DEHUMIDIFIER SYSTEM DEVICE AND METHOD

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ABSTRACT

A dehumidifier system and device for maintaining a dry air environment in enclosures by extracting the water to outside the enclosure. The dehumidifier device comprises a condensation unit, typically a thermoelectric element with a moisture collector, and a sealed pump, such as peristaltic pump, which pumps the condensed humidity out of the sealed enclosure, yet maintains the enclosure seal. The system is provided with a controller which alternately activates the thermoelectric element and the pump, in at least one mode: continuous, periodical, and programmable utilizing a humidity/relative humidity sensor. Optionally, in large-volume enclosures and containers, a fan assembly is connected to the controller so as to provide for rapid circulation of the air and removal of moisture.
DEHUMIDIFIER SYSTEM DEVICE AND METHOD

FIELD OF THE INVENTION

[0001] The present invention relates generally to dehumidi fier systems and devices, and more particularly to a dehumidi fier system device and method for active water extraction from small enclosures and containers to a space external thereto.

BACKGROUND OF THE INVENTION

[0002] Dehumidifier systems and devices are in widespread use today, especially in buildings, storage centers, and other sites where active central-air conditioning systems are installed. Gas-heated systems are also common in homes and offices and in places where the undesirable effect of the drying of the heated air results in loss of beneficial levels of humidity needed for good health. Most such devices and systems are large and thus not well-suited for dehumidification of small enclosures and containers.

[0003] For these latter applications, a passive system is generally employed utilizing chemicals in powder or gel form, such as silica-gel or other hydrophobic materials which are introduced to absorb undesirable moisture. Applications include small, closed containers for storing, shipping, or displaying tobacco products, electronic components, and the like. In some applications, nitrogen or some other dry gas is introduced under low pressure into a container so as to displace the naturally humid air of the atmosphere. The presence of pressurized gas is intended to prevent the reentry of the surrounding air.

[0004] There are several problems with the above-mentioned devices and systems. One is that the moisture-laden air extracted from a defined, treated space is frequently not exhausted external to the closed system and therefore there exists the potential for such moisture-laden air to recycle and return to the treated space.

[0005] Another problem is that nitrogen filled containers which are pressurized require a high level of closure and this generally involves additional expense, such as providing, specially shaped gaskets, tight-fitting covers, and the like. Furthermore, in some applications, such as optical systems, pressure is not always a positive factor. Furthermore, pressurized systems require a modicum of maintenance, which adds to the cost of using such systems for protection against humidity and moisture.

[0006] Thus there is a need for a dehumidifier system which actively extracts water moisture from small enclosures and containers to a space external thereto; which does not require the introduction of pressurized dry gases and the related expense of providing a high level of closure for such an application; and which reduces the need for an inordinate amount of maintenance.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is a principal object of the present invention to overcome the disadvantages of prior art dehumidifier systems, and provide a dehumidifier system and device for maintaining a dry air environment in enclosures, by extracting the water to outside the enclosure.

[0008] In accordance with a preferred embodiment of the present invention, there is provided a dehumidifier device for removing condensed humidity out of a sealed enclosure, said dehumidifier device comprising:

[0009] a controller;

[0010] a condenser unit, having a thermoelectric element in close proximity to a moisture collector; and

[0011] a sealed pump unit comprising:

[0012] a pump mounted in a housing, and

[0013] a hose for directing moisture external to said sealed enclosure,

wherein when said controller operates said condenser unit and said sealed pump unit, collected moisture is pumped out of said sealed enclosure through said hose.

[0014] The dehumidifier device of the present invention comprises a condensation unit, typically a thermoelectric element with a moisture collector, and a sealed pump, such as a peristaltic pump, which pumps the condensed humidity out of the sealed enclosure, yet maintains the enclosure sealing. The system is provided with a controller which alternately activates the thermoelectric element and the pump, either continuously, periodically, or in accordance with a humidity or relative humidity sensor. Optionally, in large-volume enclosures and containers, a fan assembly is connected to the controller so as to provide for more efficient circulation of the air since it is desirable to have a more rapid removal of moisture.

[0015] The device is particularly useful in keeping a dry environment in enclosures where humidity can damage such items as electronic devices and components, food, mechanical systems; or where humidity can fog a viewing window, such as in outdoor displays. While the commonly used existing solution of applying a silica-gel inside the enclosure is simple and relatively low-cost, it cannot provide a solution for longer periods, since the silica-gel has limited capacity and needs to be dried before it can be re-used. The dehumidifier device described herein has an unlimited capacity, and thus can provide a dry environment solution for long periods, as well as overcome imperfect sealing.

[0016] The invention is also shown in an embodiment having a vaporizing heater unit provided on the exhaust side of the condenser unit for vaporizing any moisture exhausted from the system and preventing unwanted, and perhaps damaging water leaks resulting from the action of the dehumidifier.

[0017] Additional features and advantages of the invention will become apparent from the following drawings and description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] For a better understanding of the invention with regard to the embodiments thereof, reference is made to the accompanying drawings, in which like numerals designate corresponding elements or sections throughout, and in which:

[0019] FIG. 1A is a general, cross-section view of the system of the invention in accordance with a preferred embodiment thereof;

[0020] FIG. 1B is an enlarged, detailed view of the invention from FIG. 1A;
FIG. 2 is an enlarged, detailed, cross-section view of the arrangement of the condenser unit and funnel components of the invention from FIG. 1; and

FIG. 3 is a perspective view of another embodiment of the invention showing a heater unit mounted in proximity to the exhaust hose.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 1A is a general, cross-section view of the system of the invention in accordance with a preferred embodiment thereof. FIG. 1A shows an enclosure 10 where it is desired to maintain a dry environment and indicates a view B of the device of the invention internally mounted in enclosure 10.

FIG. 1B is an enlarged, detailed view of the invention from FIG. 1A.

In a preferred embodiment of the invention, the dehumidifier system comprises a fan assembly 12, having a propeller 14 mounted inside a propeller housing 16, a condenser unit 18, a pump unit 20, and a pump housing 22. Condenser unit 18 comprises a thermoelectric element 24 provided with a central moisture collector 26 (indicated with hatch lines) formed with a funnel 28. Collector 26 and funnel 28 are typically made of stainless steel. Collector 26 is attached to thermoelectric element 24 utilizing a heat-conducting grease. An isolator hub 30, positioned in close proximity to collector 26, isolates the cold surface of thermoelectric element 24 from pump housing 22. Pump unit 20, in a preferred embodiment of the invention, is a sealed liquid pump that can move moisture out, but prevents air from getting into enclosure 10 so as to maintain the integrity of the sealed enclosure.

In another embodiment of the invention, the moisture is condensed and turned directly into ice formed on the cold face of thermoelectric element 24, cooled when in the cooling mode resulting from application of the Peltier effect. This embodiment makes a simpler and less expensive device as it does not require a condenser unit 18, a funnel 28, nor application of grease. For example, if the cold face is vertical and the ice is melts, hose 34 is disposed in such a way as to catch the water formed from the ice which falls by gravity directly into the opening of hose 34.

FIG. 1 shows a peristaltic-type pump assembly 20, by way of example, which moves a liquid down a flexible hose 34, by rotating a two-wheel, rollers element 32 which presses hose 34 connected to the bottom portion of funnel 28, and penetrates enclosure 10 through an air-tight seal (not visible) exiting at exhaust 38 to the outside environment. A controller 36 comprises an electronic circuit, which controls fan assembly 12, thermoelectric element 24, and pump unit 20, either continuously, periodically, or in accordance with humidity/relative humidity sensors (not shown).

When fan assembly 12 is activated, it blows air on condenser unit 18. Thermoelectric element 24 cools down moisture collector 26 through isolator hub 30 disposed above thermoelectric element 24, keeping the bottom plate 31 at room temperature due to pump housing 22 which functions as a heat sink. The humid air blowing on the upper portion of moisture collector 26 is cooled, thus condensing water from enclosure 10 and forming moisture on moisture collector 26. By capillary action, the water drops are drawn down into the central hole in moisture collector 26, and are caught below isolator hub 30, where they are directed to enter peristaltic hose 34. Pump unit 20 then pushes the water drops further down peristaltic hose 34 until they are extracted outside enclosure 10 through exhaust 38.

Alternatively, instead of collecting the moisture as it drops, it is frozen to form ice which builds up on a surface of thermoelectric element 24 when the surface is cooled to form a cold face by the Peltier effect. The depth of ice build-up is regulated to about 1 mm in thickness and then heated by changing the polarity of thermoelectric element 24. This turns the ice back into water which falls by gravity into the pump inlet of hose 34.

A numerical example of how the dehumidifier device works is described below: assuming an enclosure of 1 liter, filled with air at 20°C, 70% relative humidity. The absolute amount of water in the air is 70% the saturated vapor amount the air can hold at this temperature is 70%*17 mGram=12 mGram. Thermoelectric element 24 is then cooled to -10°C, where the saturated vapor amount the air can hold is only 2.3 mGram, so water drops up to 10 mGrams (10 mm³) in size will be condensed and flow down funnel 28 into peristaltic hose 34 pumped by pump unit 20, pushing the water drops out of enclosure 10, and leaving a potential relative humidity of 2.3/17=13%.

Pump unit 20 can be operated as soon as, and as long as humidity is sensed between moisture collector 26 and isolator hub 30. Such sensing can be obtained, for example, by measuring the resistance between collector 26 and isolator hub 30, the bottom side of isolator hub 30 being provided with a conductive coating.

In another embodiment of the invention, to eliminate getting an under-pressure inside enclosure 10 due to the operation of pump unit 20, another hose (not shown) is provided which returns outside air to enclosure 10 in the same volume as the water pumped out. Alternatively, a regulating valve (not shown) is added to enclosure 10, which opens if the inside pressure drops below a certain threshold.

In an alternative embodiment of the invention, the whole dehumidifier device is minimized in dimension to the size of a small chip where the peristaltic pump unit 20 is replaced with, for example, a piezo-based micro-pump such as one commonly used in inkjet printers. Fan assembly 12 need not necessarily be disposed as part of the dehumidifier device and can be situated at any other place within the enclosure being treated.

FIG. 2 is an enlarged, detailed, cross-section view of the arrangement of the condenser unit and funnel components of the invention from FIG. 1.

In particular, condenser unit 18 is shown in close proximity to collector 26 nestled in the upper surface of isolator hub 30. A portion of rollers element 32 is also shown in a cut-away view of peristaltic hose 34. Thermoelectric element 24 is sandwiched between isolator hub 30 and bottom plate 31. Funnel 28 is fitted snugly to moisture collector 26 directing water drops collected by collector 26 into hose 34.

FIG. 3 is a perspective view of another embodiment of the invention showing a vaporizing heater unit mounted on the exhaust side of the condenser unit. In operation, fan
assembly 12 rotates propellers 14 inside their housing 16 shown in a cut-away view. The cool air (indicated by broad curving arrows) condenses any moisture within enclosure 10 onto condenser unit 18. The water drops indicated by the flowing arrows inside peristaltic hose 34 are pumped through the elements of a heater unit 40 disposed at exhaust 38 converting the water drops into steam which can easily be passed to the outside air to disperse.

[0037] In prior art systems the water exiting a dehumidifier is conveyed to a water collector or discharged through a small diameter tube, or, for small quantities of water, simply leaked out onto a floor or desk. The present invention in the embodiment shown in FIG. 3, is advantageously provided with a heating unit mounted in the exhaust, outlet, which turns condensed water exiting the system into steam. The steam is then vaporized and released to mix with the outside air.

[0038] Yet another option is to spread the water out into the air by means of a blower, for example, which disperses miniature drops of water into the air in a manner similar to some types of air coolers. Another option is to spread the water out into the air by using an ultrasonic vaporizer.

[0039] Having described the present invention with regard to certain specific embodiments thereof, it is to be understood that the description is not meant as a limitation, since further modifications may now suggest themselves to those skilled in the art, and it is intended to cover such modifications as fall within the scope of the appended claims.

1. A dehumidifier device for removing condensed humidity out of a sealed enclosure, said dehumidifier device comprising:
   a controller;
   a condenser unit, having a thermoelectric element in close proximity to a moisture collector; and
   a sealed pump unit comprising:
   a pump mounted in a housing, and
   a hose for directing moisture external to said sealed enclosure,
   wherein when said controller operates said condenser unit and said sealed pump unit, collected moisture is pumped out of said sealed enclosure through said hose.

2. The dehumidifier device of claim 1 further provided with at least one means for exhausting moisture out into the atmosphere selected from the group comprising:
   a vaporizing heater unit provided on the exhaust side of said condenser unit for vaporizing condensed water exiting said sealed enclosure;
   a blower to spread the condensed water out into the air in miniature drops; and
   an ultrasonic vaporizer.

3. The dehumidifier device of claim 1 further provided with a fan assembly connected to said controller so as to provide for rapid circulation of the air and removal of moisture in larger volume enclosures.

4. The dehumidifier device of claim 1 wherein said controller comprises an electronic circuit.

5. The dehumidifier device of claim 1 wherein said pump is provided with a one-way valve to prevent back-flow into said sealed enclosure.

6. The dehumidifier device of claim 1 wherein said pump is a peristaltic-type, liquid pump.

7. The dehumidifier device of claim 1 wherein said pump is a piezo-based micro-pump.

8. The dehumidifier device of claim 1 wherein said controller is connected to said thermoelectric element and said sealed pump unit so as to provide alternating cycles of activation and deactivation of said thermoelectric element and said sealed pump unit to produce a Peltier effect, alternatively heating and cooling said condenser unit.

9. The dehumidifier device of claim 8 wherein said condenser unit is oriented so as to provide a cold face directly exposed to air flow when alternatively cooled by said Peltier effect.

10. The dehumidifier device of claim 8 wherein said cold face is cooled to a temperature less than zero degrees Celsius so that moisture contacting said cold face immediately turns into ice.

11. The dehumidifier device of claim 8 wherein said cold face is periodically heated by changing the polarity of the Peltier effect applied to said thermoelectric element so that the ice on said cold face is melted and the resulting water is exhausted from said dehumidifier device.

12. The dehumidifier device of claim 8, wherein said alternating cycles of activation and deactivation comprise at least one of the operating modes selected from the group:
   continuous; periodic; and programmable.

13. The dehumidifier device of claim 12 wherein said programmable operating mode is a function provided by a humidity/relative humidity sensor.

14. The dehumidifier device of claim 1 further comprising a second hose which returns outside air to said sealed enclosure in the same quantity as water pumped out thereby to eliminate getting an under-pressure inside said sealed enclosure due to the operation of said pump unit.

15. A dehumidifier system for removing condensed moisture from humidity out of a sealed enclosure comprising:
   a controller for operating said system;
   a condenser unit, having a thermoelectric element in close proximity to a moisture collector; and
   a sealed pump unit comprising:
   a pump mounted in a housing, and
   a hose for directing moisture external to said sealed enclosure,
   wherein when said controller operates said condenser unit and said sealed pump unit, moisture is collected and pumped through said hose external to said sealed enclosure.

16. A method for dehumidifying air and removing moisture from a sealed enclosure, said method comprising the steps of:
   providing a condenser unit having a thermoelectric element in close proximity to a moisture collector;
   providing a sealed pump unit comprising:
   a pump mounted in a housing, and
   a hose for directing moisture external to said sealed enclosure;
   providing a controller in communication with said condenser unit and said pump unit,
   wherein when said controller is activated, said condenser unit extracts moisture from said sealed enclosure and said pump pumps said moisture external to said sealed enclosure via said hose.
17. The method of claim 16 further comprising the steps of:
  connecting said controller to said thermoelectric element
  and said sealed pump unit so as to provide alternating
  cycles of activation and deactivation of said thermoelec-
  tric element and said sealed pump unit to produce a
  Peltier effect, alternatively heating and cooling said con-
  denser unit;
  orienting said condenser unit so as provide a cold face
  directly exposed to air flow when alternatively cooled by
  said Peltier effect;
  cooling said cold face to a temperature less than zero
  degrees Celsius so that moisture contacting said cold
  face immediately turns into ice; and
  heating said cold face periodically by changing the polarity
  of the Peltier effect applied to said thermoelectric ele-
  ment so that the ice on said cold face is melted and the
  resulting water is exhausted from said dehumidifier
  device.

18. The method of claim 16 wherein said controller alter-
  nately activates said thermoelectric element and said pump in
  at least one of the modes selected from the group:
  continuous;
  periodical; and
  programmable.

19. The method of claim 17 wherein said programmable
  operating mode is a function provided by a humidity/relative
  humidity sensor.

20. The method of claim 16 further comprising:
  vaporizing condensed water exiting said sealed enclosure;
  and
  promoting rapid circulation of the air and removal of mois-
  ture in large-volume enclosures.

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