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(54) Cooling and dehumidifying system of an air-conditioning unit

(57) A cooling and dehumidifying system for an air-conditioning unit is provided. The cooling and dehumidifying system comprises cooling coils and a heat pipe system for cooling and controlling relative humidity of an indoor area. The heat pipe system comprises an evaporator and a condenser. The heat pipe system works together with the cooling coils. A device for controlling the refrigerant's flow in the system is provided. The system includes a sensor for detecting the indoor temperature and a sensor for detecting the indoor relative humidity.

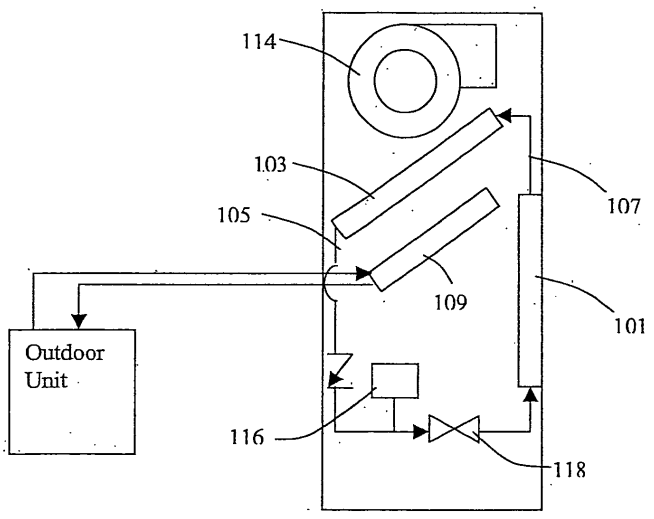

Fig. 1A

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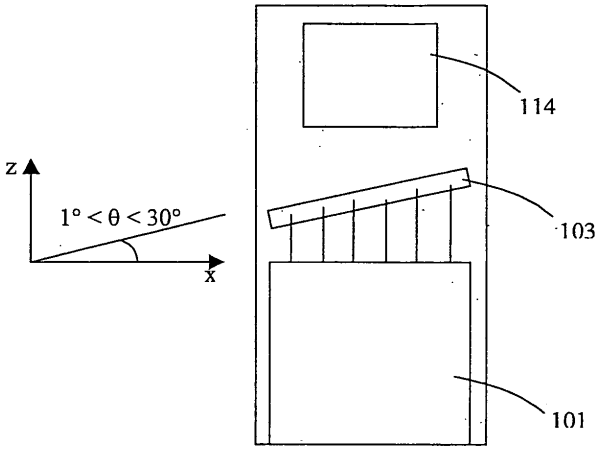

Fig. 1B

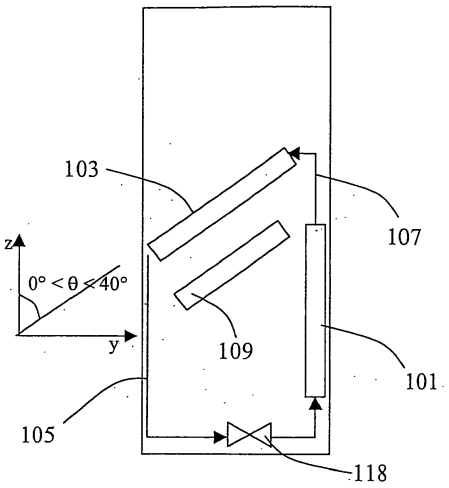

Fig. 1C

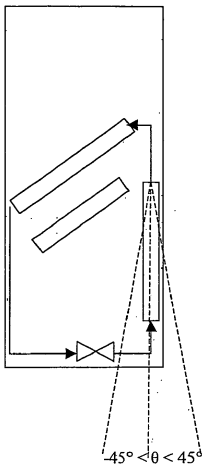

Fig. 1D

Description

Field of the Invention

[0001] The present invention relates to a cooling and dehumidifying system for an air-conditioning unit used for an indoor application.

Background of the Invention

[0002] An air-conditioning unit for an indoor cooling application typically includes a unit for cooling the air located inside a building and a unit located outside a building for cooling the refrigerant from the indoor unit and for circulating the cooled refrigerant back into the indoor unit.

[0003] The air-conditioning unit will provide a desired cooling according to a preset temperature. The presence of high moisture content in the air may negatively affect the operation of the air conditioning unit. An effective cooling application in hot and humid places, such in tropical countries where the humidity level is relatively very high is needed so that an optimum level of relative humidity can be obtained in an enclosed space.

[0004] In light of the above, it is the objective of the present invention to provide a cooling and dehumidifying system for an air-conditioning unit so that the optimum level of relative humidity is achieved. It is another objective of the present invention to provide a cooling and the humidifying system for the air-conditioning unit that allows a compact air-conditioning unit be formed.

Summary of the Invention

[0005] The present invention relates to a cooling and dehumidifying system for an air-conditioning unit used for an indoor application. The cooling and dehumidifying system comprises cooling coils and a heat pipe system for cooling and controlling relative humidity of an indoor space. The heat pipe system comprises an evaporator and a condenser where the evaporator is in communication with the condenser. The heat pipe system works together with the cooling coils for cooling the air forced into the air-conditioning unit. The evaporator, condenser and the cooling coils contain working fluid called refrigerant. A device for controlling the refrigerant's flow between the evaporator and condenser is provided. The system includes a sensor for detecting the indoor temperature and a sensor for detecting the indoor relative humidity.

[0006] In operation, the air in an indoor space such as a room is drawn into the air-conditioning unit. The air will flow passing through the evaporator, cooling coils and condenser. The evaporator serves as a first cooling element for removing heat from the air. The evaporator provides a sensible cooling without removing moisture. The cooling coils serve as a second cooling element for removing further heat from the air making the air cooler and removing moisture from the air by condensation process. The cooled air will further flow through the condenser before entering back into the room. The condenser serves as a heating element for reheating the cool air so as to lower its relative humidity. When reheated, the moisture content of the cooled air substantially remains the same and the capacity of water that the air can hold increase and, thus, lowering the relative humidity of the air.

[0007] The cooling coils are arranged between the evaporator and the condenser so that the air that forced into the air-conditioning unit will first pass the evaporator, the cooling coils and last the condenser. The refrigerant will flow between the evaporator and condenser for cooling and heating the air The evaporator and the condenser are connected via pipelines. A receptacle for collecting condensate from the condenser and a device for controlling the refrigerant flow are provided between the receptacle and the evaporator. The heat pipe system are arranged as to allow a compact air-conditioning unit be designed.

Brief Description of the Drawings

[0008] The present invention will be described by the way of example only, with reference to the accompanying drawings, in which:

Figs. 1A, 1B, 1C and 1D shows multiple views of a cooling and dehumidifying system for an air-conditioning unit according to an embodiment of the present invention;
Fig. 2 shows a diagram of the cooling and dehumidifying system for an air-conditioning unit of Fig. 1A;
Figure 3 shows dehumidification control by a solenoid valve;
Figure 4 shows dehumidification control by an electronic expansion valve;
Figure 5 shows dehumidification control by a modulating valve;
Figs. 6A and 6B shows psychometric charts of air-conditioning unit with and without the heat pipe system.

Detailed Description of an Embodiment of the Present Invention

[0009] Figs. 1A, 1B, 1C, 1D and 2 show multiple views of a cooling and dehumidifying system for an air-conditioning unit according to an embodiment of the present invention. The cooling and dehumidifying system comprises cooling coils and a heat pipe system. As shown in Figs. 1A, 1B, 1C, 1D, and 2, the heat pipe system comprises an evaporator 101 and a condenser 103 connected to one another via a single liquid line 105 and a plurality of vapor lines 107.

[0010] The lines 105 and 107 are copper pipes. The evaporator 101 and condenser 103 contain a working fluid such as a refrigerant type R22, R410a or R407c. The refrigerant works in a closed loop of the heat pipe

system without requiring external mechanical energy. The evaporator 101 and condenser 103 are of fin-tube heat exchangers with copper pipes and aluminum fins. The copper pipes include a main inlet header pipe that branches into several small diameter pipes running through the heat exchanger, and a main outlet header pipe. The heat pipe system are arranged to be in proximity with a cooling coils 109 so that the components are packaged as one unitary system. The cooling coils 109 are arranged between the evaporator 101 and condenser 103. A blower 114 is provided to draw air into the air-conditioning unit.

[0011] When the indoor air is drawn into the air-conditioning unit, the air will be channeled through the evaporator 101, cooling coils 109, and condenser 103 before entering back into the indoor space. When the air passes through the evaporator 103, the refrigerant inside the evaporator 101 will absorb heat from the air and turn into vapor. The vapor will travel to the condenser 103 via a plurality of vapor lines 107. In the process, a portion of heat from the air is transferred, which means a portion of heat is also removed from the air.

[0012] Figure 1B shows a side view of the air-conditioning unit. The condenser 103 is disposed in a slanted position to allow the refrigerant to flow effectively by gravity to the evaporator 101 via a single liquid line 105. The angle for the slanted position is coordinated to have a rolling angle between 0° and 30° degree and a pitching angle between 0° to 40° degree relative to the horizontal position.

[0013] Fig: 1C shows a front view of the air-conditioning unit. The cooling coils 109 are arranged in a slanted position at an angle between 0° to 40° degree relative to horizontal position to allow condensate water to flow effectively by the gravity or by forced with a pump to towards a collecting receptacle to be removed.

[0014] Figure ID shows a front view of the air-conditioning unit The evaporator 101 is disposed in a slanted position at an angle of between -45° and 45° degree relative to the vertical position. The arrangements of the heat pipe system and the cooling coils 109 allow flexibility in designing a compact air-conditioning unit and save space.

[0015] At least a flow control valve is disposed at the single liquid line 105 for controlling the refrigerant flow towards the evaporator 101. A receptacle 116 for collecting refrigerant may be provided to collect condensate from the condenser 103 and to prevent the refrigerant from flowing back to the condenser 103. The flow control valves include solenoid valves, electronic expansion valves (EXV) and modulating valve.

[0016] A sensor for detecting the temperature of the air and a sensor for detecting the relative humidity level of the air are placed at the evaporator 101. The sensor will measure the current relative humidity level in the room and determine whether its value above or below the preset level. For example, if the value exceeds the preset level, the humidity sensor will provide a signal to the flow control valve to open allowing the refrigerant to flow into the evaporator and condenser so that more moisture will be removed by condensation process. If the relative humidity drops below the preset level, the humidity sensor will provide a signal to the flow control valve to close disallowing the refrigerant to flow into the evaporator.

[0017] Fig. 3 shows a flow diagram of controlling the heat pipe system using a solenoid valve. A humidity sensor will detect the current relative humidity level and send the humidity information to a microprocessor. When the detected value is higher than the preset level, the microprocessor will send a signal to the flow control valve 118 to open which allows the refrigerant to flow into the evaporator 101 for removing more heat that will pass through the evaporator 101. When the detected value is equal to or lower than the preset level, the microprocessor will send a signal to close the flow control valve 118 which disallows the refrigerant to flow into the evaporator.

[0018] Referring to figure 4, an example of algorithm for an Electronic Expansion Valve (EXV) is described. Firstly, the desired relative humidity value for the indoor space is set. Secondly, a humidity sensor will sense the current relative humidity in the space and sends the information to a microprocessor. If the value is equal to the preset level within the tolerance of the equipment (e.g. 3%), no change is necessary and therefore, the EXV remains open. The system will continue to monitor for any humidity changes in the space. If the current humidity value higher than the preset level, the microprocessor will signal the EXV to selectively open by a number of steps (n). If the humidity value is lower than the preset level, the microprocessor will signal the EXV to close by a number of steps (n). The variable "n" is a number between 0 and 500.

[0019] Referring to figure 5, an example of the algorithm for a Modulating Valve is described. Firstly, a desired relative humidity level is set. A sensor will detect and measure the current relative humidity in the room and sends a signal to a microprocessor. If the humidity value is equal the preset level within the tolerance of the equipment (e.g. 3%), no change is necessary and therefore, the modulating valve remains open. The system will continue to monitor for any relative humidity changes in the space. If the value is higher than the preset level, the microprocessor will send analogue signal to the modulating valve to open the valve. If the humidity value is lower than the preset level, the microprocessor will send an analogue signal to the modulating valve to close the valve.

[0020] The process for conventional cooling is shown in figure 6A. Point A shows the inlet condition of the room air. From point A to point B, sensible heat is removed from the air until the air reaches dew point (Point B). From point B to point C, latent heat and sensible heat is removed from the air. Point C shows the condition of the air leaving the conventional air conditioner. Point D is the final temperature of the air after mixing with the warmer

room air.

[0021] The process for cooling with the heat pipe system of the present invention is shown in figure 6B. Point A shows the inlet condition of the room air. From point A to point A', sensible heat is first removed from the air by the heat pipe evaporator. From point A' to point B, the sensible heat is removed from the air until dew point temperature is reached (Point B). From point B to C, latent heat and sensible heat is removed from the air. From point C to point D', the heat absorbed by the heat pipe evaporator is released in the heat pipe condenser, therefore providing a heating process on the air leaving Point C. Point D' shows the air condition leaving the heat pipe system. Point D is the final temperature of the air after mixing with the warmer room air. Point C shows the condition of the air leaving the cooling coils.

Claims

1. A cooling and dehumidifying system for an air-conditioning unit comprising

   a) a blower for drawing air into the air-conditioning unit;
   b) a heat pipe system for cooling and dehumidifying the air wherein the heat pipe system includes
   an evaporator for removing heat from the air,
   a condenser for heating the air;
   wherein the evaporator is in communication with the condenser to allow a working fluid to flow between the evaporator and the condenser;
   c) cooling coils for removing heat and for removing moisture from the air **characterized in that** the system is controlled by a control system having at least a sensor for detecting humidity of the air and a control valve for selectively controlling the refrigerant's flow between the evaporator and condenser.

2. A cooling and dehumidifying system for an air-conditioning unit as claimed in Claim 1 wherein the evaporator is arranged in a manner where the forced air will first pass the evaporator and followed by the cooling coils and the condenser.

3. A cooling and dehumidifying system for an air-conditioning unit as claimed in Claim 1 wherein the condenser is arranged at a slanting position that has pitching and rolling angles relative to a horizontal axis.

4. A cooling and dehumidifying system for an air-conditioning unit as claimed in Claim 3 wherein the pitching angle is between 0° to 40° degree to a horizontal axis and the rolling angle is between 1° to 30° degree relative to a horizontal axis.

5. A cooling and dehumidifying system for an air-conditioning unit as claimed in Claim 1 wherein the evaporator is arranged in a slanting position that has a pitching angle in the range of -45° to 45° degree from a vertical axis.

6. A cooling and dehumidifying system for an air-conditioning unit claimed in Claim 1 wherein the communication between the evaporator and the condenser is via pipes wherein the pipes includes a single pipe for channeling condensate from the condenser to evaporator and a plurality of pipes for channeling vapor
   from the evaporator to the condenser.

7. A cooling and dehumidifying system for an air-conditioning unit as claimed in Claim 1 wherein the evaporator and condenser have fin-tube heat exchanger configuration with copper pipes and aluminum fins.

8. A cooling and dehumidifying system for an air-conditioning unit claimed in Claim 1 wherein the sensor sends signal to the control valve to open and close the valve to respectively allow and disallow the refrigerant to flow into the evaporator.

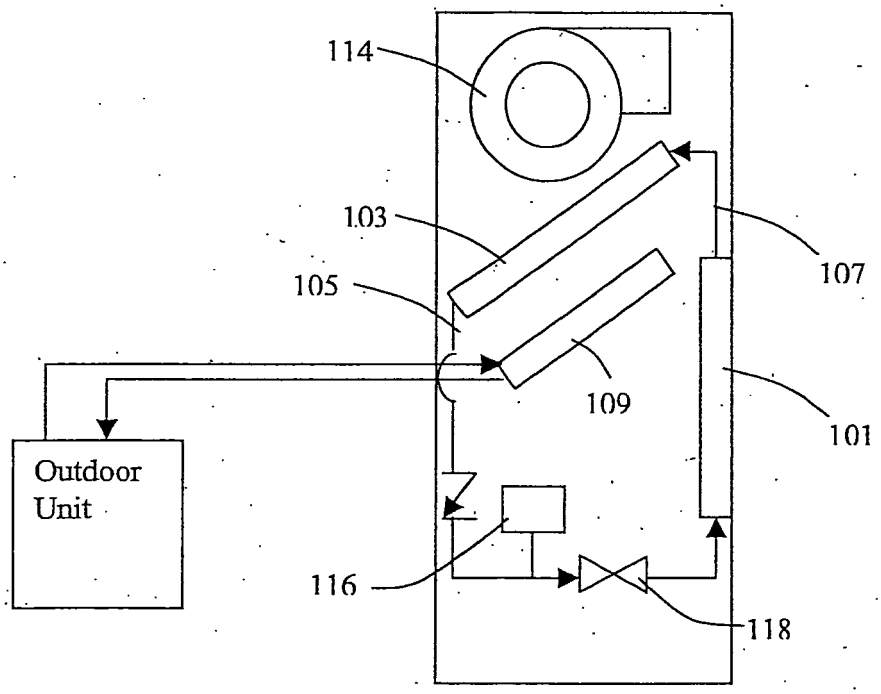

Fig. 1A

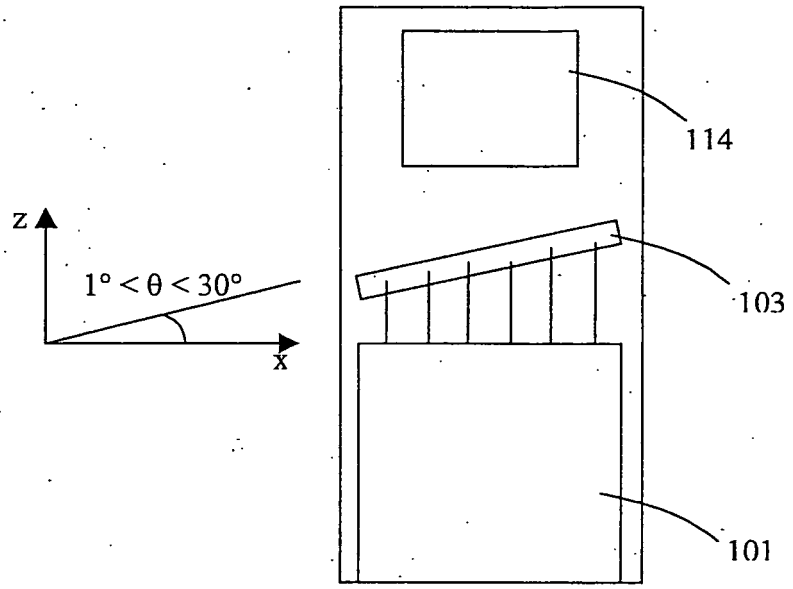

Fig. 1B

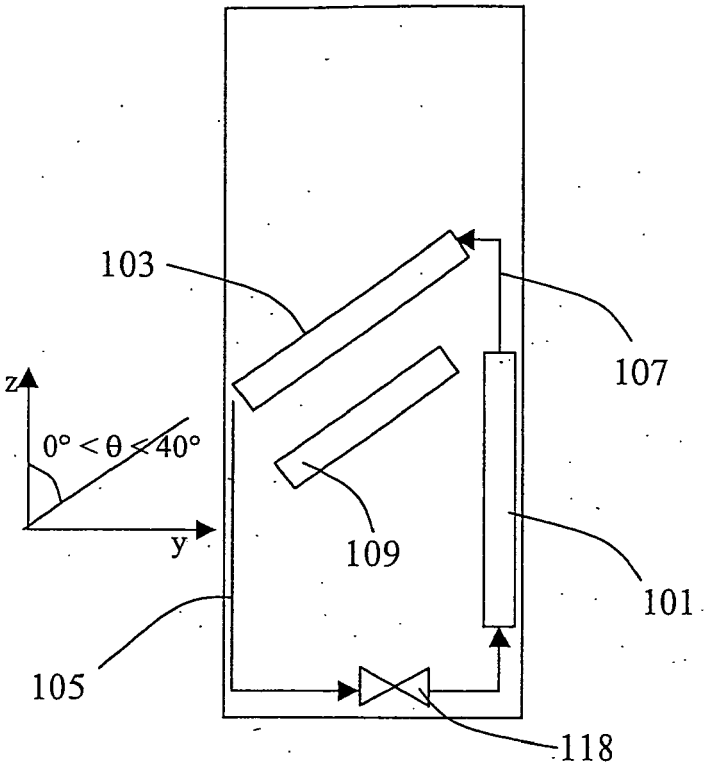

Fig. 1C

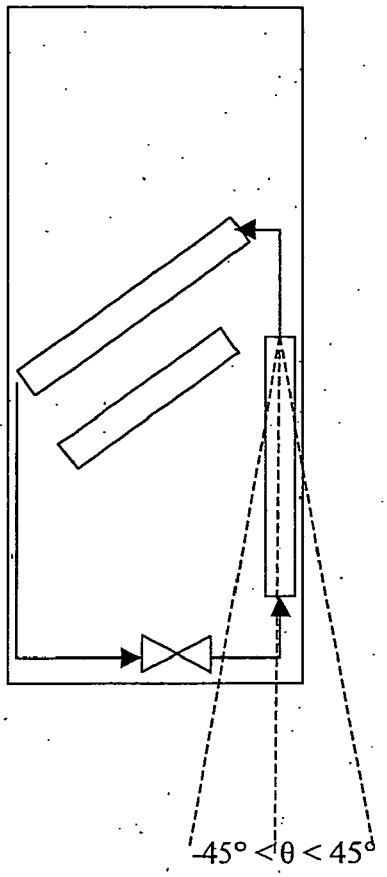

Fig. 1D

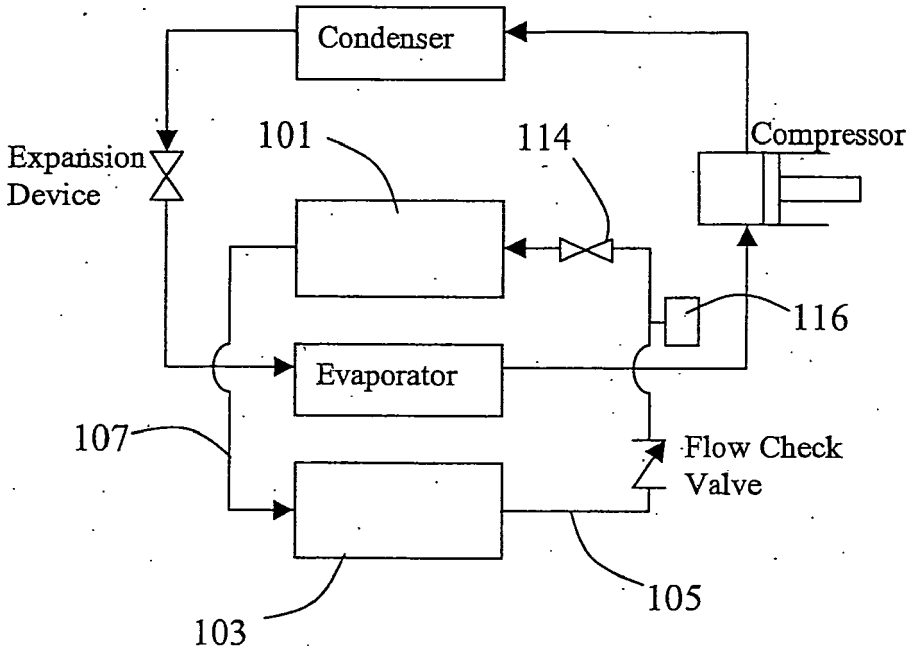
Condenser
Expansion Device
101
114
Compressor
116
Evaporator
107
Flow Check Valve
105
103

Fig. 2

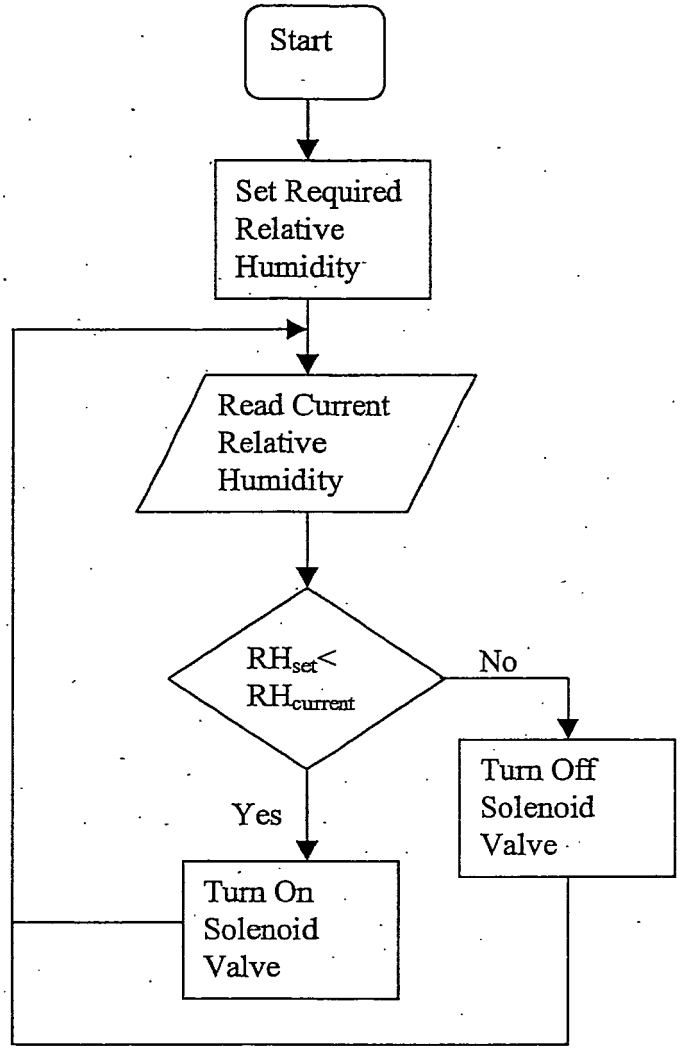
Start
Set Required Relative Humidity
Read Current Relative Humidity
RHset< RHcurrent
No
Yes
Turn Off Solenoid Valve
Turn On Solenoid Valve

Fig. 3

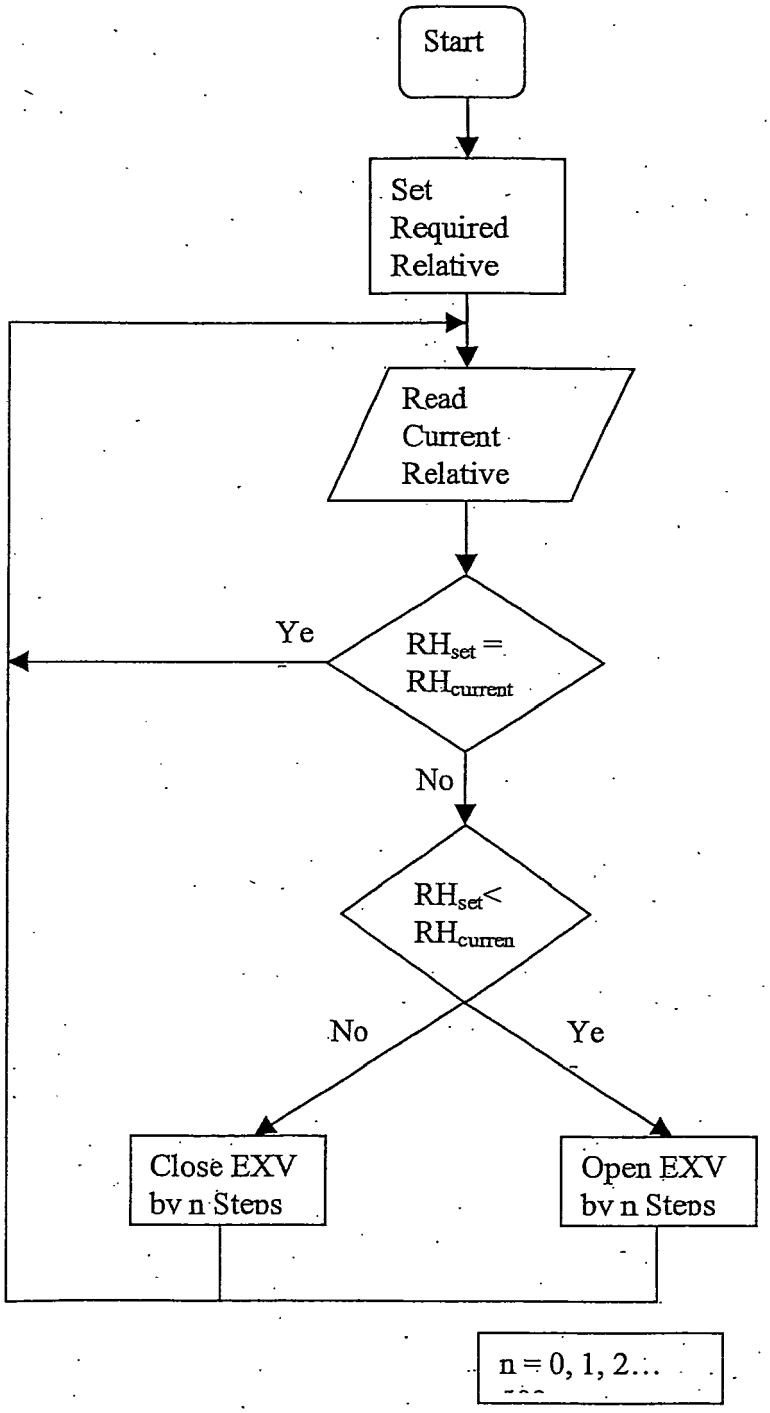
Start
Set Required Relative
Read Current Relative
Ye
RHset = RHcurrent
No
RHset< RHcurren
No
Ye
Close EXV bv n Steps
Open EXV bv n Steps
n = 0, 1, 2...

Fig. 4

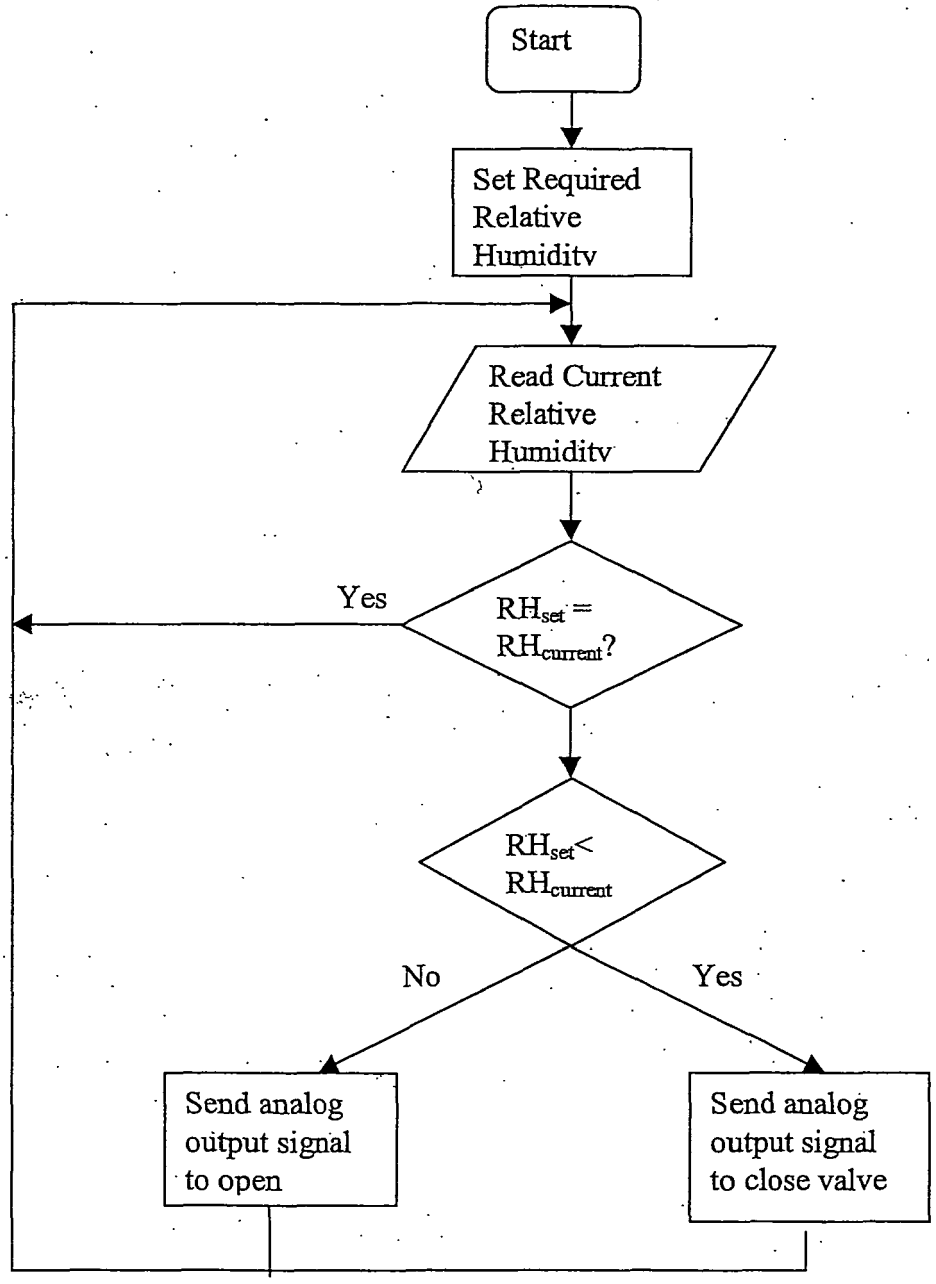
Start
Set Required Relative Humiditv
Read Current Relative Humiditv
Yes
RHset = RHcurrent?
RHset< RHcurrent
No
Yes
Send analog output signal to open
Send analog output signal to close valve

Fig. 5

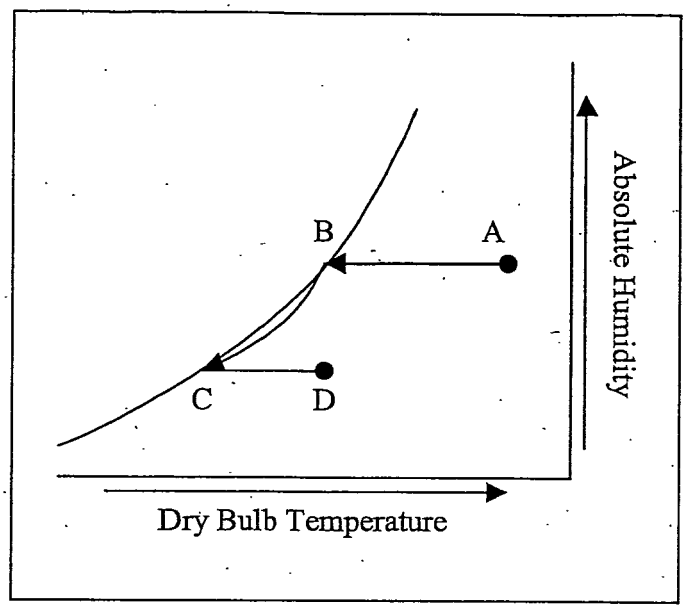
Absolute Humidity
B
A
C
D
Dry Bulb Temperature

Fig. 6A

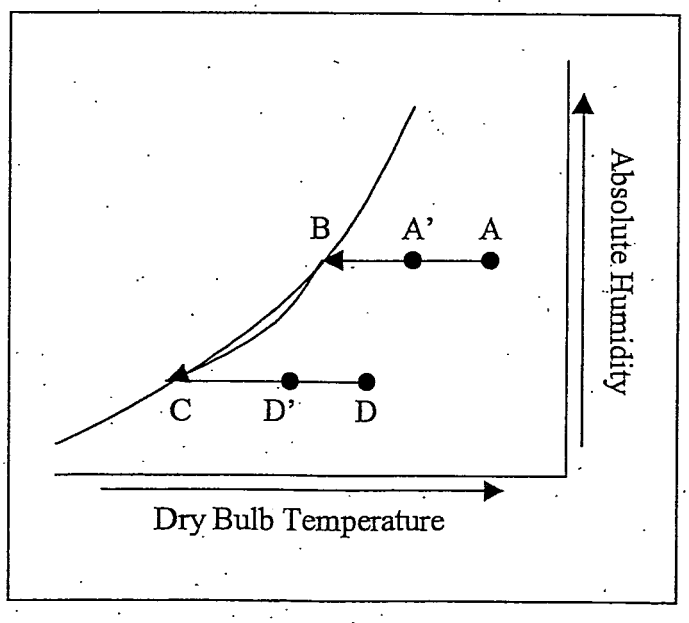
Absolute Humidity
B
A'
A
C
D'
D
Dry Bulb Temperature

Fig. 6B

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EUROPEAN SEARCH REPORT

Application Number
EP 11 00 0910

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 6 591 902 B1 (TRENT RICHARD W [US]) 15 July 2003 (2003-07-15) * column 4,, line 23 - line 54; figures 1-6 * * column 9 - column 10 * * column 12, line 1 - line 26 * * column 17, line 45 - line 59 * -----	1,2,6,8 3-5,7	INV. F24F1/00 F24F3/153
Y	US 5 404 938 A (DINH KHANH [US]) 11 April 1995 (1995-04-11) * abstract; figure 9 * -----	3-5,7	
A	CH 657 692 A5 (SCHOENMANN WILFRED ERNST) 15 September 1986 (1986-09-15) * abstract; figure 1 * -----	1-8	
A	US 6 578 629 B1 (TRENT RICHARD W [US]) 17 June 2003 (2003-06-17) * figures 1-2 * -----	1-8	
			TECHNICAL FIELDS SEARCHED (IPC) F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 October 2011	Decking, Oliver

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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27-10-2011

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