(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 431 677 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
**29.06.2011 Bulletin 2011/26**

(21) Application number: **02768028.9**

(22) Date of filing: **24.09.2002**

(51) Int Cl.:
***F24F 11/02*** *(2006.01)*

(86) International application number:
**PCT/JP2002/009788**

(87) International publication number:
**WO 2003/029728 (10.04.2003 Gazette 2003/15)**

# (54) AIR CONDITIONER

KLIMAANLAGE

CLIMATISEUR

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR**

(30) Priority: **28.09.2001 JP 2001298725**

(43) Date of publication of application:
**23.06.2004 Bulletin 2004/26**

(73) Proprietor: **DAIKIN INDUSTRIES, LTD.**
**Osaka-shi, Osaka 530-8323 (JP)**

(72) Inventors:
- **SHIMODA, Junichi**
  **Kanaoka Factory, Sakai Plant**
  **Sakai-shi, Osaka 591-8511 (JP)**
- **MOMOSAKI, Makoto**
  **Kakogawa-shi, Hyogo 675-0111 (JP)**

(74) Representative: **HOFFMANN EITLE**
**Patent- und Rechtsanwälte**
**Arabellastraße 4**
**81925 München (DE)**

(56) References cited:
**JP-A- 4 098 038**
**JP-A- 7 120 085**
**JP-A- 58 006 346**
**US-A- 5 305 822**
**US-A- 5 675 979**



EP 1 431 677 B1

Printed by Jouve, 75001 PARIS (FR)

## Description

## Technical Field

**[0001]** This invention relates to the control of an air conditioning system.

## Background Art

**[0002]** There have been widely known conventional air conditioning systems that operates on a refrigeration cycle by circulating refrigerant in a refrigerant circuit. As air conditioning systems of another type, there are known ones in which the capacity of a compressor can be varied by changing the RPM of a motor for the compressor. In this type of air conditioning system, the temperature of the room air is detected and the capacity of the compressor is controlled based on the difference between the detected temperature and a set temperature.

**[0003]** For example, during cooling operation, when the detected value of the room temperature is higher than a set temperature set by a user, the capacity of the compressor is increased to enhance air-conditioning capacity. On the other hand, when the difference between the detected value of the room temperature and the set temperature set by the user is small, the capacity of the compressor is decreased to lower air-conditioning capacity. Furthermore, when the detected value of the room temperature is smaller than the set temperature set by the user, the compressor is deactivated to stop the cooling of the room air. In this manner, the above-described air conditioning system uses the difference between the room temperature and the set temperature as a control parameter to control the capacity of the compressor so that the room temperature reaches the set temperature.

**[0004]** Furthermore, during the cooling operation of the above air conditioning system, the room air is sent to an indoor heat exchanger and cooled therein. During the time, the indoor heat exchanger produces dew condensation on its surface to reduce the amount of moisture in the air. Even without production of dew condensation at the indoor heat exchanger, if the room temperature changes through the cooling operation, the relative humidity of the room air also changes accordingly. In this manner, the cooling operation of the air conditioning system changes not only the room temperature but also the relative humidity.

**[0005]** An air-conditioning system having the features in the preamble of claim 1 or 2 is known from US-A-5,305,822.

- Problems to be solved -

**[0006]** Nevertheless, in the control of the conventional air conditioning system, consideration has been given to the temperature of the room air but not to the relative humidity at all. Therefore, even if the temperature of the room air is maintained at a set temperature, the relative humidity is not always maintained within a suitable range. As a result, it is difficult for the conventional air conditioning system to ensure the comfort of people in the room.

**[0007]** Meanwhile, there also exist conventional air conditioning systems that are capable of carrying out so-called "dry operation". In general, during dry operation, operation control is made to decrease the temperature of the indoor heat exchanger by setting the amount of air sent to the indoor heat exchanger to be smaller than during cooling operation. Furthermore, during dry operation, the air conditioning system carries out the operation to ensure the amount of moisture to be removed from the room air while keeping the cooling capacity at a low level. In other words, the dry operation is merely the operation in which greater emphasis is placed on room humidity control rather than room temperature control. Therefore, it is impossible to suitably control both the temperature and relative humidity through dry operation.

**[0008]** As described above, in the conventional air conditioning system, both the temperature and relative humidity of the room air cannot be concurrently controlled in a suitable manner. Therefore, the user has to select either one of the cooling operation in which emphasis is placed on temperature control and the dry operation in which emphasis is placed on humidity control.

**[0009]** The present invention has been made in view of the foregoing points, and an object thereof is to improve the comfort of people in a room during cooling operation of an air conditioning system by suitably controlling both the room temperature and relative humidity.

## Disclosure of Invention

**[0010]** A first solution provided by the present invention is directed to an air conditioning system that operates on a refrigeration cycle by circulating refrigerant in a refrigerant circuit (**20**) and conducts at least cooling operation in which the refrigerant evaporates in an indoor heat exchanger (**37**) of the refrigerant circuit (**20**). In addition, the system further includes: heat exchanger temperature detecting means (**76**) for detecting the temperature of the indoor heat exchanger (**37**) as an evaporation temperature of the refrigerant during cooling operation, room temperature detecting means (**75**) for detecting the dry-bulb temperature of a room air being sent to the indoor heat exchanger (**37**); room humidity detecting means (**78**) for detecting the relative humidity of the room air being sent to the indoor heat exchanger (**37**); setting means (**81**) for setting a target control value for the evaporation temperature of the refrigerant during cooling operation at specified time intervals, based on a detected value of the heat exchanger temperature detecting means (**76**), a detected value of the room temperature detecting means (**75**) and a user-input set temperature, within a range up to an upper limit determined according to a detected value of the room humidity detecting means (**78**); and capacity control means (**82**) for controlling the capacity of a compressor (**30**) of the refrigerant circuit (**20**) so that the detected value of the heat exchanger temperature detecting means (**76**) reaches the target control value set by the setting means (**81**).

**[0011]** A second solution provided by the present invention is directed to an air conditioning system for operating on a refrigeration cycle by circulating refrigerant in a refrigerant circuit (**20**) and conducts at least cooling operation in which the refrigerant evaporates in an indoor heat exchanger (**37**) of the refrigerant circuit (**20**). In addition, the system further includes: room temperature detecting means (**75**) for detecting the dry-bulb temperature of a room air being sent to the indoor heat exchanger (**37**); room humidity detecting means (**78**) for detecting the relative humidity of the room air being sent to the indoor heat exchanger (**37**); setting means (**81**) for setting a target control value for the evaporation temperature of the refrigerant during cooling operation so that a detected value of the room temperature detecting means (**75**) reaches a set temperature, and for limiting the target control value to within a range up to an upper limit determined according to a detected value of the room humidity detecting means (**78**); and capacity control means (**82**) for controlling the capacity of a compressor (**30**) of the refrigerant circuit (**20**) so that the detected value of the heat exchanger temperature detecting means (**76**) reaches the target control value set by the setting means (**81**).

**[0012]** A third solution provided by the present invention is, in the first or second solution, that the setting means (**81**) drops the upper limit of the target control value for the evaporation temperature of the refrigerant in a stepwise manner as the detected value of the room humidity detecting means (**78**) increases.

**[0013]** A fourth solution provided by the present invention is, in the first or second solution, that the setting means (**81)** stores the minimum and maximum values in a target range for the room relative humidity, and that when the detected value of the room humidity detecting means (**78**) is equal to or larger than the minimum value in the target range, the setting means (**81**) takes for the upper limit of the target control value a value lower than the wet-bulb temperature of an air whose dry-bulb temperature is a detected value of the indoor heat exchanger (**37**) and whose relative humidity is the minimum value in the target range.

**[0014]** A fifth solution provided by the present invention is, in the fourth solution, that when the detected value of the room humidity detecting means (**78**) exceeds the maximum value in the target range for the room relative humidity, the setting means (**81**) drops the upper limit of the target control value below that of the target control value when the detected value of the room humidity detecting means (**78**) falls within the target range.

**[0015]** A sixth solution provided by the present invention is, in the first or second solution, that the setting means **(81)** sets the target control value within the range down to 0°C.

**[0016]** A seventh solution provided by the present invention is, in the sixth solution, that only when the room is brought into high humidity conditions that the detected value of the room humidity detecting means (**78**) exceeds a predetermined reference value, the setting means (**81**) sets the target control value within the range down to a predetermined lower limit which is higher than 0°C.

- Operations -

**[0017]** In the first solution, refrigerant circulates in the refrigerant circuit (**20**) of the air conditioning system to complete a refrigeration cycle. In other words, in the refrigerant circuit (**20**), refrigerant circulates while changing its phase so that compression, condensation, expansion and evaporation of the refrigerant sequentially take place. Furthermore, the air conditioning system is provided with heat exchanger temperature detecting means (**76**), room temperature detecting means (**75**), room humidity detecting means (**78**), setting means (**81**) and capacity control means (**82**).

**[0018]** The air conditioning system conducts at least cooling operation. More specifically, the air conditioning system may conduct cooling operation alone, or may selectively conduct cooling operation and heating operation. In the air conditioning system of this solution, refrigerant and room air exchange heat with each other at the indoor heat exchanger (**37**). During cooling operation, the refrigerant in the indoor heat exchanger (**37**) absorbs heat from the room air to evaporate.

**[0019]** The heat exchanger temperature detecting means (**76**) detects the temperature of part of the indoor heat exchanger (**37**) in which refrigerant is changing its phase. During cooling operation, since the indoor heat exchanger (**37**) serves as an evaporator, the detected value of the heat exchanger temperature detecting means (**76**) corresponds to the evaporation temperature of the refrigerant.

**[0020]** The room temperature detecting means (**75**) detects the temperature of the room air being sent to the indoor heat exchanger (**37**). The room humidity detecting means (**78**) detects the relative humidity of the room air being sent to the indoor heat exchanger (**37**). In other words, for the room air before exchanging heat with the refrigerant at the indoor heat exchanger (**37**), its temperature is detected by the room temperature detecting means (**75**) while its relative humidity is detected by the room humidity detecting means (**78**).

**[0021]** Input to the setting means (**81**) are a detected value of the heat exchanger temperature detecting means (**76**), a detected value of the room temperature detecting means (**75**) and a detected value of the room humidity detecting means (**78**). In addition, a set temperature set by a user of the air conditioning system is also input to the setting means (**81**). This setting means (**81**) carries out, for example, a calculation using the detected values of the heat exchanger temperature detecting means (**76**) and room temperature detecting means (**75**) to set a target control value for the evaporation temperature of refrigerant during cooling operation. This target control value is set so that the room air reaches the set temperature. Furthermore, the setting means (**81**) re-sets the target control value after each elapse of a predetermined time period. In other words, the setting means (**81**) updates the target control value at specified time intervals.

**[0022]** At the time, he setting means (**81**) sets the target control value within a range up to the upper limit determined according to the detected value of the room humidity detecting means (**78**). For example, even when the value obtained, for example, by the calculation using the detected value of the heat exchanger temperature detecting means (**76**), exceeds the upper limit, the setting means (**81**) sets the target control value at a value equal to or smaller than the upper limit.

**[0023]** Input to the capacity control means (**82**) are the detected value of the heat exchanger temperature detecting means (**76**) and the target control value set by the setting means (**81**). The capacity control means (**82**) controls the capacity of the compressor (**30**) so that the detected value of the heat exchanger temperature detecting means (**76**) reaches the target control value. More specifically, during cooling operation, the capacity control means (**82**) controls the capacity of the compressor (**30**) so that the evaporation temperature of refrigerant in the indoor heat exchanger (**37**) matches the target control value.

**[0024]** In the second solution, refrigerant circulates in the refrigerant circuit (**20**) of the air conditioning system to complete a refrigeration cycle. In other words, in the refrigerant circuit (**20**), refrigerant circulates while changing its phase so that compression, condensation, expansion and evaporation of the refrigerant sequentially take place. Furthermore, the air conditioning system is provided with room temperature detecting means (**75**), room humidity detecting means (**78**), setting means (**81**) and capacity control means (**82**).

**[0025]** The air conditioning system conducts at least cooling operation. More specifically, the air conditioning system may conduct cooling operation alone, or may selectively conduct cooling operation and heating operation. In the air conditioning system of this solution, refrigerant and room air exchange heat with each other at the indoor heat exchanger (**37**). During cooling operation, the refrigerant in the indoor heat exchanger (**37**) absorbs heat from the room air to evaporate.

**[0026]** The room temperature detecting means (**75**) detects the temperature of the room air being sent to the indoor heat exchanger (**37**). The room humidity detecting means (**78**) detects the relative humidity of the room air being sent to the indoor heat exchanger (**37**). In other words, for the room air before exchanging heat with the refrigerant at the indoor heat exchanger (**37**), its temperature is detected by the room temperature detecting means (**75**) while its relative humidity is detected by the room humidity detecting means (**78**).

**[0027]** Input to the setting means (**81**) are a detected value of the room temperature detecting means (**75**) and a detected value of the room humidity detecting means (**78**). In addition, a set temperature set by a user of the air conditioning system is also input to the setting means (**81**). This setting means (**81**) sets a target control value for the evaporation temperature of refrigerant during cooling operation so that the detected value of the room temperature detecting means (**75**) reaches the set temperature.

**[0028]** In this setting means (**81**), however, the target control value for the evaporation temperature of refrigerant during cooling operation is limited to within a range up to an upper limit determined according to a detected value of the room humidity detecting means (**78**). For example, even when the value derived based on the detected value of the room temperature detecting means (**75**) and the set temperature exceeds the upper limit, the setting means (**81**) sets the target control value at a value equal to or smaller than the upper limit. The capacity control means (**82**) controls the capacity of the compressor (**30**) so that the evaporation temperature of refrigerant in the indoor heat exchanger (**37**) matches the target control value.

**[0029]** In the third solution, the setting means (**81**) changes the upper limit of the target control value for the evaporation temperature of the refrigerant according to the detected value of the room humidity detecting means (**78**). In this setting means (**81**), the upper limit of the target control value for the evaporation temperature of the refrigerant becomes lower in a stepwise manner as the detected value of the room humidity detecting means (**78**) increases.

**[0030]** In the fourth solution, the setting means (**81**) compares the input detected value of the room humidity detecting means (**78**) with the minimum value in a target range for the room relative humidity. When the detected value of the room humidity detecting means (**78**) is equal to or larger than the minimum value in the target range, the setting means (**81**) derives the wet-bulb temperature of an air whose dry-bulb temperature is a detected value of the room temperature detecting means (**75**) and whose relative humidity is the minimum value in the target range, and sets the target control value while taking for the upper limit a value lower than the wet-bulb temperature.

**[0031]** In other words, in this solution, when the detected value of the room humidity detecting means (**78**) is equal to or larger than the minimum value in the target range, the target control value set by the setting means (**81**) is always lower than the wet-bulb temperature of the room air at that time. Therefore, in this case, when the room air is cooled at the indoor heat exchanger (**37**), moisture in the room air concurrently condenses to provide dehumidification of the room.
**[0032]** In the fifth solution, the setting means (**81**) compares the input detected value of the room humidity detecting means (**78**) with the maximum value in the target range for the room relative humidity. When the detected value of the room humidity detecting means (**78**) is higher than the maximum value in the target range, the setting means (**81**) takes, for the upper limit of the target control value, a lower value than that of the target control value when the detected value of the room humidity detecting means (**78**) is anywhere from the minimum value to the maximum value in the target range. In other words, when the detected value of the room humidity detecting means (**78**) is higher than the maximum value in the target range, the setting means (**81**) of this solution lowers the upper limit of the target control value to set the target control value relatively low, thereby ensuring the amount of moisture to be removed from the room air.
**[0033]** In the sixth solution, the setting means (**81**) sets the target control value while taking 0°C for the lower limit. In other words, the target control value set by the setting means (**81**) always has any value not lower than 0°C and does not fall below 0°C. Therefore, the temperature of the indoor heat exchanger (**37**) may temporarily fall below 0°C but is never held below 0°C for hours, i.e., is fundamentally held at 0°C or more.
**[0034]** In the seventh solution, only when the room is brought into high humidity conditions that the room relative humidity exceeds the reference value, the setting means (**81**) sets the target control value while taking a value higher than 0°C for the lower limit. At this time, when a low value is set as the target control value, the temperature of the indoor heat exchanger (**37**) is decreased accordingly. Therefore, if a low target control value is set under the above high humidity conditions, this may cause an adverse effect such that the amount of moisture condensed in the indoor heat exchanger (**37**) may be increased too much for drainage of produced water to catch up with. To avoid this, the setting means (**81**) sets the target control value relatively high only under the above high humidity conditions, thereby preventing the amount of moisture condensed in the indoor heat exchanger (**37**) from being excessive.

- Effects -

**[0035]** When setting the target control value of the evaporation temperature of refrigerant during cooling operation, the setting means (**81**) of this invention determines the upper limit of the target control value according to the detected value of the room relative humidity detecting means (**78**) while considering the detected value of the room temperature detecting means (**75**) and so on. In other words, the setting means (**81**) sets the target control value by considering not only the temperature of the room air but also the relative humidity thereof. Therefore, the air conditioning system of this invention can concurrently control both the room temperature and relative humidity in a suitable manner without forcing the user to select the operation centred on temperature control or the operation centred on humidity control unlike the conventional technique. Therefore, according to this invention, the room temperature and relative humidity can be adjusted in a comfort region thereby improving the comfort of people in the room.
**[0036]** Particularly in the sixth solution, since the setting means (**81**) takes 0°C for the lower limit of the target control value, the indoor heat exchanger (**37**) is fundamentally maintained at 0°C or higher. Therefore, according to this solution, the indoor heat exchanger (**37**) can be avoided from moisture freezing thereby preventing any adverse effect resulting from freezing.
**[0037]** Furthermore, in the seventh solution, the setting means (**81**) takes a value higher than 0°C for the lower limit of the target control value when the room is under high humidity conditions that the amount of moisture condensed in the indoor heat exchanger (**37**) is expected to be excessive. Therefore, according to this solution, the amount of drain produced in the indoor heat exchanger (**37**) is prevented from being excessive, thereby avoiding any problem resulting from production of excessive drain.

## Brief Description of Drawings

**[0038]**

Figure **1** is a piping diagram showing the configuration of an air conditioner according to an embodiment.
Figure **2** is a map that is recorded in a target setting section of a controller.
Figure **3** is a plot of relative humidity vs. temperature showing the range within which the target value for evaporation temperature can be set in the target setting section.

## Best Mode for Carrying Out the Invention

**[0039]** Hereinafter, description will be made about an embodiment of the present invention with reference to the drawings. An air conditioner (**10**) as an air conditioning system according to the present invention is structured to selectively conduct cooling operation and heating operation.

**[0040]** As shown in Figure **1**, the air conditioner (**10**) includes a refrigerant circuit (**20**) and a controller (**80**). The refrigerant circuit (**20**) is constituted by an outdoor circuit (**21**), an indoor circuit (**22**), a liquid-side connection pipe (**23**), and a gas-side connection pipe (**24**). The outdoor circuit (**21**) is disposed in an outdoor unit (**11**). The outdoor unit (**11**) is provided with an outdoor fan (**12**). On the other hand, the indoor circuit (**22**) is disposed in an indoor unit (**13**). The indoor unit (**13**) is provided with an indoor fan (**14**).

**[0041]** In the outdoor circuit (**21**), a compressor (**30**), a four-way selector valve (**33**), an outdoor heat exchanger (**34**), a receiver (**35**), and a motor-operated expansion valve (**36**) are disposed. Furthermore, in the outdoor circuit (**21**), a bridge circuit (**40**), a subcooling circuit (**50**), a liquid-side shut-off valve (**25**), and a gas-side shut-off valve (**26**) are also disposed. Moreover, the outdoor circuit (**21**) is connected to a gas communication pipe (**61**) and a pressure equalising pipe (**63**).

**[0042]** In the outdoor circuit (**21**), a discharge port (**32**) of the compressor (**30**) is connected to a first port of the four-way selector valve (**33**). A second port of the four-way selector valve (**33**) is connected to one end of the outdoor heat exchanger (**34**). The other end of the outdoor heat exchanger (**34**) is connected to the bridge circuit (**40**). The bridge circuit (**40**) is connected to the receiver (**35**), the motor-operated expansion valve (**36**), and the liquid-side shut-off valve (**25**). Description on this point will be described below. An intake port (**31**) of the compressor (**30**) is connected to a third port of the four-way selector valve (**33**). A fourth port of the four-way selector valve (**33**) is connected to the gas-side shut-off valve (**26**).

**[0043]** The bridge circuit (**40**) is configured by connecting a first line (**41**), a second line (**42**), a third line (**43**), and a fourth line (**44**) in the form of a bridge. In the bridge circuit (**40**), an outlet end of the first line (**41**) is connected to an outlet end of the second line (**42**), an inlet end of the second line (**42**) is connected to an outlet end of the third line (**43**), an inlet end of the third line (**43**) is connected to an inlet end of the fourth line (**44**), and an outlet end of the fourth line (**44**) is connected to an inlet end of the first line (**41**).

**[0044]** Check valves are provided one each in the first to fourth lines (**41-44**). The first line (**41**) is provided with the check valve (**CV-1**) for allowing only refrigerant flow from its inlet end toward its outlet end. The second line (**42**) is provided with the check valve (**CV-2**) for allowing only refrigerant flow from its inlet end toward its outlet end. The third line (**43**) is provided with the check valve (**CV-3**) for allowing only refrigerant flow from its inlet end toward its outlet end. The fourth line (**44**) is provided with the check valve (**CV-4**) for allowing only refrigerant flow from its inlet end toward its outlet end.

**[0045]** The other end of the outdoor heat exchanger (**34**) is connected, in the bridge circuit (**40**), to the inlet end of the first line (**41**) and the outlet end of the fourth line (**44**). The outlet ends of the first line (**41**) and the second line (**42**) both in the bridge circuit (**40**) are connected to an upper end part of the receiver (**35**) formed in the shape of a cylindrical container. A lower end part of the receiver (**35**) is connected via the motor-operated expansion valve (**36**) to the inlet ends of the third line (**43**) and the fourth line (**44**) both in the bridge circuit (**40**). The inlet end of the second line (**42**) and the outlet end of the third line (**43**) both in the bridge circuit (**40**) are connected to the liquid-side shut-off valve (**25**).

**[0046]** In the indoor circuit (**22**), an indoor heat exchanger (**37**) is provided. One end of the indoor circuit (**22**) is connected to the liquid-side shut-off valve (**25**) through the liquid-side connection pipe (**23**). The other end of the indoor circuit (**22**) is connected to the gas-side shut-off valve (**26**) through the gas-side connection pipe (**24**). In other words, the liquid-side connection pipe (**23**) and the gas-side connection pipe (**24**) are disposed across the outdoor unit **(11)** and the indoor unit **(13).** After the installation of the air conditioner (**10**), the liquid-side shut-off valve (**25**) and the gas-side shut-off valve (**26**) are always put into open position.

**[0047]** The subcooling circuit (**50**) is connected at one end thereof to the line between the lower end of the receiver (**35**) and the motor-operated expansion valve (**36**), and connected at the other end to the inlet port (**31**) of the compressor (**30**). In the subcooling circuit (**50**), a first solenoid valve (**51**), a thermostatic expansion valve (**52**) and a subcooling heat exchanger (**54**) are disposed in the order of one end to the other of the circuit. The subcooling heat exchanger (**54**) is arranged to conduct heat exchange between the refrigerant flowing from the receiver (**35**) toward the motor-operated expansion valve (**36**) and the refrigerant flowing through the subcooling circuit (**50**). A temperature-sensing bulb (**53**) of the thermostatic expansion valve (**52**) is attached to the subcooling circuit (**50**) downstream of the subcooling heat exchanger (**54**).

**[0048]** The gas communication pipe (**61**) is connected at one end to the upper end part of the receiver (**35**), and connected at the other end to the line between the motor-operated expansion valve (**36**) and the bridge circuit (**40**). Furthermore, the gas communication line (**61**) is provided on its way with a second solenoid valve (**62**).

**[0049]** The pressure equalising pipe (**63**) is connected at one end to the gas communication pipe (**61**) between the second solenoid valve (**62**) and the receiver (**35**), and connected at the other end to the outdoor circuit (**21**) between the discharge port (**32**) and the four-way selector valve (**33**) of the compressor (**30**). Furthermore, the pressure equalising pipe (**63**) is provided with a pressure equalising check valve (**53**) for allowing only refrigerant flow from its one end toward the other end.

**[0050]** The compressor (**30**) is of hermetic, high-pressure dome type. More specifically, this compressor (**30**) is formed by containing a scroll type compression mechanism and a motor for driving the compression mechanism in a cylindrical housing. The refrigerant taken in through the inlet port (**31**) is introduced directly into the compression mechanism. The refrigerant compressed in the compression mechanism is first discharged to the inside of the housing and then let out through the discharge port (**32**). The compression mechanism and the motor are not shown in the figure.

**[0051]** The motor for the compressor (**30**) is supplied with electric power through an unshown inverter. When the power supply frequency output from the inverter is changed, the RPM of the motor is also changed and the compressor capacity is in turn changed. Namely, the compressor (**30**) is structured to be variable in capacity.

**[0052]** The outdoor heat exchanger (**34**) is formed of a cross fin coil type fin-and-tube heat exchanger. This outdoor heat exchanger (**34**) is composed of two parts connected in series with each other. The outdoor heat exchanger (**34**) is supplied with an outdoor air by the outdoor fan (**12**). Furthermore, the outdoor heat exchanger (**34**) conducts heat exchange between the refrigerant circulating in the refrigerant circuit (**20**) and the outdoor air.

**[0053]** The indoor heat exchanger (**37**) is formed of a cross fin coil type fin-and-tube heat exchanger. This indoor heat exchanger (**37**) is supplied with a room air by the indoor fan (**14**). Furthermore, the indoor heat exchanger (**37**) conducts heat exchange between the refrigerant in the refrigerant circuit (**20**) and the room air.

**[0054]** The four-way selector valve (**33**) changes between a position in which communication is provided between the first and second ports and between the third and fourth ports (a position shown in the solid lines in Figure **1**) and a position in which communication is provided between the first and fourth ports and between the second and third ports (a position shown in the broken lines in Figure **1**). This changeover operation of the four-way selector valve (**33**) inverts the circulating direction of refrigerant in the refrigerant circuit (**20**).

**[0055]** The air conditioner (**10**) is provided with various kinds of sensors. The detected values of these sensors are input into the controller (**80**) for use in operation control over the air conditioner (**10**).

**[0056]** More specifically, the line connected to the intake port (**31**) of the compressor (**30**) is provided with a low-pressure sensor (**71**) for detecting the pressure of an intake refrigerant of the compressor (**30**), and an intake pipe temperature sensor (**77**) for detecting the temperature of the intake refrigerant. The line connected to the discharge port (32) of the compressor (**30**) is provided with a discharge pipe temperature sensor (**74**) for detecting the temperature of a discharge refrigerant of the compressor (**30**).

**[0057]** Furthermore, the outdoor unit (**11**) is provided with an outdoor air temperature sensor (**72**) for detecting the temperature of the outdoor air. The outdoor heat exchanger (**34**) is provided with an outdoor heat exchanger temperature sensor (**73**) for detecting the temperature of its heat transfer pipe.

**[0058]** Moreover, the indoor unit (**13**) is provided with an room temperature sensor (**75**) for detecting the temperature of the room air being sent to the indoor heat exchanger (37), and a relative humidity sensor (**78**) for detecting the temperature of the room air being sent to the indoor heat exchanger (**37**). The room temperature sensor (**75**) has the function of outputting the detected value as a detected room temperature, and thus constitutes a room temperature detecting means. On the other hand, the relative humidity sensor (**78**) has the function of outputting the detected value as a detected room humidity, and thus constitutes a room humidity detecting means.

**[0059]** The indoor heat exchanger (**37**) is provided with an indoor heat exchanger temperature sensor (**76**) for detecting the temperature of its heat transfer pipe. This indoor heat exchanger temperature sensor (**76**) is attached to part of the heat transfer pipe of the indoor heat exchanger (**37**) at the inside of which refrigerant falls into a gas-liquid two-phase condition during operation. The indoor heat exchanger temperature sensor (**76**) constitutes a heat exchanger temperature detecting means for detecting the temperature of the indoor heat exchanger (**37**) as the evaporation temperature or the condensation temperature of the refrigerant and outputting the detected value as a detected heat exchanger temperature.

**[0060]** The controller (**80**) includes a target value setting section (**81**) that is a setting means. The target value setting section (**81**) inputs the detected room temperature from the room temperature sensor (**75**), the detected heat exchanger temperature from the indoor heat exchanger temperature sensor (**76**), and a set temperature from an unshown remote controller. The set temperature is input thereto through the user's operation of the remote controller. The detected room humidity from the relative humidity sensor (**78**) is also input to the target value setting section (**81**). Furthermore, the target value setting section (**81**) is configured to set a target control value, based on the detected room temperature, the detected heat exchanger temperature and the set temperature, within a range up to the upper limit determined according to the detected room humidity.

**[0061]** The controller (**80**) also includes a capacity control section (**82**) that is a capacity control means. The capacity control section (**82**) inputs the detected heat exchanger temperature from the indoor heat exchanger temperature sensor (**76**), and the target control value set by the target value setting section (**81**). The capacity control section (**82**) changes the power supply frequency output from the inverter so that the detected heat exchanger temperature can reach the target control value. When the power supply frequency output from the inverter is changed, the RPM of the motor for the compressor (**30**) is also changed and the capacity of the compressor (**30**) is in turn changed. Therefore, the capacity control section (**82**) is configured to control the capacity of the compressor (**30**) to match the detected heat exchanger temperature with the target control value.

- Actions during Operation -

**[0062]** Description will be made next about the actions of the air conditioner **(10)** during operation. This air conditioner (**10**) selectively conducts a cooling operation under refrigerating action and a heating operation under heat-pumping action.

*Cooling Operation*

**[0063]** During cooling operation, the four-way selector valve **(33)** is changed to the position shown in the solid lines in Figure **1**, the motor-operated expansion valve **(36)** is adjusted to a predetermined opening, the first solenoid valve (**51**) is made open, and the second solenoid valve (**62**) is made closed. In addition, the outdoor fan (**12**) and the indoor fan (**14**) are operated. Under these conditions, the refrigerant circulates in the refrigerant circuit (**20**) so that the system operates on a refrigeration cycle in which the outdoor heat exchanger (**34**) serves as a condenser and the indoor heat exchanger (**37**) serves as an evaporator.

**[0064]** More specifically, the refrigerant discharged from the discharge port (**32**) of the compressor (**30**) is sent through the four-way selector valve (**33**) to the outdoor heat exchanger (**34**). In the outdoor heat exchanger (**34**), the refrigerant condenses by releasing heat to the outdoor air. The condensed refrigerant flows through the first line (**41**) of the bridge circuit (**40**) into the receiver (**35**). Part of the high-pressure liquid refrigerant having flowed out of the receiver (**35**) is diverted to the subcooling circuit (**50**), while the rest flows into the subcooling heat exchanger (**54**).

**[0065]** The refrigerant flowing into the subcooling circuit (**50**) is reduced in pressure by the thermostatic expansion valve (**52**) to turn into a low-pressure refrigerant, and then flows into the subcooling heat exchanger (**54**). In the subcooling heat exchanger (**54**), heat is exchanged between the high-pressure liquid refrigerant from the receiver (**35**) and the low-pressure refrigerant reduced in pressure by the thermostatic expansion valve (**52**). Thus, in the subcooling heat exchanger (**54**), the low-pressure refrigerant absorbs heat from the high-pressure liquid refrigerant to evaporate so that the high-pressure liquid refrigerant is cooled. The low-pressure refrigerant evaporated in the subcooling heat exchanger (**54**) flows through the subcooling circuit (**50**) and is then taken into the compressor (**30**). On the other hand, the high-pressure liquid refrigerant cooled in the subcooling heat exchanger (**54**) is sent to the motor-operated expansion valve (**36**).

**[0066]** In the motor-operated expansion valve (**36**), the sent high-pressure liquid refrigerant is reduced in pressure. The refrigerant reduced in pressure by the motor-operated expansion valve (**36**) is sent from the third line (**43**) of the bridge circuit (**40**) through the liquid-side connection pipe (**23**) to the indoor heat exchanger (**37**). In the indoor heat exchanger (**37**), the refrigerant absorbs heat from the room air to evaporate. In other words, in the indoor heat exchanger (**37**), the room air taken into the indoor unit (**13**) releases heat to the refrigerant. This heat release causes the room temperature to drop. Furthermore, in normal operating conditions, moisture of the room air condenses in the indoor heat exchanger (**37**). Thus, in the indoor heat exchanger (**37**), the room air is cooled and concurrently reduced in humidity. A conditioned air obtained through the cooling and moisture reduction of the room air is fed from the indoor unit (**13**) to the room for use in cooling.

**[0067]** The refrigerant evaporated in the indoor heat exchanger (**37**) flows through the gas-side connection pipe (**24**) and the four-way selector valve (**33**), and is taken into the compressor (**30**) through the intake port (**31**). The compressor (**30**) compresses the intake refrigerant and discharges the compressed refrigerant through the discharge port (**32**) again. In the refrigerant circuit (**20**), the refrigerant circulates in the above manner to perform the refrigerating action.

*Heating Operation*

**[0068]** During heating operation, the four-way selector valve (**33**) is changed to the position shown in the broken lines in Figure **1,** the motor-operated expansion valve (**36**) is adjusted to a predetermined opening, and the first solenoid valve (**51**) and the second solenoid valve (**62**) are closed. In addition, the outdoor fan (**12**) and the indoor fan (**14**) are operated. Under these conditions, the refrigerant circulates in the refrigerant circuit (**20**) so that the system operates on a refrigeration cycle in which the indoor heat exchanger (**37**) serves as a condenser and the outdoor heat exchanger (**34**) serves as an evaporator.

**[0069]** More specifically, the refrigerant discharged from the discharge port (**32**) of the compressor (**30**) is sent through the four-way selector valve (**33**) and the gas-side connection pipe (**24**) to the indoor heat exchanger (**37**). In the indoor heat exchanger (**37**), the refrigerant releases heat to the room air to condense. In other words, in the indoor heat exchanger (**37**), the refrigerant applies heat to the room air taken into the indoor unit (**13**). This heat application raises the temperature of the room air to produce a warm conditioned air. The conditioned air thus produced is fed from the indoor unit (**13**) to the room for use in heating.

**[0070]** The refrigerant condensed in the indoor heat exchanger (**37**) flows through the liquid-side connection pipe (**23**) and the second line (**42**) of the bridge circuit (**40**) into the receiver (**35**). The refrigerant having flowed out of the receiver (**35**) is reduced in pressure by the motor-operated expansion valve (**36**), and then sent through the fourth line (**44**) of the bridge circuit (**40**) to the outdoor heat exchanger (**34**). In the outdoor heat exchanger (**34**), the refrigerant evaporates by absorbing heat from the outdoor air.

**[0071]** The refrigerant evaporated in the outdoor heat exchanger (**34**) passes through the four-way selector valve (**33**) and is then taken into the compressor (**30**) through the intake port (**31**). The compressor (**30**) compresses the intake refrigerant and discharges the compressed refrigerant through the discharge port (**32**) again. In the refrigerant circuit **(20),** the refrigerant circulates in the above manner to perform the heat-pumping action.

*Actions of Controller*

**[0072]** Next, description will be made about the actions of the controller (**80**) for controlling the compressor capacity.

**[0073]** First, the action of the target value setting section (**81**) will be described. The target value setting section (**81**) inputs the detected room temperature from the room temperature sensor (**75**), the detected heat exchanger temperature from the indoor heat exchanger temperature sensor (**76**), and the set temperature from the remote controller.

**[0074]** The target value setting section (**81**) carries out calculations shown in the below Equations <1> and <2> at specified time intervals (for example, every 60 seconds). Thus, the target value setting section **(81)** sets a target evaporation temperature (TeS) as a target control value at the specified time intervals during cooling operation, and sets a target condensation temperature (TcS) as a target control value at the specified time intervals during heating operation:

$$TeS = TeSo - KT1 + KT2 \quad \ldots \langle 1 \rangle$$

$$TcS = TcSo + KT1 - KT2 \quad \ldots \langle 2 \rangle$$

TeS : Target evaporation temperature (target control value during cooling operation)
TeSo : Refrigerant evaporation temperature at rated cooling capacity
TcS : Target condensation temperature (target control value during heating operation)
TcSo : Refrigerant condensation temperature at rated heating capacity
KT1 : Term for a capacity increase due to a temperature difference between the room temperature and the set temperature
KT2 : Correction term derived by learning

Both the evaporation temperature at rated cooling capacity (TeSo) and the condensation temperature at rated heating capacity (TcSo) are predetermined reference values and are previously recorded in the target value setting section (**81**). The evaporation temperature at rated cooling capacity (TeSo) is the refrigerant evaporation temperature when the cycle exhibits the rated capacity under the standard cooling conditions defined in Japanese Industrial Standards (JIS) B8615-1 : 1999. On the other hand, the condensation temperature at rated heating capacity (TcSo) is the refrigerant condensation temperature when the cycle exhibits the rated capacity under the standard heating conditions defined in Japanese Industrial Standards (JIS) B8615-1 : 1999.

**[0075]** In the above calculations, the term (KT1) for a capacity increase due to a temperature difference between the room temperature and the set temperature is calculated from the below Equation <3>. This term (KT1) corresponds to a first correction value, and is determined by the difference between the detected room temperature (Tr) and the set temperature (TrS):

$$KT1 = Tr - TrS \quad \ldots \langle 3 \rangle$$

Tr : Detected room temperature
TrS : Set temperature

**[0076]** On the other hand, the correction term (KT2) derived by learning is determined based on the map shown in Figure **2**. This correction term (KT2) corresponds to a second correction value. In the map of Figure **2,** the abscissa axis e1 is calculated from different equations for cooling operation and heating operation. Specifically, the abscissa axis e1 is calculated according to the below equations:

Cooling operation : e1 = Te - TeS'
Heating operation : e1 = TcS' - Tc
Te : Detected heat exchanger temperature during cooling operation (measured value of the refrigerant evaporation temperature)
TeS' : Target evaporation temperature being currently set
Tc : Detected heat exchanger temperature during heating operation (measured value of the refrigerant condensation temperature)
TcS' : Target condensation temperature being currently set

**[0077]** Described next is an exemplary case of determining the correction term (KT2) by learning based on the map of Figure **2**. When e1<-0.75 and 0.75≤ΔTrS(=Tr-TrS), KT2=-2.0 holds. When -0.75≤e1<-0.25 and 0.25≤ΔTrS<0.75, KT2=-1.0 holds. When -0.25≤e1<0.25 and -0.25≤ΔTrS<0.25, KT2=0 holds. The correction term (KT2) by learning is determined from the map of Figure 2 in this manner.

**[0078]** The target value setting section (**81**) acts as described above to set the target evaporation temperature (TeS) as a target control value during cooling operation and set the target condensation temperature (TcS) as a target control value during heating operation. It should be noted that in the target value setting section (**81**), possible values of the target evaporation temperature (TeS) as a target control value during cooling operation are limited to a predetermined range.

**[0079]** As shown in Figure **3**, in the target value setting section (**81**), the range in which the target evaporation temperature (TeS) can be set is changed depending upon the detected room humidity provided from the relative humidity sensor (**78**). Furthermore, the target value setting section (**81**) stores a value of "40%" as the minimum value in the target range for the room relative humidity and a value of "60%" as the maximum value in the target range. Here, the limits of the target evaporation temperature (TeS) in the target value setting section (**81**) will be described taking as an example the condition that the dry-bulb temperature of the room air (i.e., detected room temperature) is 27°C.

**[0080]** More specifically, when the detected room humidity is below 40%, the target value setting section (**81**) sets the target evaporation temperature (TeS) in the range from a first lower limit to a first upper limit inclusive. In this example, the first lower limit is fixed at "0°C", and the first upper limit is fixed at "19°C". In this case, when the calculated value obtained by calculation using Equation <1> is 0°C to 19°C inclusive, the target value setting section (**81**) selects the calculated value as the target evaporation temperature (TeS). When the calculated value is below 0°C, however, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 0°C. Furthermore, when the calculated value is above 19°C, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 19°C.

**[0081]** When the detected room humidity is 40% to 60% inclusive, i.e., when the detected room humidity falls within the target range for the relative humidity, the target value setting section (**81**) sets the target evaporation temperature (TeS) within the range of the first lower limit to a second upper limit inclusive. In this example, the second upper limit is fixed at "16°C". In this case, when the calculated value obtained by calculation using Equation <1> is 0°C to 16°C inclusive, the target value setting section (**81**) selects the calculated value as the target evaporation temperature (TeS). When the calculated value is below 0°C, however, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 0°C. Furthermore, when the calculated value is above 16°C, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 16°C.

**[0082]** When the detected room humidity is above 60% and below 80%, the target value setting section (81) sets the target evaporation temperature (TeS) within the range of the first lower limit to a third upper limit inclusive. In this example, the third upper limit is fixed at "13°C". In this case, when the calculated value obtained by calculation using Equation <1> is 0°C to 13°C inclusive, the target value setting section (**81**) selects the calculated value as the target evaporation temperature (TeS). When the calculated value is below 0°C, however, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 0°C. Furthermore, when the calculated value is above 13°C, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 13°C.

**[0083]** When the detected room humidity is 80% or more, the target value setting section (**81**) sets the target evaporation temperature (TeS) within the range of a second lower limit to the third upper limit inclusive. In this example, the second lower limit is fixed at "12°C". In this case, when the calculated value obtained by calculation using Equation <1> is 12°C to 13°C inclusive, the target value setting section (**81**) selects the calculated value as the target evaporation temperature (TeS). When the calculated value is below 12°C, however, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 12°C. Furthermore, when the calculated value is above 13°C, the target value setting section (**81**) sets the target evaporation temperature (TeS) only at 13°C.

**[0084]** Next, description will be made about standpoints in determining the first to third upper limits and the first and second lower limits in the target value setting section (**81**).

**[0085]** The first upper limit is determined to restrict the lower-side pressure of the refrigeration cycle to a predetermined value or less by considering the operation limit of the compressor (**30**). In other words, the first upper limit is determined regardless of the dry-bulb temperature and the wet-bulb temperature of the room air, and held constant even when these values vary. Therefore, when the detected room humidity is below 40%, the target evaporation temperature (TeS) may be set higher than the wet-bulb temperature of the room air to produce no dew condensation at the indoor heat exchanger (**37**). In such a case, however, it is desirable to conduct no room dehumidification because the detected room humidity has already fallen below the target range. Instead of this, when no room dehumidification is required, the target evaporation temperature (TeS) can be set relatively high. Thereby, the compressor (**30**) is operated at a capacity as small as possible to reduce power consumption of the motor for the compressor (**30**).

**[0086]** The second upper limit is determined to be always lower than the wet-bulb temperature of the air having a dry-bulb temperature equal to a detected room temperature and having a relative humidity of 40%. For example, when the detected room temperature is 27°C, the wet-bulb temperature of the air having a dry-bulb temperature of 27°C and a relative humidity of 40% is 17.5 °C. Therefore, the second upper limit is given as 16°C. The second upper limit varies depending upon the detected room temperature. Furthermore, when the detected room humidity reaches or exceeds 40% which is the minimum value in the target range for the relative humidity, the target evaporation temperature (TeS) is always set lower than the wet-bulb temperature of the room air to condense moisture thereof in the indoor heat exchanger (**37**), resulting in dehumidify the room air.

**[0087]** The third upper limit is determined to be always lower than the second upper limit. For example, when the detected room temperature is 27°C, the second upper limit is 16°C. Therefore, the second upper limit is given as 13°C. This third upper limit varies, like the second upper limit, depending upon the detected room temperature. Furthermore, when the detected room humidity reaches or exceeds 60% which is the maximum value in the target range for the relative humidity, the target evaporation temperature (TeS) is always set lower than the second upper limit to increase the amount of moisture to be condensed in the indoor heat exchanger (**37**), resulting in increasing the amount of moisture to be removed from the room air.

**[0088]** The first lower limit is determined taking it into consideration to maintain the detected heat exchanger temperature at the freezing point of water or higher. The setting of the first lower limit aims at preventing ice accretion on the indoor heat exchanger (**37**) and thereby avoiding the occurrence of problems such as increased resistance to air flow due to freezing.

**[0089]** The second lower limit is determined taking it into consideration to suppress the amount of drain to be produced. More specifically, in high humidity conditions where the detected room humidity exceeds 80% which is a reference value, when the refrigerant evaporation temperature in the indoor heat exchanger (**37**) excessively drops, the amount of moisture condensed may be too increased for the discharge of drain to catch up with, or may cause the production of dew condensation at the casing surface of the indoor unit (**13**). Therefore, in such high humidity conditions, the target evaporation temperature (TeS) is set relatively high in order to prevent dew condensation on the indoor unit **(13)** and thereby ensure reliability.

**[0090]** As has been described so far, when the detected room humidity is below 40%, the target evaporation temperature (TeS) is limited to the first upper limit or lower in the target value setting section (**81**). When the detected room humidity is not lower than 40% and below 60%, the target evaporation temperature (TeS) is limited to the second upper limit, which is lower than the first upper limit, or lower. When the detected room humidity is 60% or higher, the target evaporation temperature (TeS) is limited to the third upper limit, which is lower than the second upper limit, or lower. To sum up, in the target value setting section (**81**), the upper limit of the target evaporation temperature (TeS) becomes lower as the detected room humidity rises.

**[0091]** Next, the action of the capacity control section (**82**) will be described. The capacity control section (**82**) inputs the detected heat exchanger temperature from the indoor heat exchanger temperature sensor (**76**), and the target control value set by the target value setting section (**81**). Then, the capacity control section (**82**) controls the capacity of the compressor (**30**) by changing the power supply frequency output from the inverter so that the detected heat exchanger temperature can match the target control value.

**[0092]** More specifically, during cooling operation, when the detected heat exchanger temperature (i.e., measured value of the refrigerant evaporation temperature) is higher than the target evaporation temperature (TeS), the capacity control section (**82**) increases the power supply frequency output of the inverter. On the contrary, when the detected heat exchanger temperature is lower than the target evaporation temperature (TeS), the capacity control section (**82**) decreases the power supply frequency output of the inverter. During heating operation, when the detected heat exchanger temperature (i.e., measured value of the refrigerant condensation temperature) is lower than the target condensation temperature (TcS), the capacity control section (**82**) increases the power supply frequency output of the inverter. On the contrary, when the detected heat exchanger temperature is higher than the target condensation temperature (TcS), the capacity control section (**82**) decreases the power supply frequency output of the inverter.

**[0093]** Next, description will be made about standpoints in determining the map of Figure 2 by taking cooling operation as an example.

**[0094]** When the detected heat exchanger temperature (Te) is lower than the target evaporation temperature (TeS) (e1 has a negative value) and the detected room temperature (Tr) is higher than the set temperature (TrS) (ΔTrS has a positive value), the target evaporation temperature (TeS) may be set too high even though it is necessary to cool the air much more. In such a case, the correction term (KT2) by learning is set at a negative value so that the target evaporation temperature (TeS) can be set relatively low.

**[0095]** On the contrary, when the detected heat exchanger temperature (Te) is higher than the target evaporation temperature (TeS) (e1 has a positive value) and the detected room temperature (Tr) is lower than the set temperature (TrS) (ΔTrS has a negative value), the target evaporation temperature (TeS) may be set too low even though it is unnecessary to cool the air so much. In such a case, the correction term (KT2) by learning is set at a positive value so that the target evaporation temperature (TeS) can be set relatively high.

**[0096]** When the detected heat exchanger temperature (Te) is higher than the target evaporation temperature (TeS) (e1 has a positive value) and the detected room temperature (Tr) is higher than the set temperature (TrS) (ΔTrS has a positive value), it is necessary to cool the air much more and the target evaporation temperature (TeS) may be set relatively low. When the detected heat exchanger temperature (Te) is lower than the target evaporation temperature (TeS) (e1 has a negative value) and the detected room temperature (Tr) is lower than the set temperature (TrS) (ΔTrS has a negative value), it is unnecessary to cool the air much and the target evaporation temperature (TeS) may be set relatively high. Therefore, in these conditions as well as the condition where the detected heat exchanger temperature (Te) substantially matches the target evaporation temperature (TeS) and the detected room temperature (Tr) substantially matches the set temperature (TrS), the correction term (KT2) by learning is set zero to maintain the target evaporation temperature (TeS) at the current value.

- Effects of the Embodiment -

**[0097]** When setting the target evaporation temperature (TeS) as the target control value during cooling operation, the target value setting section (**81**) of the present embodiment determines the upper limit of the target evaporation temperature (TeS), which is being set, according to the detected value of the relative humidity sensor (**78**) while considering the detected room temperature (Tr) and so on. In other words, the target value setting section (**81**) sets the target control value by considering not only the temperature of the room air but also the relative humidity thereof Therefore, the air conditioner (**10**) of this embodiment can concurrently control both the room temperature and relative humidity in a suitable manner without forcing the user to select the operation centred on temperature control or the operation centred on humidity control unlike the conventional techniques. Therefore, according to this embodiment, the room temperature and relative humidity can be adjusted in a comfort region thereby improving the comfort of people in the room.

**[0098]** Particularly in this embodiment, since the target value setting section (**81**) takes 0°C for the first lower limit, the indoor heat exchanger (**37**) is fundamentally maintained at 0°C or higher. Therefore, according to this embodiment, the indoor heat exchanger (**37**) can be avoided from moisture freezing thereby preventing any adverse effect resulting from freezing.

**[0099]** Furthermore, in this embodiment, the target value setting section (**81**) takes the second lower limit higher than 0°C for the lower limit of the target evaporation temperature (TeS) when the room is under high humidity conditions that the amount of moisture condensed in the indoor heat exchanger (**37**) is expected to be excessive. Therefore, according to this embodiment, the target evaporation temperature (TeS) can be set relatively high to prevent excessive drop of the refrigerant evaporation temperature during cooling operation and thereby avoid any adverse effect of excessive drain and dew condensation on the casing of the indoor unit (**13**).

**Industrial Applicability**

**[0100]** As can be seen from the above, the present invention is useful for air conditioning systems that conduct cooling operation.

**Claims**

**1.** An air conditioning system that operates on a refrigeration cycle by circulating refrigerant in a refrigerant circuit (20) and conducts at least cooling operation in which refrigerant evaporates in an indoor heat exchanger (37) of the refrigerant circuit (20), said air conditioning system comprising:

heat exchanger temperature detecting means (76) for detecting the temperature of the indoor heat exchanger (37) as an evaporation temperature of the refrigerant during cooling operation;
room temperature detecting means (75) for detecting the dry-bulb temperature of a room air being sent to the indoor heat exchanger (37);
room humidity detecting means (78) for detecting the relative humidity of the room air being sent to the indoor

heat exchanger (37);
setting means (81) for setting a target control value for the evaporation temperature of the refrigerant during cooling operation; and
capacity control means (82) for controlling the capacity of a compressor (30) of the refrigerant circuit (20) so that the detected value of the heat exchanger temperature detecting means (76) reaches the target control value set by the setting means (81), **characterized in that** the setting means is configured to set the target control value at specified time intervals, based on a detected value of the heat exchanger temperature detecting means (76), a detected value of the room temperature detecting means (75) and a user-input set temperature, within a range up to an upper limit determined according to a detected value of the room humidity detecting means (78).

**2.** An air conditioning system that operates on a refrigeration cycle by circulating refrigerant in a refrigerant circuit (20) and conducts at least cooling operation in which refrigerant evaporates in an indoor heat exchanger (37) of the refrigerant circuit (20), said air conditioning system comprising:

heat exchanger temperature detecting means (76) for detecting the temperature of the indoor heat exchanger (37) as an evaporation temperature of the refrigerant during cooling operation;
room temperature detecting means (75) for detecting the dry-bulb temperature of a room air being sent to the indoor heat exchanger (37);
room humidity detecting means (78) for detecting the relative humidity of the room air being sent to the indoor heat exchanger (37);
setting means (81) for setting a target control value for the evaporation temperature of the refrigerant during cooling operation; and
capacity control means (82) for controlling the capacity of a compressor (30) of the refrigerant circuit (20) so that the detected value of the heat exchanger temperature detecting means (76) reaches the target control value set by the setting means (81), **characterized in that** the setting means is configured to set the target control value so that a detected value of the room temperature detecting means (75) reaches a set temperature, and for limiting the target control value to within a range up to an upper limit determined according to a detected value of the room humidity detecting means (78).

**3.** The air conditioning system of Claim 1 or 2, wherein the setting means (81) drops the upper limit of the target control value for the evaporation temperature of the refrigerant in a stepwise manner as the detected value of the room humidity detecting means (78) increases.

**4.** The air conditioning system of Claim 1 or 2,
wherein the setting means (81) stores the minimum and maximum values in a target range for the room relative humidity, and
wherein when the detected value of the room humidity detecting means (78) is equal to or larger than the minimum value in the target range, the setting means (81) takes for the upper limit of the target control value a value lower than the wet-bulb temperature of an air whose dry-bulb temperature is a detected value of the room temperature detecting means (75) and whose relative humidity is the minimum value in the target range.

**5.** The air conditioning system of Claim 4, wherein when the detected value of the room humidity detecting means (78) exceeds the maximum value in the target range for the room relative humidity, the setting means (81) drops the upper limit of the target control value below that of the target control value when the detected value of the room humidity detecting means (78) falls within the target range.

**6.** The air conditioning system of Claim 1 or 2, wherein the setting means (81) sets the target control value within the range down to 0°C.

**7.** The air conditioning system of Claim 6, wherein only when the room is brought into high humidity conditions that the detected value of the room humidity detecting means (78) exceeds a predetermined reference value, the setting means (81) sets the target control value within the range down to a predetermined lower limit which is higher than 0°C.

## Patentansprüche

**1.** Klimaanlage, die in einem Kühlzyklus arbeitet, indem sie ein Kühlmittel in einem Kühlkreislauf (20) zirkuliert und wenigstens einen Kühlvorgang ausführt, bei dem ein Kühlmittel in einem Innenraumwärmetauscher (37) des Kühlkreislaufs (20) verdunstet, wobei die Klimaanlage aufweist:

eine Wärmetauschertemperaturbestimmeinrichtung (76) zum Bestimmen der Temperatur des Innenraumwärmetauschers (37) als eine Verdunstungstemperatur des Kühlmittels während des Kühlvorgangs,
eine Raumtemperaturbestimmeinrichtung (75) zum Bestimmen der Trockenthermometertemperatur einer Raumluft, die zu dem Innenraumwärmetauscher (37) gesandt wird,
eine Raumluftfeuchtigkeitsbestimmeinrichtung (78) zum Bestimmen der relativen Luftfeuchtigkeit der Raumluft, die zu dem Innenraumwärmetauscher (37) gesandt wird,
eine Einstelleinrichtung (81) zum Einstellen eines Zielregelwerts für die Verdunstungstemperatur des Kühlmittels während des Kühlvorgangs, und
eine Kapazitätsregeleinrichtung (82) zum Regeln der Kapazität eines Kompressors (30) des Kühlkreislaufs (20), so dass der von der Wärmetauschertemperaturbestimmeinrichtung (76) bestimmte Wert den Zielregelwert, der durch die Einstelleinrichtung (81) eingestellt ist, erreicht, **dadurch gekennzeichnet, dass** die Einstelleinrichtung dafür konfiguriert ist, den Zielregelwert in vorbestimmten Zeitintervallen auf der Grundlage eines von der Wärmetauschertemperaturbestimmeinrichtung (76) bestimmten Werts, eines von der Raumtemperaturbestimmeinrichtung (75) bestimmten Werts und einer vom Benutzer eingegebenen eingestellten Temperatur innerhalb eines Bereichs, der bis zu einer oberen Grenze, die gemäß einem von der Raumluftfeuchtigkeitsbestimmeinrichtung (78) bestimmten Wert festgesetzt wird, einzustellen.

2. Klimaanlage, die in einem Kühlzyklus arbeitet, indem sie ein Kühlmittel in einem Kühlkreislauf (20) zirkuliert und wenigstens einen Kühlvorgang ausführt, bei dem ein Kühlmittel in einem Innenraumwärmetauscher (37) des Kühlkreislaufs (20) verdunstet, wobei die Klimaanlage aufweist:

   eine Wärmetauschertemperaturbestimmeinrichtung (76) zum Bestimmen der Temperatur des Innenraumwärmetauschers (37) als eine Verdunstungstemperatur des Kühlmittels während des Kühlvorgangs,
   eine Raumtemperaturbestimmeinrichtung (75) zum Bestimmen der Trockenthermometertemperatur einer Raumluft, die zu dem Innenraumwärmetauscher (37) gesandt wird,
   eine Raumluftfeuchtigkeitsbestimmeinrichtung (78) zum Bestimmen der relativen Luftfeuchtigkeit der Raumluft, die zu dem Innenraumwärmetauscher (37) gesandt wird,
   eine Einstelleinrichtung (81) zum Einstellen eines Zielregelwerts für die Verdunstungstemperatur des Kühlmittels während des Kühlvorgangs, und
   eine Kapazitätsregeleinrichtung (82) zum Regeln der Kapazität eines Kompressors (30) des Kühlkreislaufs (20), so dass der von der Wärmetauschertemperaturbestimmeinrichtung (76) bestimmte Wert den Zielregelwert, der durch die Einstelleinrichtung (81) eingestellt ist, erreicht, **dadurch gekennzeichnet, dass** die Einstelleinrichtung dafür konfiguriert ist, den Zielregelwert so einzustellen, dass ein von der Raumtemperaturbestimmeinrichtung (75) bestimmter Wert eine eingestellte Temperatur erreicht, und dass sie zum Begrenzen des Zielregelwerts innerhalb eines Bereichs bis zu einer oberen Grenze, die in Abhängigkeit von einem von der Raumluftfeuchtigkeitsbestimmeinrichtung (78) bestimmten Wert festgesetzt wird, dient.

3. Klimaanlage nach Anspruch 1 oder 2, bei der die Einstelleinrichtung (81) die obere Grenze des Zielregelwerts für die Verdunstungstemperatur des Kühlmittels schrittweise senkt während der von der Raumluftfeuchtigkeitsbestimmeinrichtung (78) bestimmte Wert ansteigt.

4. Klimaanlage nach Anspruch 1 oder 2,
   bei der die Einstelleinrichtung (81) die Minimal- und Maximalwerte in einem Zielbereich für die relative Raumluftfeuchtigkeit speichert, und
   bei der, wenn der von der Raumluftfeuchtigkeitsbestimmeinrichtung (78) bestimmte Wert größer oder gleich dem Minimalwert in dem Zielbereich ist, die Einstelleinrichtung (81) als obere Grenze des Zielregelwerts einen Wert nimmt, der kleiner ist als die Feuchtthermometertemperatur einer Luft, deren Trockenthermometertemperatur ein von der Raumtemperaturbestimmeinrichtung (75) bestimmter Wert ist und deren relative Luftfeuchtigkeit der Minimalwert in dem Zielbereich ist.

5. Klimaanlage nach Anspruch 4, bei der, wenn der von der Raumluftfeuchtigkeitsbestimmeinrichtung (78) bestimmte Wert den Maximalwert in dem Zielbereich für die relative Raumluftfeuchtigkeit überschreitet, die Einstelleinrichtung (81) die obere Grenze des Zielregelwerts unterhalb des Zielregelwerts absenkt wenn der von der Raumluftfeuchtigkeitsbestimmeinrichtung (78) bestimmte Wert innerhalb des Zielbereichs liegt.

6. Klimaanlage nach Anspruch 1 oder 2, bei der die Einstelleinrichtung (81) den Zielregelwert innerhalb des Bereichs nach unten bis zu 0°C einstellt.

7. Klimaanlage nach Anspruch 6, bei der nur dann, wenn der Raum in Bedingungen mit hoher Luftfeuchtigkeit gebracht wird, so dass der von der Raumluftfeuchtigkeitsbestimmeinrichtung (78) bestimmte Wert einen vorbestimmten Referenzwert überschreitet, die Einstelleinrichtung (81) den Zielregelwert innerhalb des Bereichs bis zu einer vorbestimmten unteren Grenze einstellt, die höher als 0°C ist.

## Revendications

1. Système de climatisation qui fonctionne sur un cycle de réfrigération en faisant circuler du fluide frigorigène dans un circuit réfrigérant (20) et conduit au moins une opération de refroidissement dans laquelle le fluide frigorigène s'évapore dans un échangeur thermique intérieur (37) du circuit réfrigérant (20), ledit système de climatisation comprenant :

   un moyen (76) de détection de température de l'échangeur thermique pour détecter la température de l'échangeur thermique intérieur (37) comme température d'évaporation du fluide frigorigène durant une opération de refroidissement ;
   un moyen (75) de détection de température ambiante pour détecter la température sèche de l'air ambiant étant envoyé à l'échangeur thermique intérieur (37) ;
   un moyen (78) de détection d'humidité ambiante pour détecter l'humidité relative de l'air ambiant étant envoyé à l'échangeur thermique intérieur (37) ;
   un moyen de réglage (81) pour régler une valeur de commande cible pour la température d'évaporation du fluide frigorigène durant une opération de refroidissement ; et
   un moyen (82) de commande de capacité pour commander la capacité d'un compresseur (30) du circuit réfrigérant (20) de sorte que la valeur détectée du moyen (76) de détection de température de l'échangeur thermique atteigne la valeur de commande cible réglée par le moyen de réglage (81), **caractérisé en ce que** le moyen de réglage est configuré pour régler la valeur de commande cible à des intervalles de temps spécifiés, sur la base d'une valeur détectée du moyen (76) de détection de température de l'échangeur thermique, d'une valeur détectée du moyen (75) de détection de température ambiante et d'une température réglée introduite par l'utilisateur, dans une plage allant jusqu'à une limite supérieure déterminée selon une valeur détectée du moyen (78) de détection d'humidité ambiante.

2. Système de climatisation qui fonctionne sur un cycle de réfrigération en faisant circuler du fluide frigorigène dans un circuit réfrigérant (20) et conduit au moins une opération de refroidissement dans laquelle le fluide frigorigène s'évapore dans un échangeur thermique intérieur (37) du circuit réfrigérant (20), ledit système de climatisation comprenant :

   un moyen (76) de détection de température de l'échangeur thermique pour détecter la température de l'échangeur thermique intérieur (37) comme température d'évaporation du fluide frigorigène durant l'opération de refroidissement ;
   un moyen (75) de détection de température ambiante pour détecter la température sèche de l'air ambiant étant envoyé à l'échangeur thermique intérieur (37) ;
   un moyen (78) de détection d'humidité ambiante pour détecter l'humidité relative de l'air ambiant étant envoyé à l'échangeur thermique intérieur (37) ;
   un moyen de réglage (81) pour régler une valeur de commande cible pour la température d'évaporation du fluide frigorigène durant une opération de refroidissement ; et
   un moyen (82) de commande de capacité pour commander la capacité d'un compresseur (30) du circuit réfrigérant (20) de sorte que la valeur détectée du moyen (76) de détection de température de l'échangeur thermique atteigne la valeur de commande cible réglée par le moyen de réglage (81), **caractérisé en ce que** le moyen de réglage est configuré pour régler la valeur de commande cible de sorte qu'une valeur détectée du moyen (75) de détection de température ambiante atteigne une température réglée, et pour limiter la valeur de commande cible à une plage allant jusqu'à une limite supérieure déterminée selon une valeur détectée du moyen (78) de détection d'humidité ambiante.

3. Système de climatisation de la revendication 1 ou 2, dans lequel le moyen de réglage (81) fait baisser la limite supérieure de la valeur de commande cible pour la température d'évaporation du fluide frigorigène progressivement

à mesure que la valeur détectée du moyen (78) de détection d'humidité ambiante augmente.

**4.** Système de climatisation de la revendication 1 ou 2,
dans lequel le moyen de réglage (81) stocke les valeurs minimale et maximale dans une plage cible pour l'humidité relative ambiante, et
dans lequel, lorsque la valeur détectée du moyen (78) de détection d'humidité ambiante est supérieure ou égale à la valeur minimale dans la plage cible, le moyen de réglage (81) prend pour limite supérieure de la valeur de commande cible, une valeur inférieure à la température humide de l'air dont la température sèche est une valeur détectée du moyen (75) de détection de température ambiante et dont l'humidité relative est la valeur minimale dans la plage cible.

**5.** Système de climatisation de la revendication 4, dans lequel, lorsque la valeur détectée du moyen (78) de détection d'humidité ambiante dépasse la valeur maximale de la plage cible pour l'humidité relative ambiante, le moyen de réglage (81) fait baisser la limite supérieure de la valeur de commande cible en-dessous de celle de la valeur de commande cible lorsque la valeur détectée du moyen (78) de détection d'humidité ambiante baisse dans la plage cible.

**6.** Système de climatisation de la revendication 1 ou 2, dans lequel le moyen de réglage (81) règle la valeur de commande cible dans la plage en-dessous de 0°C.

**7.** Système de climatisation de la revendication 6, dans lequel, uniquement lorsque la pièce est soumise à des conditions d'humidité élevée que la valeur détectée du moyen (78) de détection d'humidité ambiante dépasse une valeur de référence prédéterminée, le moyen de réglage (81) règle la valeur de commande cible dans la plage en-dessous d'une limite inférieure prédéterminée qui est supérieure à 0°C.

FIG. 1

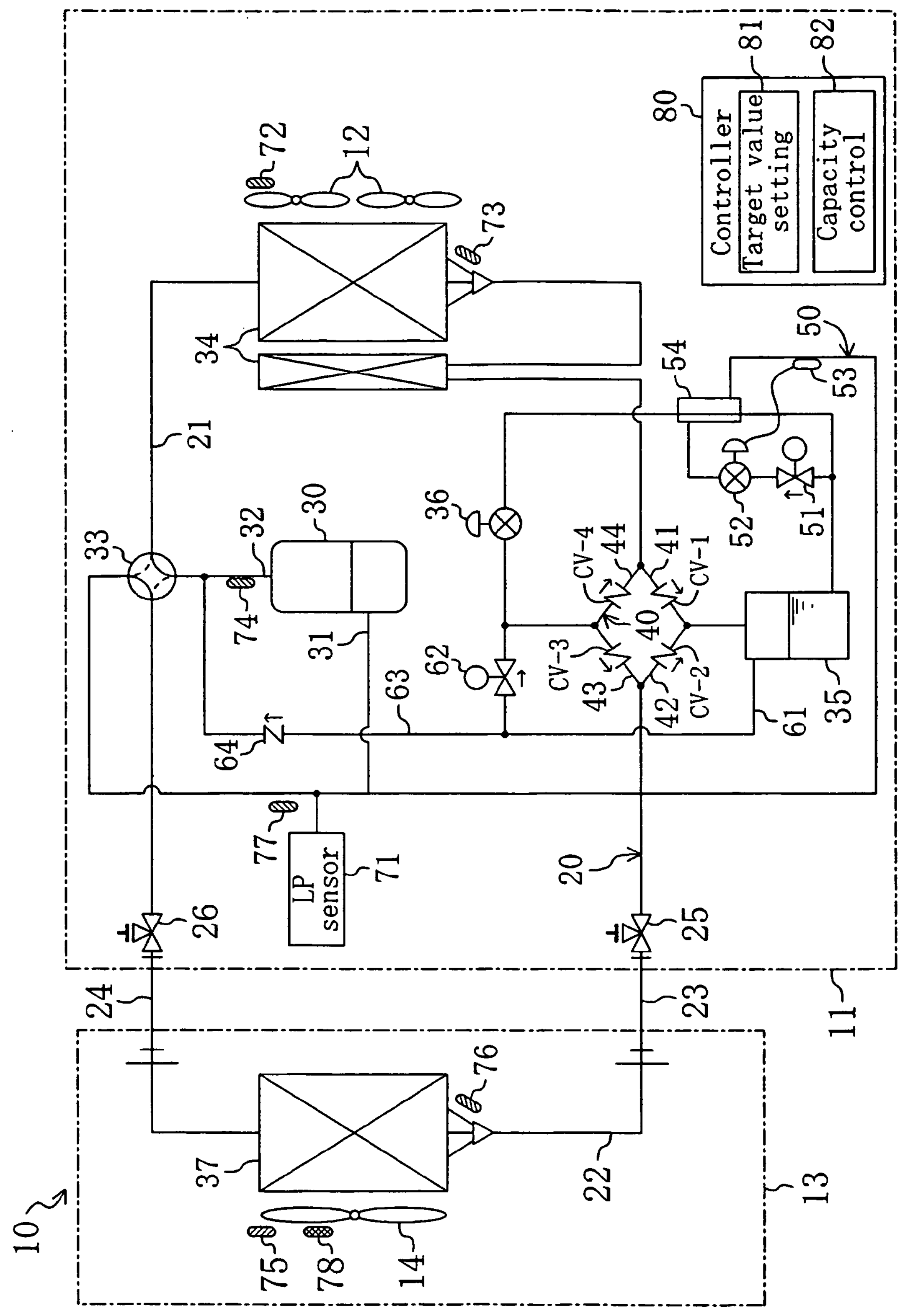

Controller
Target value setting
Capacity control
LP sensor
CV-1
CV-2
CV-3
CV-4
10
11
12
13
14
20
21
22
23
24
25
26
30
31
32
33
34
35
36
37
40
41
42
43
44
50
51
52
53
54
61
62
63
64
71
72
73
74
75
76
77
78
80
81
82

FIG. 2

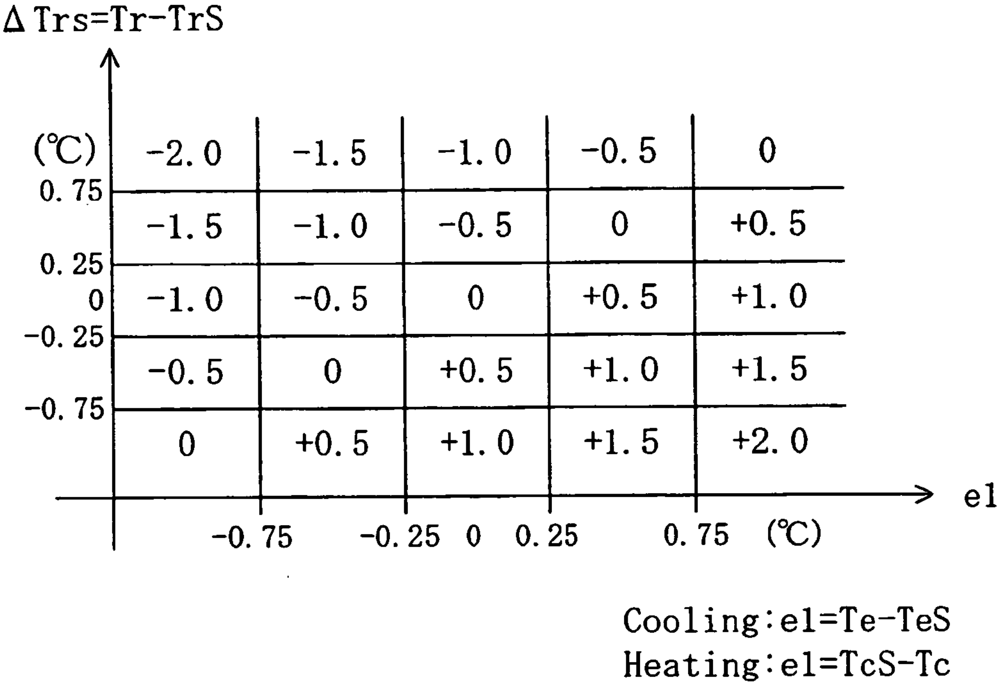
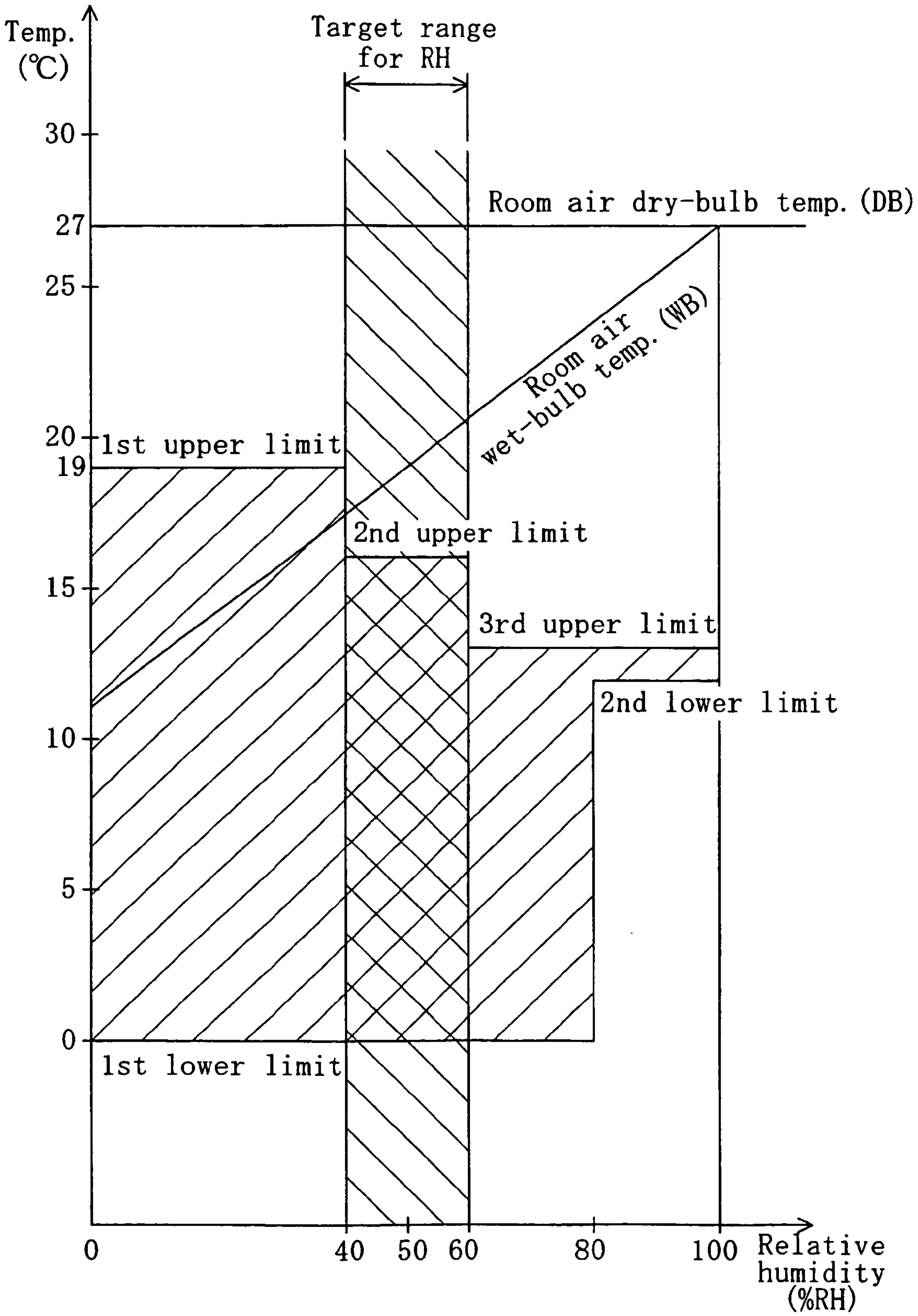

ΔTrs=Tr-TrS
(℃)
0.75
0.25
0
-0.25
-0.75
-2.0 -1.5 -1.0 -0.5 0
-1.5 -1.0 -0.5 0 +0.5
-1.0 -0.5 0 +0.5 +1.0
-0.5 0 +0.5 +1.0 +1.5
0 +0.5 +1.0 +1.5 +2.0
el
-0.75 -0.25 0 0.25 0.75 (℃)
Cooling:el=Te-TeS
Heating:el=TcS-Tc

FIG. 3


Temp. (℃)
Target range for RH
30
27
25
20
19
15
10
5
0
Room air dry-bulb temp. (DB)
Room air wet-bulb temp. (WB)
1st upper limit
2nd upper limit
3rd upper limit
2nd lower limit
1st lower limit
0
40
50
60
80
100
Relative humidity (%RH)

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- US 5305822 A **[0005]**