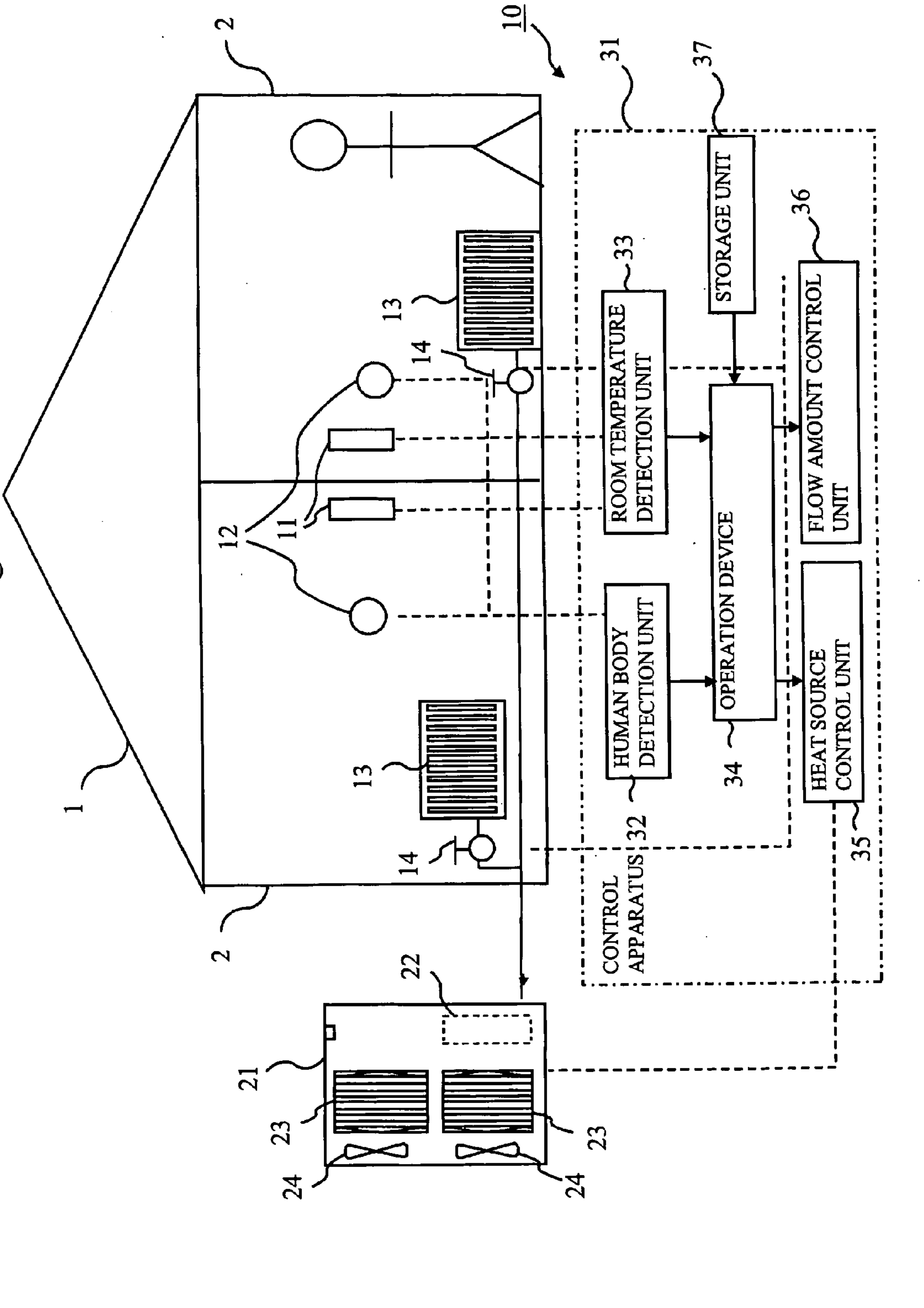
12. The air conditioning system according to claim 10 or 11, wherein
the refrigerant has a global warming potential of 1000 or less.

13. The air conditioning system according to any one of claims 10 to 12,
wherein
the refrigerant is one of R32, HFO (Hydro-Fluoro-Olefm)-1234yf, hydrocarbon, and CO_2 (carbon dioxide).

14. An air conditioning method comprising:

heating a fluid by a heat source unit (21);
performing heat exchange between the fluid heated by the heat source unit and air in a room, by a heat exchanger (13) installed in the room;
measuring a temperature of the room by a room temperature sensor (11);
detecting a human body in the room by a human detection sensor (12); and
controlling by the control apparatus (31), when a human body is detected by the human detection sensor, at least one of heating of an amount of the fluid by the heat source unit and an amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes a first temperature set in advance, and controlling by the control apparatus, when no human body is detected by the human detection sensor, the at least one of the amount of heating of the fluid by the heat source unit and the amount of flow of the fluid into the heat exchanger so that the temperature to be measured by the room temperature sensor becomes a second temperature different from the first temperature.

Fig. 1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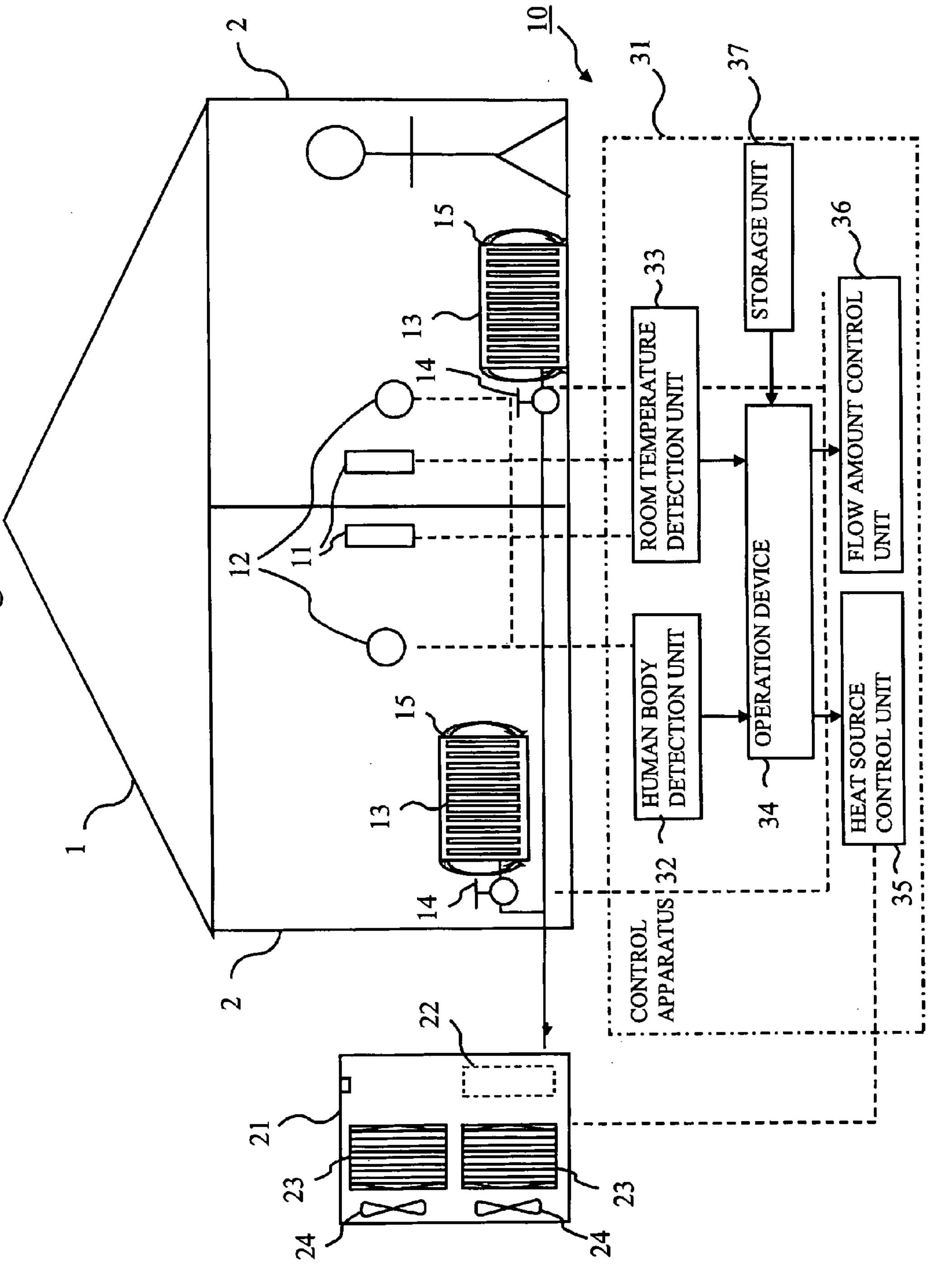
CONTROL APPARATUS
HUMAN BODY DETECTION UNIT
ROOM TEMPERATURE DETECTION UNIT
OPERATION DEVICE
STORAGE UNIT
FLOW AMOUNT CONTROL UNIT
HEAT SOURCE CONTROL UNIT

Fig. 2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CONTROL APPARATUS
HUMAN BODY DETECTION UNIT
ROOM TEMPERATURE DETECTION UNIT
OPERATION DEVICE
STORAGE UNIT
FLOW AMOUNT CONTROL UNIT
HEAT SOURCE CONTROL UNIT

Fig. 3

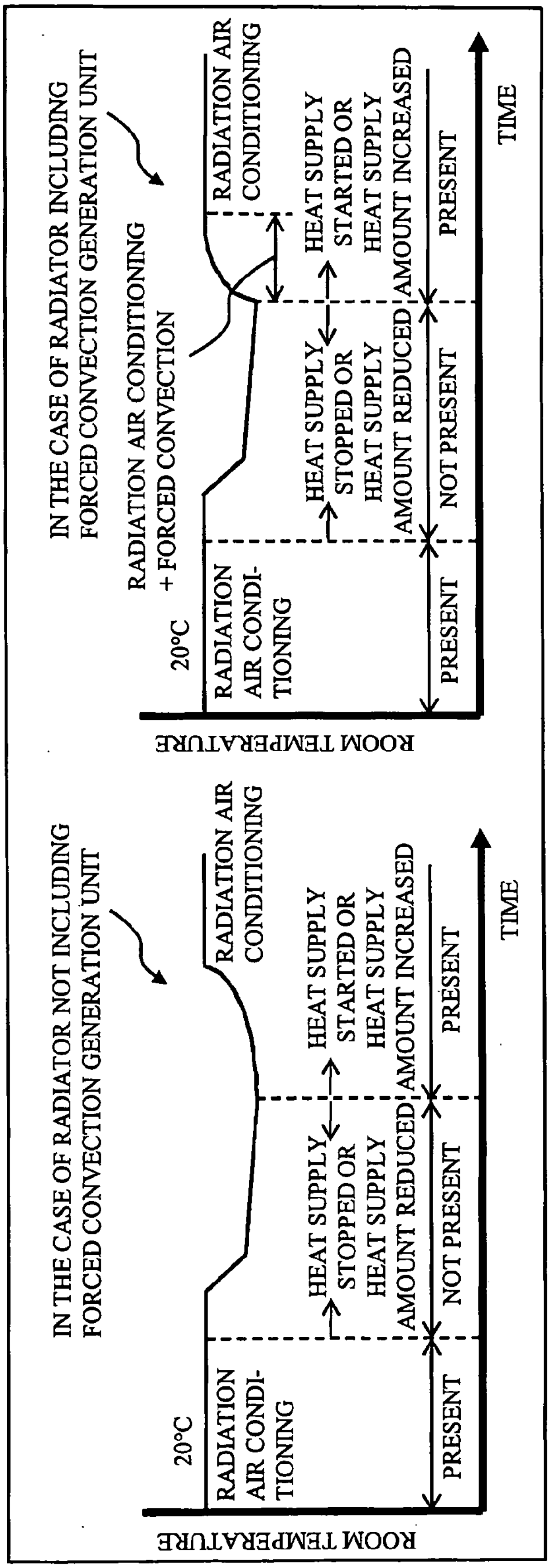
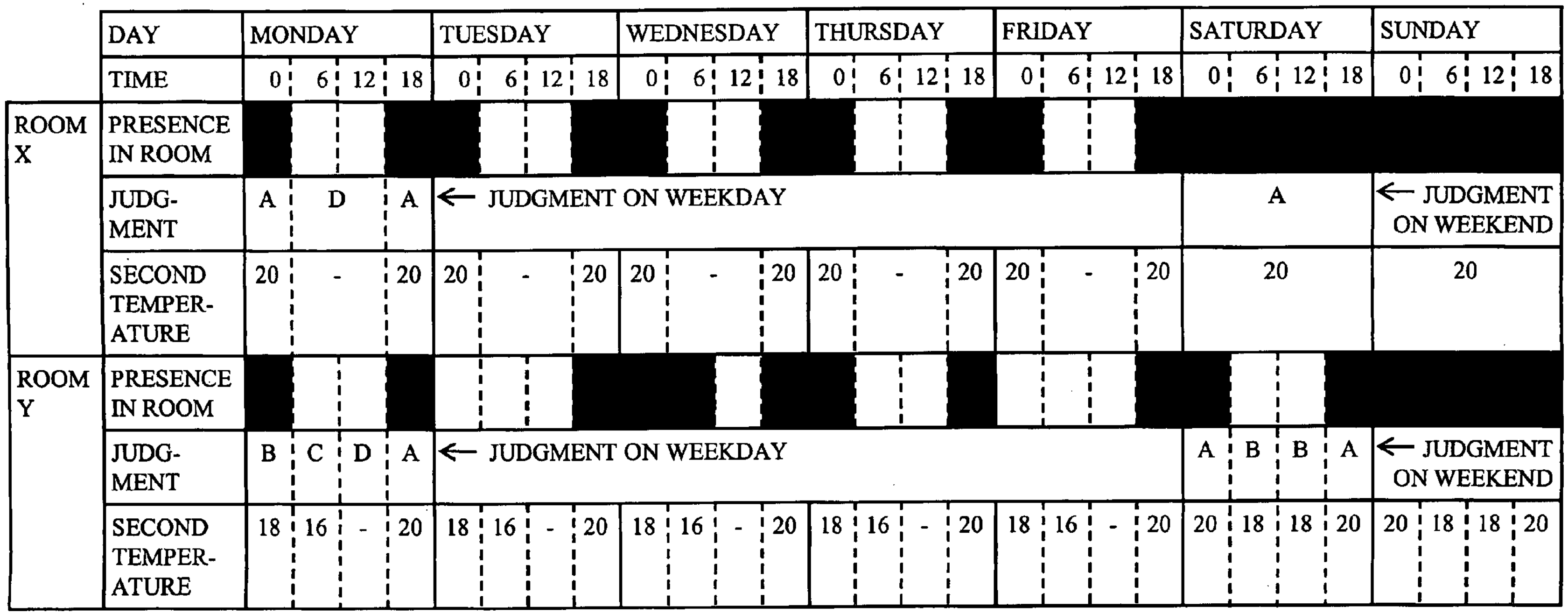

IN THE CASE OF RADIATOR NOT INCLUDING FORCED CONVECTION GENERATION UNIT
ROOM TEMPERATURE
20°C
RADIATION AIR CONDI-TIONING
RADIATION AIR CONDITIONING
HEAT SUPPLY STOPPED OR HEAT SUPPLY AMOUNT REDUCED
HEAT SUPPLY STARTED OR HEAT SUPPLY AMOUNT INCREASED
PRESENT
NOT PRESENT
PRESENT
TIME
IN THE CASE OF RADIATOR INCLUDING FORCED CONVECTION GENERATION UNIT
ROOM TEMPERATURE
20°C
RADIATION AIR CONDI-TIONING
RADIATION AIR CONDITIONING + FORCED CONVECTION
RADIATION AIR CONDITIONING
HEAT SUPPLY STOPPED OR HEAT SUPPLY AMOUNT REDUCED
HEAT SUPPLY STARTED OR HEAT SUPPLY AMOUNT INCREASED
PRESENT
NOT PRESENT
PRESENT
TIME

Fig. 4



■ : PRESENT IN ROOM
□ : NOT PRESENT

A: PRESENCE-IN-ROOM RATE 80-100%
B: PRESENCE-IN-ROOM RATE 31-79%
C: PRESENCE-IN-ROOM RATE 1-30%
D: PRESENCE-IN-ROOM RATE 0%

FIRST TEMPERATURE (TEMPERATURE SET WHEN A PERSON IS IN ROOM) IS 20°C.
IF SECOND TEMPERATURE (TEMPERATURE SET WHEN NO PERSON IS IN ROOM) IS INDICATED BY "-" THEN AIR CONDITIONING IS NOT PERFORMED.

REFERENCES CITED IN THE DESCRIPTION

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