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(54) **APPARATUS FOR CONDITIONING AIR**

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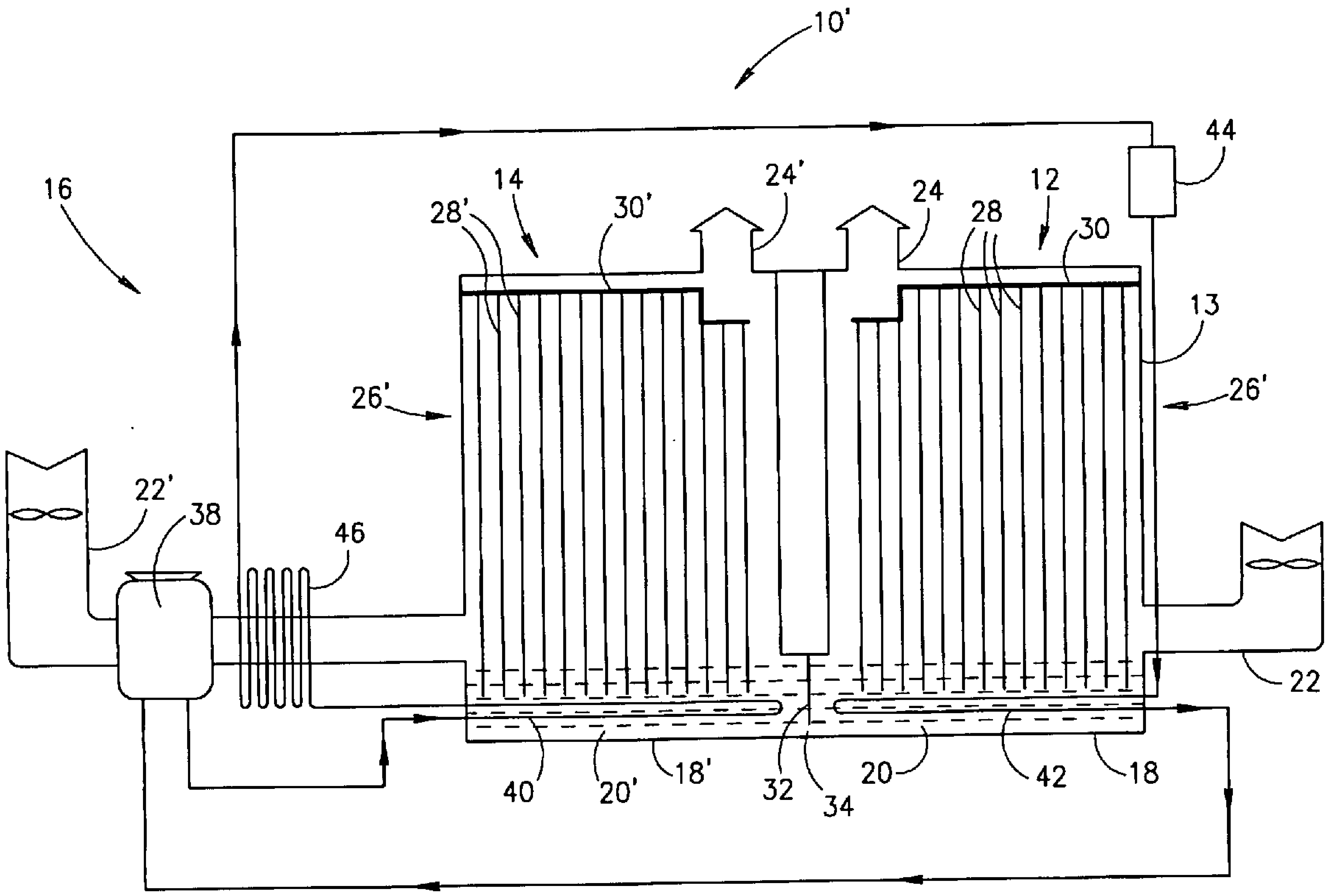
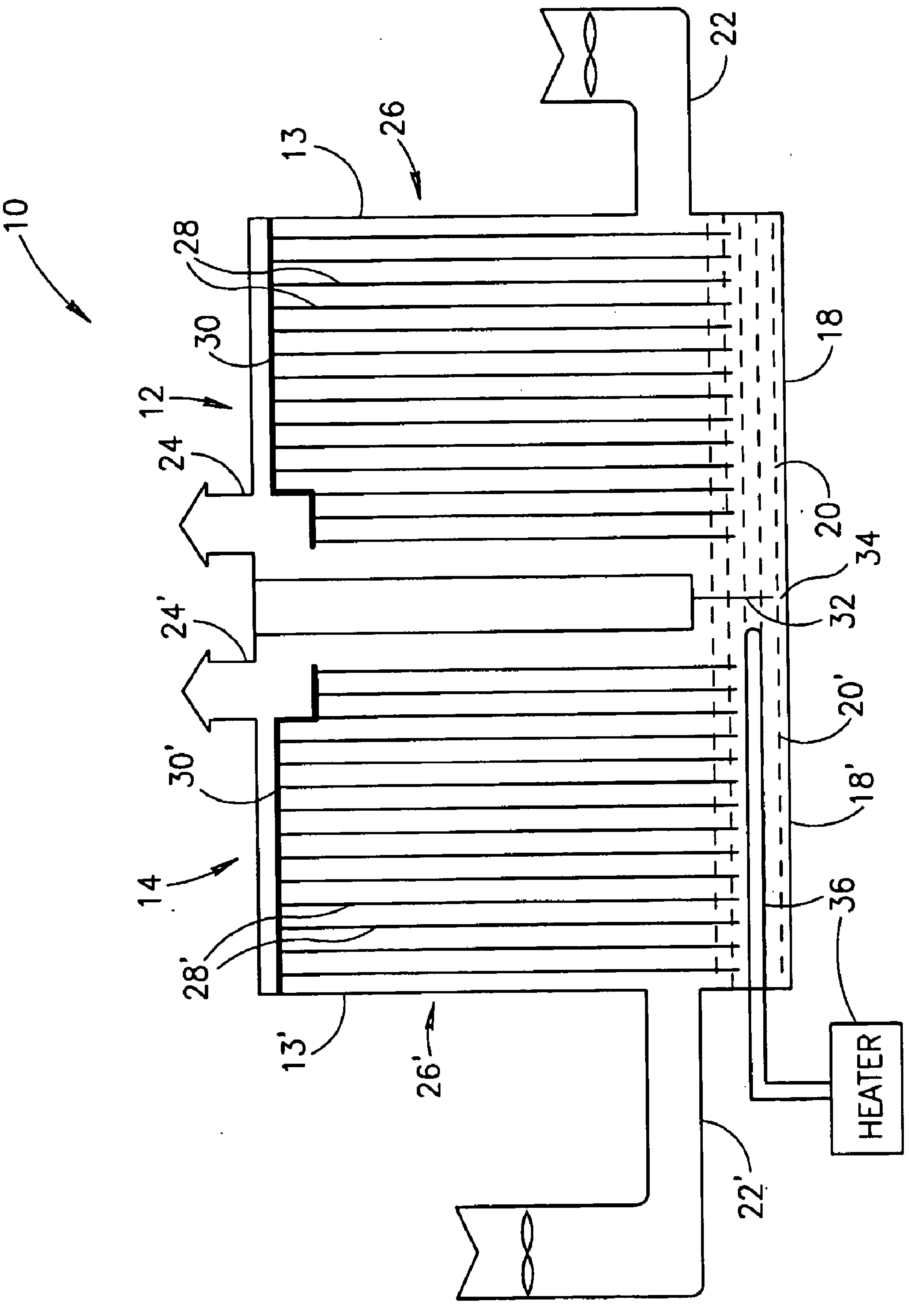
(57) **ABSTRACT**

A dehumidification method comprising: providing a liquid desiccant **(20)** at a first location **(18)**; removing moisture from the liquid desiccant at the first location to a first source of air **(22, 24)**; providing liquid desiccant **(20')** at a second location **(18')**, said liquid desiccant at said second location **(18')** being in fluid communication with the liquid desiccant at the first location **(18)**; absorbing moisture by the liquid desiccant at the second location from a second source of air **(22', 24')**; and transferring moisture from the first location **(18)** to the second location **(18')** substantially only by diffusion and gravity.




10
12
13
13'
14
18
18'
20
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22
22'
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24'
26
26'
28
28'
30
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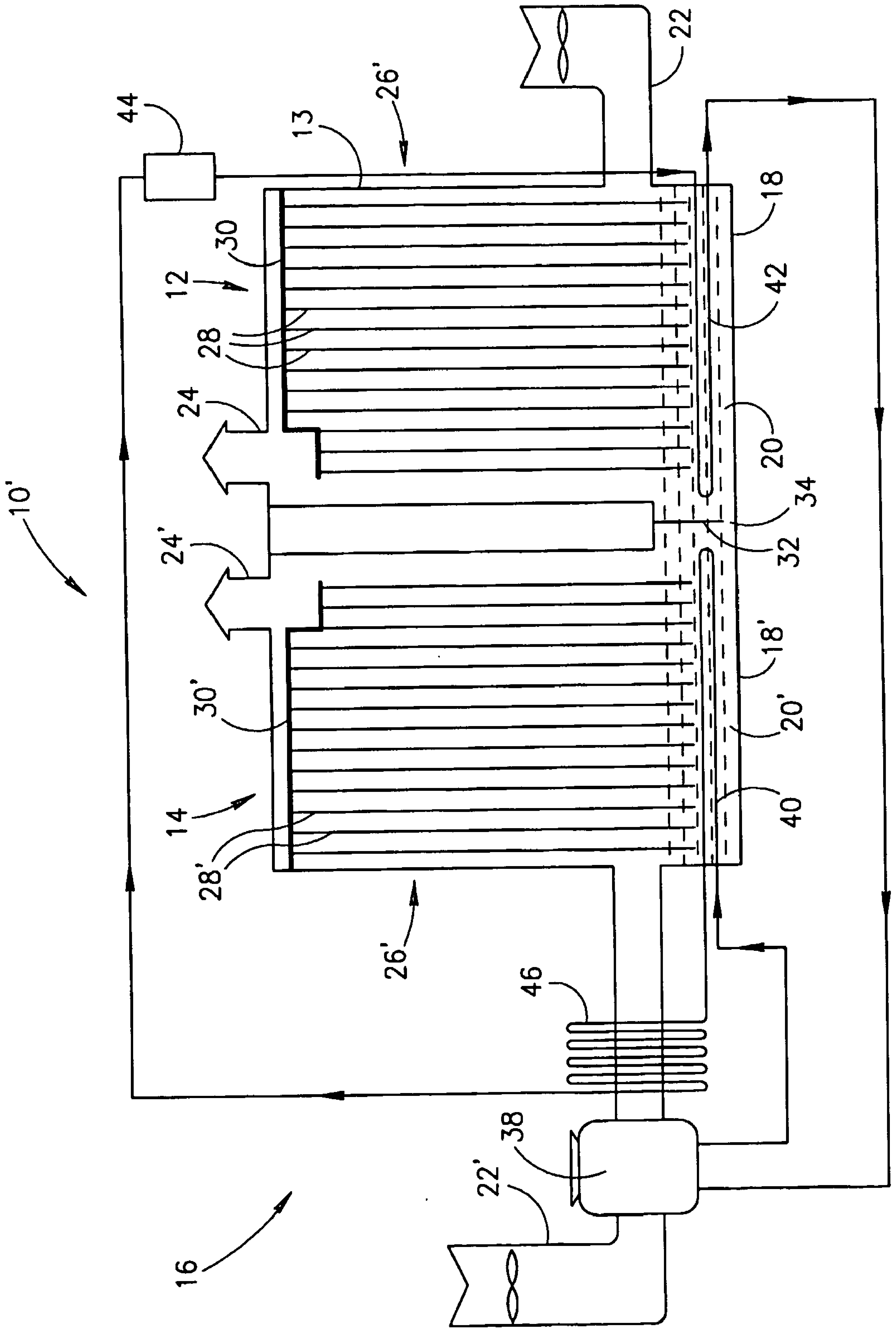
32
34
36
HEATER

FIG.1



10'
44
26'
13
22
18
30
12
42
28
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20'
14
40
28'
26'
46
38
22'
16

FIG.2

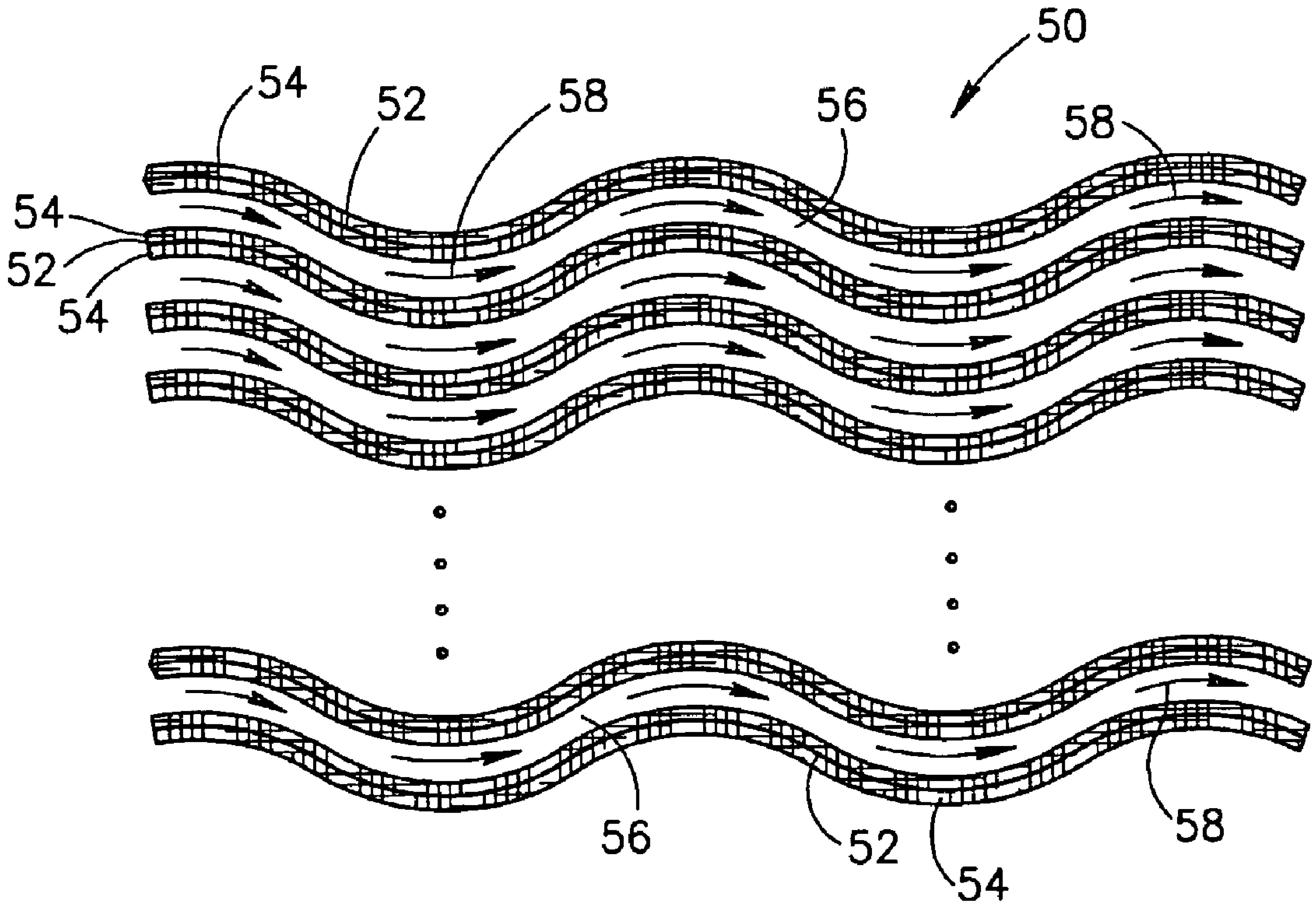

FIG.3

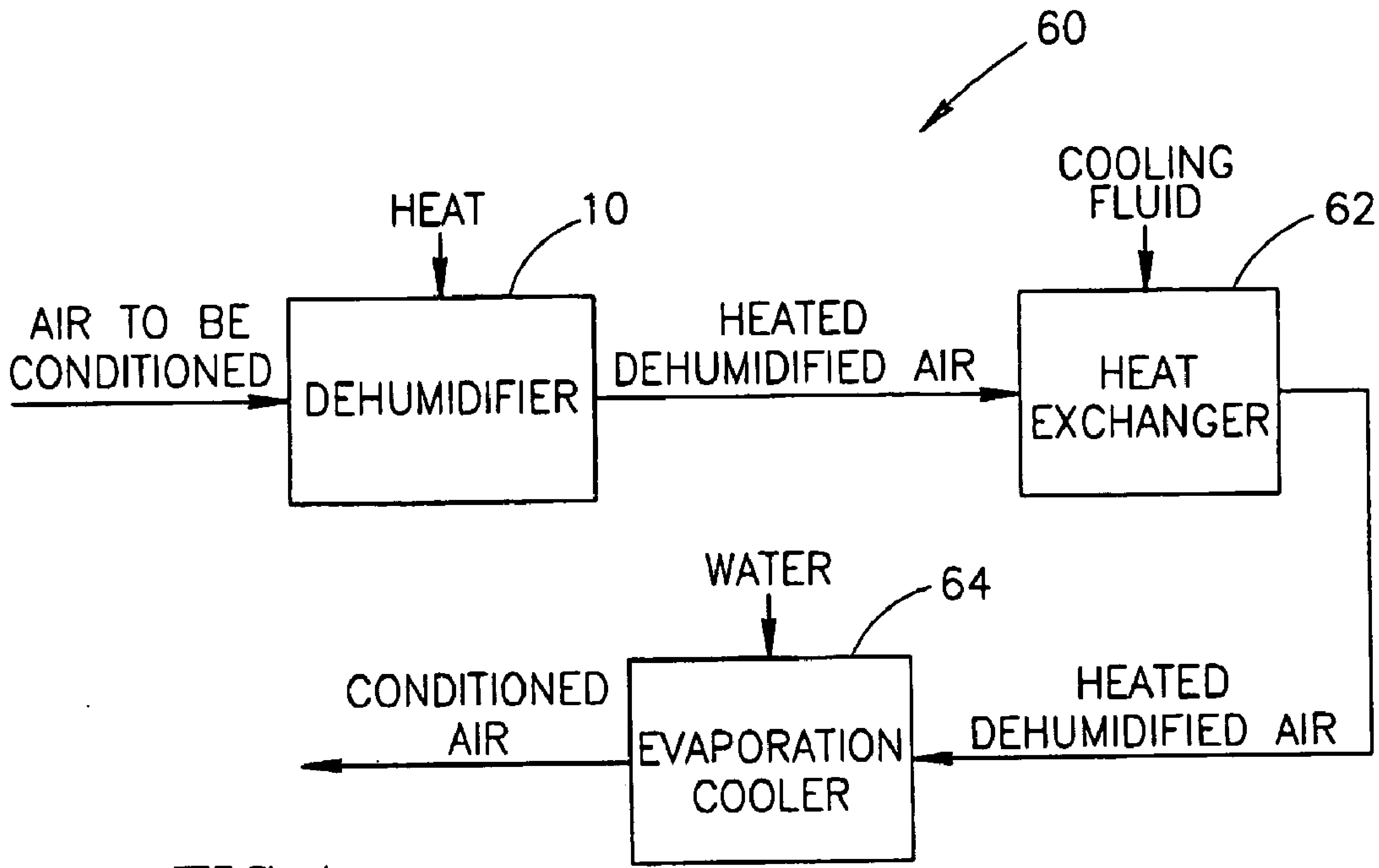
60
HEAT
10
COOLING FLUID
62
AIR TO BE CONDITIONED
DEHUMIDIFIER
HEATED DEHUMIDIFIED AIR
HEAT EXCHANGER
WATER
64
CONDITIONED AIR
EVAPORATION COOLER
HEATED DEHUMIDIFIED AIR

FIG.4

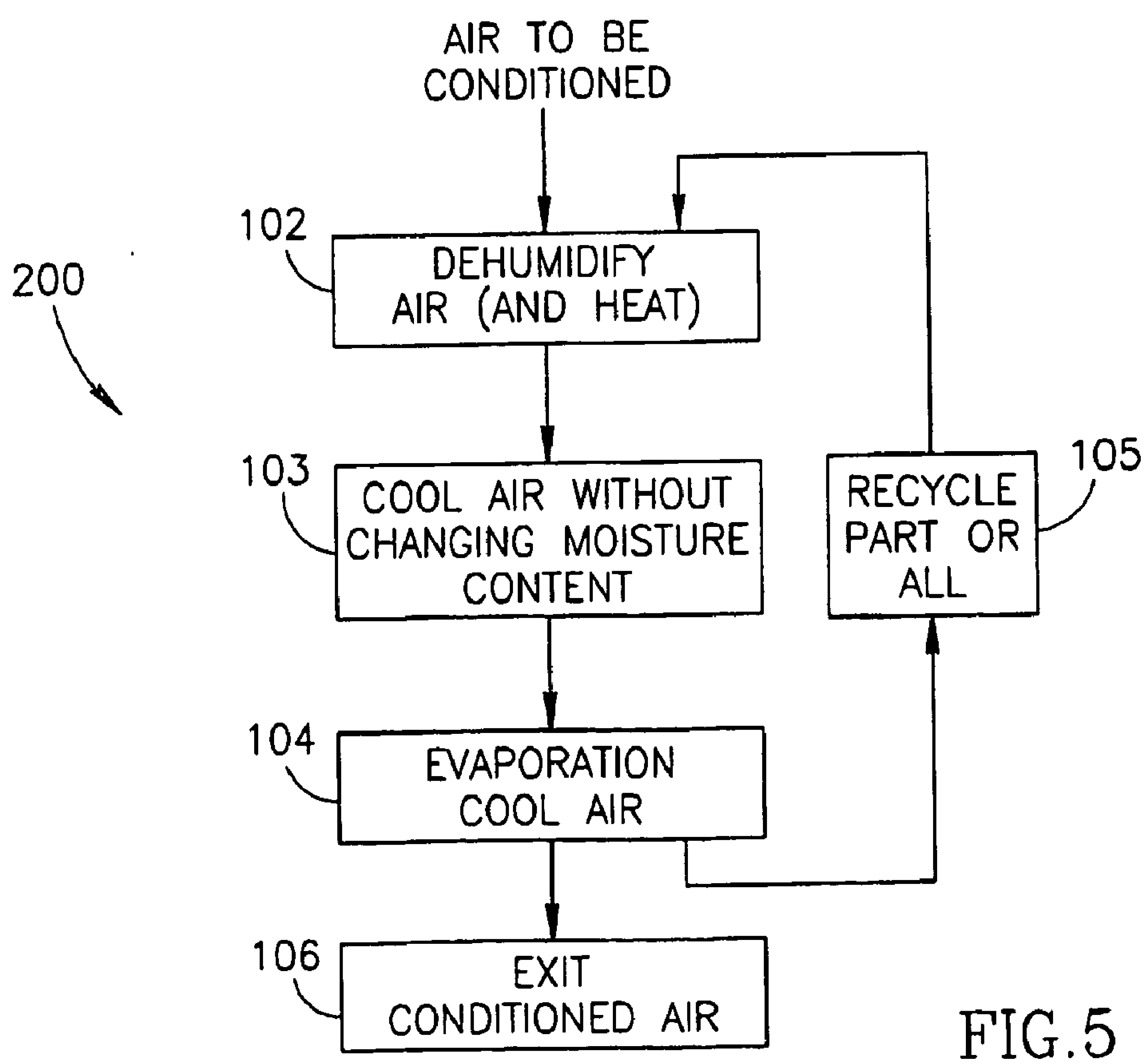
AIR TO BE CONDITIONED
102
DEHUMIDIFY AIR (AND HEAT)
200
103
COOL AIR WITHOUT CHANGING MOISTURE CONTENT
RECYCLE PART OR ALL
105
104
EVAPORATION COOL AIR
106
EXIT CONDITIONED AIR

FIG.5

APPARATUS FOR CONDITIONING AIR

FIELD OF THE INVENTION

[0001] The invention relates to systems for conditioning air utilizing a liquid desiccant.

BACKGROUND OF THE INVENTION

[0002] The use of liquid desiccants in dehumidifier systems, both with and without associated heat pumps is well known.

[0003] In general, liquid dehumidifier systems comprise a dehumidifying section, in which air to be dehumidified contacts a liquid desiccant having a relatively low level of moisture and a regenerating section in which outside air contacts a liquid desiccant having a relatively high level of liquid desiccant. In the dehumidifying section moisture is removed from the air and adsorbed by the liquid desiccant. In the regenerating section, moisture is transferred from the moisture-rich liquid desiccant to the outside air. Means are generally provided for transferring at least moisture from the dehumidifying section to the regenerating section. In much of the prior art this transfer is provided by at least one pump which transfers moisture rich desiccant from the dehumidifying section to the regenerating section. Generally, liquid desiccant is also transferred from the regenerating section to the dehumidifying section, to restore the desiccant lost when the moisture rich desiccant is transferred in the opposite direction. This is generally required, since in the steady state, the concentrations and amounts on desiccant on both sides is constant.

[0004] Applicants PCT patent publication WO 00/55546 and a PCT patent application, filed concurrently herewith and entitled "DEHUMIDIFIER/AIR-CONDITIONING SYSTEM", the disclosures of which are incorporated by reference, describe various dehumidifying systems having one or more of various improvements. A heat pump is used to pump heat from the dehumidifying section to the regenerating section. This can result in the conditioned air being cooled as well as dehumidified. In some embodiments, an additional radiator (additional to those present in the regenerating and dehumidifying sections) is provided for the heat pump to remove additional heat from the refrigerant in the heat pump. This radiator can be placed at the entrance of the outside air to the regenerating section to thereby pre-heat this air utilizing an additional radiator. This preheating improves the efficiency of the system. Alternatively or additionally, the additional radiator can be placed at the outlet of the dehumidifying section to heat the conditioned air. Thus, in this system, the conditioned air is heated as well as dehumidified. In some embodiments described, means are provided for switching the system between a cooling/dehumidifying function and a heating/dehumidifying function. Additionally, in some embodiments, means are provided for converting the system into a heating/humidifying system.

[0005] In some embodiments disclosed in these applications, each of the dehumidifying and regenerating sections is provided with a reservoir from which liquid desiccant is taken to be used in the respective dehumidification or regeneration process. After the process, the desiccant is returned to the same respective reservoir. In some embodiments disclosed, a small aperture (or apertures) connects the two reservoirs. In these embodiments, the aperture is designed such that only moisture passes from the dehumidifier reservoir to the regenerator reservoir. In the steady state, there is no net transfer of desiccant ions between the reservoirs, via the aperture. Furthermore, such systems can be produced so that liquid transfer is only via the aperture and no pumps are used to transfer liquid between the reservoirs.

[0006] In general, in the prior art, pumps are used to pump liquid from the reservoirs to a higher position from which the liquid is dripped or sprayed into a regenerating or a dehumidifying chamber. Fans are generally used to introduce air into the dehumidifying and regenerating chambers.

[0007] Some of the features described above with respect to WO 00/55546 and the concurrently filed application were previously described in WO 99/26025, WO 99/26062 and their U.S. counterparts Ser. Nos. 09/554,397 and 09/554,398. The disclosures of all of these publications are incorporated herein by reference.

SUMMARY OF THE INVENTION

[0008] As indicated above, the prior art systems include pumps that pump liquid from the reservoirs to the regenerating or dehumidifying chambers.

[0009] In accordance with an aspect of some embodiments of the present invention, pumpless transfer is provided.

[0010] According to an aspect of the invention, transfer of moisture from a region where it is removed from the air to be dehumidified to the region where it is transferred to ambient (outside) air is substantially only by diffusion and gravity.

[0011] In an embodiment of the invention, the excess moisture travels, by diffusion, under the influence of a concentration gradient, from the location at which the moisture is removed (dehumidifying section) to a first reservoir in which the concentration of desiccant is higher than that in said location. This difference of concentration is generated by the absorption of moisture from the air to be conditioned.

[0012] The moisture is then transferred to a second reservoir in the regenerator, for example, via a hole that is designed so that there is only a net flow of moisture ions and no net flow of desiccant ions. The increased volume of liquid in the first reservoir causes the flow of low concentration desiccant from the first to the second reservoir. However, since the concentration of desiccant in the second reservoir is higher than in the first reservoir, there is a reverse flow of desiccant ions, to provide substantially zero net flow of desiccant ions. The second reservoir is heated to increase the evaporation of the moisture, and this heated liquid is further concentrated at a second location at which this moisture is transferred to "outside' air. This concentration causes a further diffusion of the moisture to the second location from the second reservoir.

[0013] As indicated above, the liquid desiccant can be maintained in the first and second locations by a wicking system which also serves as the medium for transferring the moisture from regions of low concentration liquid desiccant to high concentration liquid desiccant (between the locations and the reservoirs).

[0014] According to an aspect of the invention, wicking action is used to draw the liquid desiccant from the reservoirs to regions in which that are in contact with the air used in the dehumidifying/regenerating processes. The wicking material also allows for the transfer of moisture in either an upward or downward direction, by diffusion, in response to gradients of concentration in the liquid desiccant. In some embodiments, the wicking action is provided by sheets of material, through which air to be dehumidified or ambient air passes. In other embodiments the air flows along the surface of the material. In some embodiments of the invention, the wicking material is mounted on a heat conducting structure, to efficiently transfer heat between the reservoir and the liquid desiccant in the wicking material.

[0015] In some embodiments of the invention, a heat pump is used to transfer heat from the dehumidifying section to the regenerating section. In particular, the heat pump may have its respective heat exchangers in the reservoirs of the two sections.

[0016] In other embodiments of the invention, the heat pump is dispensed with, and the liquid in the regenerator reservoir is heated by an external heating source. While this is less efficient than using a heat-pump, in some embodiments as, for example, in cold areas, where overall heating of the air is not objectionable, this reduced efficiency is acceptable, given the lower cost of such a system. In some cases, the heat used for the regeneration is available without additional cost as waste heat from various sources, resulting in a high overall efficiency.

[0017] In some embodiments of the invention, the heated dried air is cooled by heat exchange with ambient air, to provide air at a temperature somewhat hotter than the temperature of the ambient air, but at a much lower humidity. If this air is cooled by evaporation cooling, as known in the art, the air temperature can be reduced below the ambient air temperature, optionally at a lower temperature. While cooling based on dehumidifying, heat exchange and evaporation cooling is generally known in the art, it is especially attractive when waste heat is available, using a system according to exemplary embodiments of the present invention, since such a system will give "free" cooling, since no pumps are necessary and there is only a need for fans to move the air. The only major energy source is the waste heat that is used to power the system.

[0018] In some embodiments of the invention, the aperture method of transferring moisture between the reservoirs, as described in the above referenced publications and applications is used. In such systems, there is no pumping of the desiccant liquid necessary. This is a significant advantage since many desiccant liquids are corrosive.

[0019] It should be understood that the use of wicking, rather than lifting by pumps, in the regenerating and/or dehumidifying sections is applicable to substantially any liquid desiccant dehumidifying system and not only to the systems described in the above referenced prior art. There is thus provided, in accordance with an exemplary embodiment of the invention, a moisture transfer element for a system for conditioning air, comprising:

> **[0020]** a reservoir containing liquid desiccant;
>
> **[0021]** a housing defining a chamber and having an air inlet and an air outlet; and
>
> **[0022]** a wicking structure comprising wicking material that that wicks liquid desiccant or components thereof between the reservoir and the chamber, such that air that enters the chamber via the inlet contacts liquid desiccant transported to the chamber from the reservoir, prior to leaving the chamber.

[0023] In an embodiment of the invention, the wicking material comprises at least one sheet of said wicking material having one end in the liquid desiccant in the reservoir, at least a portion of the wicking material being in the chamber.

[0024] Optionally, the wicking structure comprises a heat conducting structure that contacts the liquid desiccant in the reservoir and the wicking material in the chamber. Optionally, the heat conducting structure blocks air. Optionally, the heat conducting structure comprises a heat conducting metal.

[0025] Optionally, the heat conducting structure is formed with apertures through which air can pass. Optionally, the heat conducting structure comprises a heat conducting metal.

[0026] In an embodiment of the invention, the wicking structure is oriented such that air passing through the chamber passes along a surface of the wicking material. Alternatively, wicking structure is oriented such that air passing through the chamber passes through the wicking material.

[0027] In an embodiment of the invention, no pumps are used to transport the liquid desiccant between the reservoir and the chamber. Optionally, transportation of liquid desiccant or its components between the reservoir and the chamber is by wicking or by diffusion only.

[0028] There is further provided, in accordance with an embodiment of the invention, a system for conditioning air comprising:

> **[0029]** a dehumidifying section and a regenerating section, at least one of which comprises a moisture transfer element according to the invention, as defined above.

[0030] Optionally, both the dehumidifying and regenerating sections comprise a moisture transfer element according of the invention, as defined herein.

[0031] In an embodiment of the invention, liquid desiccant reservoirs in the dehumidifying and regenerating sections are connected by at least one aperture, the size of said aperture being such that, in a steady state condition, no net amount of desiccant ions are transported between the reservoirs. Optionally, transport of liquid desiccant or its components between the reservoirs is only via said at least one aperture.

[0032] Optionally, no pumps are used to transfer liquid desiccant between the dehumidifying and regenerating sections.

[0033] Optionally, transfer of liquid desiccant or its components is by diffusion or gravity fed flow only.

[0034] Optionally, the system includes a heater that heats liquid desiccant in said regenerator. Optionally, the system includes a liquid heat pump that transfers heat from liquid desiccant in the dehumidifying section to liquid desiccant in the regenerating section, said heater comprising a condenser of said heat pump.

[0035] there is further provided, in accordance with an embodiment of the invention, a method for conditioning air comprising:

[0036] providing a liquid desiccant at a first location;

[0037] removing moisture from the liquid desiccant at the first location to a first source of air;

[0038] providing liquid desiccant at a second location, said liquid desiccant at said second location being in fluid communication with the liquid desiccant at the first location;

[0039] absorbing moisture by the liquid desiccant at the second location from a second source of air; and

[0040] transferring moisture from the first location to the second location substantially only by diffusion and gravity.

[0041] Optionally, the method includes heating the liquid desiccant in the first location. Optionally, where the first location is in a regenerator for liquid desiccant and the second location is in a dehumidifier and including transferring heat, via a heat pump, from the dehumidifier to the regenerator.

BRIEF DESCRIPTION OF FIGURES

[0042] Exemplary, non-limiting embodiments of the invention are described in the following description, read with reference to the figures attached hereto. In the figures, identical and similar structures, elements or parts thereof that appear in more than one figure are generally labeled with the same or similar references in the figures in which they appear. Dimensions of components and features shown in the figures are chosen primarily for convenience and clarity of presentation and are not necessarily to scale. The attached figures are:

[0043] **FIG. 1** is a schematic representation of a dehumidifying system in accordance with an exemplary embodiment of the invention;

[0044] **FIG. 2** is a schematic representation of an alternative dehumidifying system, in accordance with an exemplary embodiment of the invention;

[0045] **FIG. 3** is a schematic representation of a wicking system, useful in the embodiments of **FIGS. 1 and 2**, in accordance with an embodiment of the invention;

[0046] **FIG. 4** is a schematic representation of a cooling system in which the embodiment of **FIG. 1** is utilized, in accordance with an embodiment of the invention; and

[0047] **FIG. 5** is a flow diagram of the operation of a cooling system, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0048] **FIG. 1** shows a schematic representation of an exemplary dehumidifier **10** in accordance with an embodiment of the invention. As indicated above, the use of wicking, in accordance with an aspect of the invention, can be applied to substantially any liquid dehumidifying system. For simplicity of illustration, a simple dehumidifier system, is used to illustrate this aspect of the invention. However, as indicated above, the principles described herein can be used with a variety of different liquid desiccant, dehumidifier systems.

[0049] Dehumidifier **10** comprises a dehumidifying section **12** and a regenerating section **14**.

[0050] Dehumidifying section **12** comprises a reservoir **18**, in which a liquid desiccant **20** is held. This desiccant may comprise water together with a desiccant salt, or may comprise any other liquid desiccant as known in the art. Dehumidifying section **12** comprises a housing **13** formed with an inlet **22** for introduction of air to be dehumidified and an outlet **24** for dehumidified air. Generally, the air is fan driven into the opening. For convenience of the drawings, inlet **22** is shown at the bottom of the housing and outlet **24** is shown at its top. However, in general, since the flow is from side to side, the inlet and outlet can be in the middle of the side walls of the housing.

[0051] A wick fed dehumidifying structure **26** is held within housing **13**. In the embodiment shown a series of sheets **28** of wicking material are attached to a barrier **30**. The lower end of sheets **28** sit within liquid desiccant **20**, such that liquid desiccant is wicked up on sheets **28** and moistens them. It should be understood that sheets **28** form a partial barrier to flow between inlet **22** and outlet **24** such that air, entering inlet **22**, passes through the sheets and interacts with the liquid desiccant contained in them. Means, such as weights or a bracket, may be provided at the bottoms of sheets **28** to keep them from moving under the influence of the air passing through them.

[0052] Regenerating section **14** is constructed in a manner similar to that of dehumidifying section **12**. For ease of reference like components are referred to with primed numbers corresponding to the reference numbers used to describe corresponding elements in dehumidifying section **12**. Thus regenerating section **14** comprises a reservoir **18'**, in which a liquid desiccant **20'** is held. This desiccant is of the same basic type as desiccant **20** in reservoir **18**, except that the concentration and temperature of the desiccant is different. Regenerating section **14** comprises a housing **13'** formed with an inlet **22'** for introduction of ambient air, which is to carry away moisture from the regenerator. After humidification of the ambient air, the air exits from an outlet **24'** for dehumidified air. Generally, the air is fan driven into the opening.

[0053] A wick fed dehumidifying structure **26'** is held within housing **13'**. In the embodiment shown a series of sheets **28'** of wicking material are attached to a barrier **30'**. The lower end of sheets **28** sit within liquid desiccant **20'**, such that liquid desiccant is wicked up on sheets **28'** and moistens them. It should be understood that sheets **28'** form a partial barrier to flow between inlet **22'** and outlet **24'** such that air, entering inlet **22'**, passes through the sheets and interacts with the liquid desiccant contained in them. Means, such as weights or a bracket, may be provided at the bottoms of sheets **28'** to keep them from moving under the influence of the air passing through them.

[0054] A barrier **32** having an aperture **34** formed therein, separates reservoirs **18** and **18'**. As described in applicants above referenced publications and applications, if the aperture is properly sized, in the steady state there is no net flow of desiccant ions between reservoirs **18** and **18'**. Only moisture ions have a net flow between the two reservoirs.

[0055] In operation, a concentration differential is formed between liquid desiccants **20** and **20'**. As a result, the more concentrated desiccant **20** in dehumidifying section **12** absorbs moisture from the air being conditioned and the ambient air removes moisture from the desiccant **20'**. In order to provide for the concentration differential required, a heater, shown schematically at **36** heats liquid desiccant **20'**. This hotter liquid desiccant, when it contacts the air flowing through sheets **28'**, gives up some moisture and heat. A concentration differential then forms between the liquid desiccant in the sheets and the liquid desiccant in reservoir **18'**. This concentration differential causes a net flow of water ions from the reservoir to the sheets. The liquid desiccant in the sheets also is cooled by the evaporation of the water.

[0056] This flow of water causes an increased concentration and reduced amount of desiccant in reservoir **18'**. The drop in level of liquid desiccant cause a height equalizing flow of liquid desiccant from reservoir **18** to reservoir **18'** via aperture **34**. The flow includes both water and desiccant ions. In addition, the higher concentration of desiccant ions in reservoir **18'** causes a diffusion of desiccant from reservoir **18'** to reservoir **18**. The net effect at steady state is no net flow of desiccant ions between the two reservoirs. However, at steady state, the concentration of desiccant ions in reservoir **18** is lower than that in reservoir **18'**.

[0057] Liquid desiccant is wicked up by sheets **28** in the same manner as it is wicked up by sheets **28'**. However, since liquid desiccant in reservoir **18** is at a lower temperature than that in reservoir **18'**, the desiccant in dehumidifying section **12** absorbs moisture from the air being conditioned. The liquid desiccant is also heated (and heats the air) in the dehumidifying process. In the steady state, there is a net flow of water down the sheet into the reservoir.

[0058] To summarize, once steady state is established, moisture is absorbed in the desiccant in sheets **28** in dehumidifying section **12** from the "room" air. By diffusion (and perhaps, to some extent, by gravity), this moisture travels down the sheets to reservoir **18**. From reservoir **18** the moisture travels, again by gravity and to some extent by diffusion, to reservoir **18'**. From reservoir **18'** the moisture travels up sheet **28'** (by diffusion) in regenerating section **14**. Moisture is removed from the liquid desiccant by the outside air.

[0059] In an exemplary, but not limiting embodiment of the invention, the concentration at the desiccant concentration at the top of sheets **28** is (for example) 20%; the concentration in reservoir **18** is (for example) 25%; the concentration in reservoir **18'** is 30% and the concentration in sheets **28'** is 35%.

[0060] Since a sheet of wicking material may not conduct heat well and the heat carrier by the water may not be sufficient to provide desiccant in the sheets at a desired temperature, it may be desirable to increase the conduction of heat between the respective reservoirs and the liquid desiccant in the sheets. One way of doing this is to provide an apertured metal support to which the sheets are attached. This support provides both heat conduction and physical support for the sheets. To improve conduction, the lower portions of the sheets should also be situated in the desiccant liquid in the reservoir. Alternatively, a large number of threadlike wicks supported by long wires are used. Further alternatively, the structure described below with reference to **FIG. 3** is used.

[0061] **FIG. 2** shows an alternative dehumidifier system **10'**, in accordance with another embodiment of the invention. Dehumidifier system **10'** differs from dehumidifier **10** of **FIG. 1** in that dehumidifier system **10'** includes a heat pump generally denoted by reference number **16**. Other than the effects of the heat pump, as described below (and in the publications and applications described above), the operation of dehumidifying section **12** and regenerating section **14** in dehumidifier **10'** is similar in operation to the corresponding sections in dehumidifier **10** (**FIG. 1**). Heat pump **16** includes a compressor **38**, a condenser **40** situated in liquid desiccant **20'** in reservoir **18'**, an evaporator **42** situated in liquid desiccant **20** in reservoir **18** and an expansion valve **44** between the condenser and the evaporator. Heat pump **16** by transferring heat from desiccant **20** to desiccant **20'**, provides two desirable effects, namely the removal of heat generated during the dehumidifying process and the heating of desiccant **20'** to aid in the removal of moisture therefrom. In addition, an additional heat exchanger **46** (a secondary condenser) is preferably provided which removes additional heat from refrigerant in heat pump **16**, following the removal of heat at condenser **40**. Optionally, the air entering at inlet **22'** is also heated by heat exchange from compressor **38**. As described, this system dehumidifies and cools the conditioned air.

[0062] Alternatively, the additional heat exchanger can be placed at outlet **24** to heat the conditioned air. Such a system dehumidifies and heats the conditioned air.

[0063] Alternatively or additionally, a secondary evaporator (in a manner similar to the use of the secondary condenser **46**) is placed at the air outlet of the regenerator, to condense water, so that hot and wet air is not emitted. This process can be used as a desalination process, with moisture removed from the exiting air being collected.

[0064] Alternatively, the dehumidifying system includes two additional heat exchangers and a switching arrangement to switch between them to provide dehumidified conditioned air that is either heated or cooled. This embodiment parallels the embodiment shown in **FIG. 4C** of the above referenced concurrently filed PCT application. This is illustrative of how the present invention can be applied to different types of dehumidifying systems.

[0065] As indicated above, the liquid desiccant is cooled by the regeneration process (i.e., evaporation of part of its moisture cools the liquid desiccant) and heated by the dehumidifying process (condensation of the moisture heats the desiccant). The heating and cooling is counteracted by the action of heat pump **16** and (as to the heating) by heater **36** (**FIG. 1**). However, for most efficient operation, the thermal impedance between the condenser/evaporator/heating element, should be as low as possible.

[0066] **FIG. 3** shows a cross sectional view of an embodiment of a wicking system **50** in accordance with an embodiment of the invention, looking down on the structure from the top. The wicking system comprises a plurality of heat conducting (e.g., metal) plates **52**, optionally in the form of corrugated sheets. At least one side, and optionally both sides of the sheets are covered with a wicking material **54**, which can be either cotton fabric or felt or a synthetic material or any material that will wick the liquid desiccant. Plates **52** are optionally spaced slightly apart, by a space **56**. The lower ends of the metal plates are optionally attached to the respective condenser/evaporator/heating element (**FIGS. 1 and 2**), so that they conduct heat between the desiccant wicked by the wicking material and the element. At the upper end, the space between the plates is capped (as by barrier **30** of **FIGS. 1 and 2**) and wicking system **50** is oriented such that air must travel along the corrugations, in space **56**, as shown by arrows **58**. The corrugations (or other similar structure) are provided to increase the path of the air and its surface contact with the desiccant. However, plates **52** may also be flat. The spacing between the plates may be determined based on calculations of air resistance and dehumidification, or an optimal value may be determined experimentally.

[**0067**] Alternatively, plates **52** may be formed with apertures and covered with the wicking material, such that air passes through the apertures. In this embodiment the plates or oriented similarly to the sheets **28** of **FIGS. 1 and 2**, such that the air passes through the apertures. Other structures and configurations for supporting the wicking material in the chambers and configuring the wicking material will occur to persons of skill in the art.

[**0068**] The support of the wicking material are optionally made of a material, such as, for example, a metal, which will provide good heat transfer from the heat exchanger in the liquid to the liquid on the wicking material and to the air. Different material may make differences in the sensible/latent heat ratio. This unit can replace air conditioning in some cases where enough sensible heat is removed by the liquid and the supports. This unit can be used for desalination, while heat could be provided from sun or any other free heating source, and cooling is from the outside air.

[**0069**] **FIG. 4** shows a system **60** (in block form) and **FIG. 5** shows a flow chart **200** for an air-conditioning and/or dehumidifying system based dehumidifier **10** of **FIG. 1**, in accordance with an embodiment of the invention. Ambient air enters dehumidifier **10** and exits as dehumidified, heated air (**102**). The exiting air is optionally heated to high temperature, to increase the system efficiency and reduce the number of times the air has to be treated. The heated dehumidified air is then cooled (**103**) by transfer of heat in a heat exchanger **62** with outside air, to provide cooler dehumidified air. The cooled dehumidified air is not as cool as the conditioned air, but depending on the structure of the heat exchanger, it can be reasonably close to the temperature of the outside air used in the regenerator. In particular, if heat is exchanged between the heated dehumidified air and the air entering the regenerator, the amount of heat required from heater **36** (**FIG. 1**) can be reduced. Alternatively or additionally, heat can be transferred from the heated dehumidified air to water in a heat exchanger. The cooler dehumidified air is then evaporation cooled (**104**) (for example, by contacting it with water, as is well known in the art, in an evaporation cooler **64**), resulting in air that has a lower enthalpy than the air that input the dehumidifier in the first place. This lower enthalpy can manifest itself as air that only dehumidified, by air that is cooled or by air that is both cooled and dehumidified.

[**0070**] While a single cycle is shown in **FIG. 4** the cycle can be repeated (**105**) (utilizing all or part of the conditioned air) in order to provide a desired temperature/humidity. Eventually, the conditioned air exits (**106**) the system. It should be noted that if waste heat is available (as for example in an industrial facility), this heat can be used to heat desiccant **20'** in reservoir **18'**. Thus, the heating/dehumidification system would have relatively no cost, other than for fans for moving the air.

[**0071**] The invention has been described in the context of particular non-limiting embodiments. However, other combinations of air conditioning and dehumidifiers in accordance with the invention, as defined by the claims will occur to persons of skill in the art. For example, the principles defined herein can be applied to dehumidifiers of the types described in the above referenced application and publications as well as to many other dehumidifying systems known in the art. Additionally, while many features are shown in the exemplary embodiments, some of these features, although desirable, are not essential.

[**0072**] In particular, while the embodiments shown in the above disclosure have wicked means for transferring the liquid desiccant from both reservoirs to the respective dehumidifying and regenerating chambers, the invention may include, for one of the reservoirs, a pumping system to pump the desiccant into the chamber, as is known in the art.

[**0073**] As used in the claims the terms "comprise", "include" or "have" or their conjugates mean "including but not limited to".

1. A system for conditioning air comprising:

a dehumidifying section and a regenerating section, at least the dehumidifying section including a moisture transfer element, comprising:

a reservoir containing liquid desiccant;

a housing defining a chamber and having an air inlet and an air outlet, said chamber being situated generally above the reservoir; and

a wicking structure comprising wicking material that that wicks liquid desiccant or components thereof between the reservoir and the chamber, such that air that enters the chamber via the inlet contacts liquid desiccant transported to the chamber from the reservoir, prior to leaving the chamber,

wherein moisture is transported from the air to the reservoir by diffusion, optionally aided by one or both of wicking and gravity only.

2. A system according to claim 1 wherein the regenerating section includes a moisture transfer element, comprising:

a reservoir containing liquid desiccant;

a housing defining a chamber and having an air inlet and an air outlet, said chamber being situated generally above the reservoir; and

a wicking structure comprising wicking material that that wicks liquid desiccant or components thereof between the reservoir and the chamber, such that air that enters the chamber via the inlet contacts liquid desiccant transported to the chamber from the reservoir, prior to leaving the chamber,

wherein moisture is transported from the reservoir by diffusion, optionally aided by wicking only.

3. A system according to claim 1 wherein the wicking material comprises at least one sheet of said wicking material having one end in the liquid desiccant in the reservoir, at least a portion of the wicking material being in the chamber.

4. A system according to claim 1 wherein the wicking structure comprises a heat conducting structure that contacts the liquid desiccant in the reservoir and the wicking material in the chamber.

5. A system according to claim 4 wherein the heat conducting structure blocks air.

6. A system according to claim 5 wherein the heat conducting structure comprises a heat conducting metal.

7. A system according to claim 4 wherein the heat conducting structure is formed with apertures through which air can pass.

8. A system according to claim 7 wherein the heat conducting structure comprises a heat conducting metal.

9. A system according to claim 1 in which said wicking structure is oriented such that air passing through the chamber passes along a surface of the wicking material.

10. A system according to claim 1 in which said wicking structure is oriented such that air passing through the chamber passes through the wicking material.

11. A system according to claim 1 in which no pumps are used to transport the liquid desiccant between the reservoir and the chamber.

12. A system according to claim 1 in which the wicking structure is stationary.

13. A system according to claim 1 in which liquid desiccant reservoirs in the dehumidifying and regenerating sections are connected by at least one aperture, the size of said aperture being such that, in a steady state condition, no net amount of desiccant ions are transported between the reservoirs.

14. A system according to claim 13 in which transport of liquid desiccant or its components between the reservoirs is only via said at least one aperture.

15. A system according to claim 1 in which no pumps are used to transfer liquid desiccant between the dehumidifying and regenerating sections.

16. A system according to claim 1 in which transfer of liquid desiccant or its components between said dehumidifying and regenerating sections is by diffusion or gravity fed flow only.

17. A system according to claim 1 and including a heater that heats liquid desiccant in said regenerator.

18. A system according to claim 17 comprising a liquid heat pump that transfers heat from liquid desiccant in the dehumidifying section to liquid desiccant in the regenerating section, said beater comprising a condenser of said heat pump.

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