United States Patent	12385654
Kind Code	B2
Date of Patent	August 12, 2025
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Systems and methods for managing conditions in enclosed space

Abstract

A conditioning system includes a first plenum and a second plenum. The second plenum receives heated air from an enclosed space and supplies cooled air to the space. The system also includes a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside the first plenum. LAMEE**1** is configured to use a liquid desiccant to lower an enthalpy of the first air stream. A LAMEE**2** is arranged inside the first plenum downstream of LAMEE**1**. LAMEE**2** is configured to use the first air stream to evaporatively cool water flowing through LAMEE**2**. A first LAHX (LAHX**1**) is arranged inside the second plenum. LAHX**1** is configured to directly and sensibly cool the second air stream using a first cooling fluid. A second LAHX (LAHX**2**) is in fluid communication with LAMEE**1** and is configured to receive the liquid desiccant from LAMEE**1** and cool the liquid desiccant using outdoor air.

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Appl. No.:	**16/606673**
Filed (or PCT Filed):	**April 18, 2017**
PCT No.:	**PCT/CA2017/050478**
PCT Pub. No.:	**WO2018/191805**
PCT Pub. Date:	October 25, 2018

Prior Publication Data

Document Identifier **Publication Date**

Publication Classification

Int. Cl.: **F24F3/14** (20060101); **F24F5/00** (20060101); **F24F12/00** (20060101)

U.S. Cl.:

CPC **F24F3/1417** (20130101); **F24F5/0035** (20130101); **F24F12/002** (20130101);

Field of Classification Search

CPC: F24F (3/1417); F24F (5/0035); F24F (12/002); F25B (17/02)

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Background/Summary

CLAIM OF PRIORITY
(1) This application is a U.S. National Stage Filing under 35 U.S.C. § 371 from International Patent Application No. PCT/CA2017/050478, titled “SYSTEMS AND METHODS FOR MANAGING CONDITIONS IN ENCLOSED SPACE,” filed on Apr. 18, 2017 and published as WO 2018/191805 A1 on Oct. 25, 2018, the benefit of priority of which is claimed hereby, and which is incorporated by reference herein in its entirety.
DESCRIPTION OF DRAWINGS
(2) In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components, sub-components of a larger logical or physical system, or the like. The drawings illustrate generally, by way of example, but not by way of limitation, various examples described in the present disclosure.
(3) FIG. **1** schematically depicts an example conditioning system in accordance with this disclosure.
(4) FIG. **2** depicts another example conditioning system in accordance with this disclosure.
(5) FIG. **3** is a psychometric process diagram for a theoretical system substantially similar to example system of FIG. **2**.
(6) FIG. **4** depicts another example conditioning system.
(7) FIG. **5** is a psychometric process diagram for a theoretical system substantially similar to example system of FIG. **4**.
(8) FIG. **6** is a psychometric process diagram for a theoretical system with the same components and arrangements thereof as the system modeled to produce the process diagram of FIG. **5**, except the pre-cooler and the recovery coil have lower capacities/conditioning effectiveness, and a different outdoor air condition is evaluated.
(9) FIG. **7** depicts an example liquid desiccant regeneration system connected to a conditioning system in accordance with this disclosure.
(10) FIG. **8** depicts an example liquid-to-air heat exchanger configured to cool a liquid desiccant employed in a desiccant dryer liquid-to-air membrane energy exchanger.
(11) FIGS. **9** and **10** depict two other example conditioning systems.
(12) FIG. **11** depicts another example conditioning system.
(13) FIG. **12** depicts another example conditioning system.
(14) FIG. **13** depicts another example conditioning system.
(15) FIG. **14** is a flowchart depicting a method of operating a conditioning system in accordance

with this disclosure.
(16) FIG. **15** depicts another example conditioning system.

Description

DETAILED DESCRIPTION
(1) The inventor(s) recognize, among other things, an opportunity for improved performance in providing cooling to an enclosed space by employing a liquid desiccant conditioning module to lower the relative humidity of a scavenger (or outdoor) air stream before supplying the scavenger air to an indirect evaporative cooler, which indirectly and sensibly cools the process (or supply) air supplied to the enclosed space. Such systems with a liquid desiccant dryer can meet a discharge cooling set point temperature (for product/process cooling or for comfort cooling applications) over a larger range of inlet working air temperatures and humidity levels than other types of systems and potentially for any inlet working air conditions. In some cases, the water collected in the liquid desiccant dryer module exceeds the water needed in the evaporative cooler, thus potentially substantially reducing or eliminating large amounts of water usage typical of various types of heating and cooling systems.
(2) Comfort cooling of residential, commercial and institutional buildings is predominantly done using vapor-compression cooling equipment. Many process applications, such as data centers, also use mechanical cooling for primary or supplemental cooling. In most of these applications the required cooling temperature is moderate (for example, in a range from about 50 degrees Fahrenheit to about 85 degrees Fahrenheit). Vapor-compression mechanical cooling equipment can produce high cooling capacities, operate reliably and can have acceptable cost due to mass production of compressors, exchangers and other components. However, these systems require significant amounts of high grade energy (usually electricity) to operate. For example, some studies have estimated that about 15% of the total annual US domestic electricity production is consumed by air conditioning units. Moreover, it has been estimated that about ⅓ of the peak electricity demand in hot summer months is driven by air conditioning units, leading, in some cases, to issues with power grid loading and stability.
(3) The production of electricity remains carbon intensive, so electricity driven cooling systems can contribute to carbon dioxide (CO2) emissions and potentially to other issues like global warming and climate change. In addition, thermoelectric power production requires relatively large amounts of water for cooling, and the US average water consumption (evaporated water) for combined thermoelectric and hydroelectric power production is about 2 gallons/kWh. In fact, it has been estimated that the water consumed to produce the electricity required by an EER **11** air conditioner is about equivalent to the water consumed by a good efficiency evaporative cooling system producing an equivalent amount of cooling. However, evaporative cooling systems consume far less electricity.
(4) Vapor-compression systems also typically require synthetic refrigerants operating at high pressures. The deployment of large quantities of refrigerants in air conditioning and refrigeration systems can result in safety, health and environmental issues, including, for example ozone depletion caused by chlorofluorocarbon (CFC) refrigerants. Modern high efficiency refrigerants such as hydrofluorocarbons (HFCs) may have very high global warming potential and are being phased out of use. Additionally, proposed replacement hydrofluro-olefins (HFO) refrigerants and refrigerant mixtures may still have modestly high global warming potential (GWP) and are flammable, potentially toxic and expensive. Thus, there is a challenge in discovering or designing direct replacement refrigerant options for new and already installed vapor-compression systems, which has the desired properties in terms of efficiency, stability, flammability, toxicity, and environmental impact.

(5) Evaporative cooling systems are used successfully in many applications, especially in dry climates. Direct evaporative coolers are generally considered simple and efficient, but can lead to indoor humidity problems. Indirect evaporative coolers generally address the humidity issue, but may operate at lower wet bulb efficiencies. Dew-point evaporative coolers can deliver lower cooling temperatures than conventional direct or indirect evaporative systems and can maintain cooling power to higher outdoor wet bulb temperatures. However, all evaporative cooling technologies lose cooling performance as the working air humidity rises and may not be able to be used in humid climates without supplemental (usually vapor-compression) cooling equipment.
(6) The water usage efficiency of evaporative cooling systems also varies widely depending on the system design and control characteristics. The water usage of evaporative coolers can be a significant perceived or real problem. For example, large scale data centers can consume surprisingly large quantities of potable water, and in locations where evaporative cooling works best (dry climates), the water demand may not be sustainable.
(7) Absorption chillers have been employed for comfort and process cooling, especially when waste heat is available. Absorption chiller systems have been commercialized for larger scale applications and may be an alternative to mechanical cooling in integrated building designs where the required technical and maintenance support is available. Single-effect absorptions chillers have a COP<1, so significant quantities of heat are required to drive the system. Current absorption chiller designs are intended to replace electric chillers and deliver comparable cooling temperatures (for example, 40° F.-50° F.). However, this may require the use of specialized materials (alloy metals), vacuum vessels, multiple heat exchangers, relatively high grade heat input for the generator, control methods to prevent crystallization, etc. Higher efficiency double and triple effect designs are increasingly complex and expensive. The complexity, cost and maintenance requirements of absorption systems may limit their widespread acceptance as an alternative to mechanical cooling, especially in lighter load commercial and residential applications.
(8) There remains an urgent need for alternative cooling technologies for comfort conditioning applications which can largely replace mechanical cooling. The growing awareness of environmental impacts, electricity consumption and increasing regulatory pressure on refrigerants are pressing challenges for current HVAC cooling equipment. This need was identified and articulated in the U.S. Department of Energy BTO report in 2014 titled "Energy Savings Potential and RD&D Opportunities for Non-Vapor-Compression HVAC Technologies."
(9) One of the most promising technologies identified in this DOE report was desiccant enhanced evaporative cooling systems. However, there is a need for a commercially viable design which meets requirements for first cost, ongoing operation costs, performance, reliability, size/weight restrictions, etc., while avoiding the creation of any new resource utilization problems such as excessive water or natural gas consumption.
(10) The ideal system design would have good cooling performance and compactness, make use of low cost materials, and avoid the use of any environmentally harmful or toxic substances. From a thermodynamic perspective, the system should operate near atmospheric pressures with low grade heat input, employ moderate temperature changes and exchange fluxes to minimize irreversibility in the system and improve second law efficiency. Comfort conditioning only requires low grade cooling, and an exergy analysis can illustrate how wasteful it may be to use precious high grade energy sources such as electricity to drive cooling equipment. Currently this is most clearly evident in data center applications, where operators want to maximize the utilization of available electricity supplies for running computing equipment (an appropriate use of electricity) and minimize electricity consumption by cooling equipment.
(11) In one example, a system for controlling conditions in an enclosed space includes a scavenger plenum, a process plenum, a first liquid-to-air membrane energy exchanger (LAMEE**1**), a second LAMEE (LAMEE**2**), a first liquid-to-air heat exchanger (LAHX**1**), and a second LAHX (LAHX**2**). The process plenum is configured to direct scavenger air from a scavenger inlet to a scavenger

outlet. The process plenum is configured to direct process air from a process inlet to a process outlet. The process inlet receives heated air from the space and the process outlet supplies cooled air to the space. LAMEE**1** is arranged inside the scavenger plenum. LAMEE**1** is configured to use a first fluid flowing there through to reduce the humidity of the scavenger air. A first concentration of water in the first fluid at a fluid inlet of LAMEE**1** is lower than a second concentration of water in the first fluid at a fluid outlet of LAMEE**1**. LAMEE**2** is arranged inside the scavenger plenum downstream of LAMEE**1**. LAMEE**2** is configured to use the scavenger air to evaporatively cool a second fluid flowing through LAMEE**2**. A temperature of the second fluid at a fluid outlet of LAMEE**2** is lower than a temperature of the second fluid at a fluid inlet of LAMEE**2**. LAHX**1** is arranged inside the process plenum. LAHX**1** is configured to directly and sensibly cool the process air being directed through the process plenum using a third fluid flowing through LAHX**1**. LAHX**2** is in fluid communication with LAMEE**1** and is configured to receive and cool the first fluid using outdoor air.
(12) FIG. **1** depicts an example conditioning system **100**. Conditioning system **100** is configured to condition the air in an enclosed space like a data center. Conditioning system **100** is what is sometimes referred to as a 100% recirculation system, which generally means that the air within the enclosed space recirculates through the conditioning system (in this case through one portion of the system, for example, the process side of the system) in a continuous cycle of being cooled by the system to a target supply air temperature, supplied to the space, heated by elements in the space (for example, computers, servers, and other electronics), and returned to the system for cooling. Although not shown or described in detail, the conditioning system can include a make-up air unit or system, to continuously or periodically refresh the air within the space. With the addition of make-up air, in some cases, humidification and/or dehumidification units may be employed to control the humidity of the air in the enclosed space.
(13) In FIG. **1**, conditioning system **100** includes system cabinet **102**, scavenger plenum **104**, process plenum **106**, LAMEE**1 108**, LAMEE**2 110**, LAHX**1 112**, LAHX**2 114** and first fluid circuit **116** and second fluid circuit **118**. Scavenger plenum **104** includes inlet **120** and outlet **122**. Associated and generally collocated with each of inlet **120** and outlet **122** are dampers **124**, **126**, respectively. Process plenum **106** includes inlet **128**, with which is associated and collocated damper **130**, and outlet **132**, which is associated and collocated damper **134**. Conditioning system **100** also includes a liquid desiccant regeneration system, which is configured to regenerate desiccant leaving LAMEE**1 108**, which has been diluted by water from the scavenger air, and, in some cases, to supply the water removed from the desiccant to other components, including, for example, LAMEE**2 110**.
(14) Although not shown in FIG. **1**, in some examples, scavenger plenum **104** could also include a bypass inlet and bypass damper disposed between LAMEE**1 108** and LAMEE**2 110**. In such situations, system **100** to could be configured to close damper **124** at inlet **120** and open the bypass damper to bypass LAMEE**1 108** and direct the scavenger air (for example, outdoor air) in through the damper inlet and through LAMEE**2 110**.
(15) Air from the enclosed space enters system **100** through process inlet **128**. The air entering system **100** has been heated in the enclosed space and requires cooling to a target supply air temperature, which is generally determined based on the amount and characteristics of equipment housed in the enclosed space, for example, computing, networking, data storage and other equipment. Air is supplied to the enclosed space from system **100** through process outlet **132**. This supply air is cooled by system **100** and is transported into the space at or within an acceptable tolerance of the target supply air temperature.
(16) Scavenger plenum **104** and the scavenger air flowing there through can be a plenum that transports outdoor air (OA) from inlet **120** through/by LAMEE**1 108** and LAMEE**2 110**, and then exhausts the increased enthalpy OA air through scavenger outlet **122**. The scavenger and process plenums **104** and **106** are sealed from one another such that the scavenger and process air streams

do not intermix with one another (other than ordinary leakage between the two plenums, if collocated).

(17) Scavenger plenum **104** and process plenum **106** are defined by partitioned sub-sections of the interior space of cabinet **102**, as is schematically depicted in FIG. **1**. In other examples, scavenger and process plenums **104** and **106** can be separate from and mounted within system cabinet **102** of system **100**. Although some components of example systems in accordance with this disclosure are schematically depicted as outside of the overall system cabinet and/or outside of the two separate plenums, at least in some examples all of the cooling/conditioning components of example system(s) are located within a single system enclosure, which can be conveniently packaged, transported, and installed. In such cases, the scavenger and process inlets and outlets can be connected directly to or indirectly via appropriate ducting or other fluid flow conduit to additional scavenger air supply and exhaust flow paths and to additional enclosed space supply and return flow paths. Additionally, one or more of the components depicted within cabinet **102** and/or plenums **104** and **106** can be located external to and/or separate from such enclosures. Additionally, plenums may located and/or packaged separate from one another instead of sharing a common cabinet. Moreover, example systems in accordance with this disclosure can be employed in combination with other heating, cooling, humidification, dehumidification, recovery, regeneration and other components or systems located within or otherwise along these additional scavenger and process air flow paths.

(18) Example conditioning systems in accordance with this disclosure include liquid to air membrane energy exchangers (LAMEEs), which are configured to transfer heat and moisture between a liquid and an air stream to condition the temperature and humidity of the air and/or to condition the liquid flowing through the LAMEE. In an example, the membrane in a LAMEE can be a non-porous film having selective permeability for water, but not for other constituents that may be present in the liquid. Many different types of liquids can be used in combination with the non-porous membrane, including, for example, water, liquid desiccants, glycols. In an example, the membrane in the LAMEE can be semi-permeable or vapor permeable, and generally anything in a gas phase can pass through the membrane and generally anything in a liquid phase cannot pass through the membrane. In an example, the membrane in the LAMEE can be micro-porous such that one or more gases can pass through the membrane. In an example, the membrane can be a selectively-permeable membrane such that some constituents, but not others, can pass through the membrane. It is recognized that the LAMEEs included in the conditioning systems disclosed herein can use any type of membrane suitable for use with devices that are the same or equivalent to a LAMEE.

(19) LAMEE**1 108** can be used to lower the enthalpy of and dehumidify the scavenger air flowing through scavenger plenum **104**. LAMEE**1 108** can also collect water, which can be employed in/by other components of conditioning system **100** or other such systems in accordance with this disclosure. The water collection rate/capacity of LAMEE**1 108** can exceed the evaporation rate of LAMEE**2 110** (or another type of evaporative cooler), which can make operation of conditioning system **100**, or at least operation of LAMEE**2** independent of additional/external water sources. Additionally, because LAMEE**1 108** can effectively operate in a variety of ambient conditions using a liquid desiccant at temperatures (for example, on the order of 35 degrees Celsius) that are higher than the outdoor ambient dry bulb temperature, cooling/heat rejection of the desiccant exiting LAMEE**1** can occur in an air cooler (for example, a polymer fluid cooler or PFC) using only outdoor air.

(20) LAMEE**1 108** of conditioning system **100** can function to remove water from the scavenger air using a liquid desiccant to decrease the humidity of the scavenger air and thereby lower the wet bulb temperature. The temperature of the scavenger air passing through LAMEE**1 108** may be lowered modestly, but the decrease in humidity and associated effect of lowering wet bulb temperature can significantly increase the cooling capacity of LAMEE**2 110** (configured to operate

as an evaporative cooler) and thereby improve and expand the efficiency with which and the conditions under which system **100** can meet the target supply air temperature for a data center or other enclosed space.

(21) The cooling fluid circulating through LAMEE**1 108** and/or LAMEE**2 110** can include water, liquid desiccant, glycol, other hygroscopic fluids, other evaporative liquids, and/or combinations thereof. In an example, the cooling fluid employed in and flowing through LAMEE**1 108** is a liquid desiccant that is a high concentration salt solution. The presence of salt can sanitize the cooling fluid to prevent microbial growth. In addition, the desiccant salt can affect the vapor pressure of the solution and allow the cooling fluid to either release or absorb moisture from the air. The concentration of the liquid desiccant can be adjusted for control purposes to control the amount of cooling and/or dehumidification of the scavenger air or cooling fluid within/passing through/by LAMEE**1 108**.

(22) In an example, the cooling fluid employed in and flowing through LAMEE**2 110** is water and, in some cases, the water flowing through LAMEE**2 110** or a portion thereof is water removed from the scavenger air by LAMEE**1 108**. LAMEE**2 110** can include a water inlet and a water outlet for passing water through the exchanger. In other cases, other types of evaporative cooling fluids, including those listed above, can be used in combination with or as an alternative to water for LAMEE**2 110** and other such examples in accordance with this disclosure.

(23) In one example, a liquid desiccant, for example a salt solution desiccant flows into LAMEE**1 108** via a liquid inlet and out of LAMEE**1 108** via a liquid outlet. The scavenger air enters scavenger plenum **104** and flows through LAMEE**1 108** via air inlets and outlets thereof. As the scavenger air flows by the liquid desiccant, separated by the membrane(s) employed in LAMEE**1 108**, water in the scavenger air condenses through the membrane into the liquid desiccant. The scavenger air exiting LAMEE**1 108** can have a lower temperature and/or a lower humidity than the scavenger air entering LAMEE**1**, and, as a result, the enthalpy and the wet bulb temperature of the scavenger air are decreased. The reduced wet bulb temperature scavenger air flows out of LAMEE**1 108** downstream through scavenger plenum **104** into LAMEE**2 110**.

(24) LAMEE**2 110** of conditioning system **100** can recirculate a cooling fluid, including an evaporative fluid to reduce the temperature of the cooling fluid by evaporating water from the fluid into the scavenger air passing through LAMEE**2**. LAMEE**2 110** can operate as an evaporative cooler, using the cooling potential in both the scavenger air and the cooling fluid (for example, water) to reject heat. Although the examples disclosed include LAMEE**2** configured as an evaporative cooler in the scavenger plenum **104**, in other examples, different types of evaporative cooling devices can be employed, including, for example, a wetted media direct evaporative cooler. In an example, LAMEE**2 110** can use a flexible polymer membrane, which is vapor permeable, to separate the scavenger air and water or other fluid flowing through LAMEE**2**. Relative to other systems/devices, the water flow rate and air flow rate through LAMEE**2 110** may not be limited by concerns such as droplet carryover at high face velocities. In addition, LAMEE**2 110** can operate with water flow rates that enable the transport of thermal energy into the cooler similar to a cooling tower, and the elevated inlet water temperatures can boost the evaporative cooling power of LAMEE**2**.

(25) LAMEE**2 110** can be referred to herein as an evaporative cooler and/or an evaporative cooler LAMEE. As scavenger air flows through LAMEE**2 110**, the water, or both the scavenger air and the water, can be cooled to temperatures approaching the entering air wet bulb (WB) temperature, as a portion of the water flowing through LAMEE**2** evaporates into the scavenger air. The scavenger air exiting LAMEE**2 110** can pass through scavenger fan **136** and exit scavenger plenum **104** at the outlet thereof as exhaust.

(26) Due to the evaporative cooling process in LAMEE**2 110**, a temperature of the water at the outlet of the exchanger can be less than a temperature of the water at the inlet. In other words, the water flowing through the LAMEE**2 110** is cooled by the device between the inlet and the outlet.

The reduced-temperature, or “cooled” water from LAMEE**2 110** can be used to provide cooling to process air flowing through/by LAHX**1 112**.

(27) LAMEE**1 108** can be referred to as a dehumidification LAMEE and/or desiccant driven dehumidification LAMEE. As noted above, LAMEE**2 110** can be referred to as an evaporative cooler LAMEE. As shown in FIG. **1**, dehumidification LAMEE**1 108** is arranged upstream of evaporative cooler LAMEE**2 110** in scavenger plenum **104** to reduce the humidity of the scavenger air prior to evaporative cooling in the evaporative cooler LAMEE**2**. Pre-drying the scavenger air boosts the cooling potential in system **100** by lowering the wet bulb temperature of the scavenger air and thereby lowering the ideal and actual cooling limits of evaporative cooler LAMEE**2 110**. Dehumidification LAMEE**1 108** may also pre-cool the scavenger air. Desiccant driven dehumidification may allow cooling of the process air by system **100** to even lower temperatures with modest amounts of additional energy input.

(28) Dehumidification LAMEE**1 108** may be similar in construction to evaporative cooler LAMEE**2 110**. However, dehumidification LAMEE**1 108** can employ a different cooling fluid than evaporative cooler LAMEE**2 110**. For example, the desiccant fluid flowing through LAMEE**1 108** may be a lithium chloride solution, while the cooling (or “evaporative”) fluid flowing through LAMEE**2 110** may be pure water or water of a relatively high purity.

(29) Example conditioning system **100** also includes two liquid-to-air heat exchangers, LAHX**1 112** and LAHX**2 114**, which generally exchange heat between a cooling fluid flowing through the exchanger and air flowing over/by the exchanger. LAHX**1 112** is arranged in process plenum **106** and is the cooling component in conditioning system **100** that ultimately directly and sensibly cools the process air from the enclosed space.

(30) LAHX**1 110** can be a variety of types of liquid-to-air exchangers, including, for example, cooling coils. Cooling coils are commonly formed of coiled copper tubes embedded in a matrix of fins. A variety of particular configurations, capacities, etcetera can be employed in examples according to this disclosure. Other example LAHXs that can be used include micro-channel heat exchangers. The cooling fluid circulating through one or both of LAHX**1 110** and LAHX**2 112** can include water, liquid desiccant, glycol, other hygroscopic fluids, other evaporative liquids, and/or combinations thereof. Additionally, the cooling fluid flowing through LAHX**1 112** can be the same as or different than the cooling fluid flowing through LAMEE**2 110**, as described in more detail with other examples in accordance with this disclosure.

(31) LAHX**2 114** is configured to cool the liquid desiccant exiting LAMEE**1 108** and return the desiccant to the fluid inlet of LAMEE**1**. As noted above, in some examples, the inlet temperature threshold (or set point) of LAMEE**1 108** can be higher than the outdoor air dry bulb temperature. In at least some such cases, LAHX**2 114** can cool the liquid desiccant to the inlet temperature threshold of LAMEE**1 108** using only outdoor air in a sensible cooling process. In some cases, however, a combination of outdoor air and some kind of evaporative cooling augmentation (for example, adiabatic cooling or water sprays) may be employed in LAHX**2 114** to cool the liquid desiccant exiting LAMEE**1 108**.

(32) LAHX**1 112** can be a variety of types of fluid cooling components and/or liquid-to-air exchangers. In one example, LAHX**1 110** is a polymer fluid cooler (PFC), which is configured to employ outdoor air to cool the liquid desiccant exiting LAMEE**1 108** to a target inlet desiccant temperature. Such a PFC can be, for example, a PolyCoil polymeric heat exchanger from Cesaroni Technology Inc. of Gormley, Ontario in Canada. Additional details and examples of the types of components employed as LAHX**1 110** (or another similar component in other examples according to this disclosure) is illustrated in and described with reference to FIGS. **7** and **8**.

(33) Referring again to FIG. **1**, conditioning system **100** also includes scavenger fan (or fan array) **136** and process fan (or fan array) **138**, which drive the scavenger air and the process air, respectively, through system **100**. Example conditioning system **100** and other example systems in accordance with this disclosure can include more or fewer fans than shown in the example of FIG.

1. Moreover, the fans can be located in different locations within the system **100** relative to what is shown in FIG. **1**. For example, one or both of scavenger fan **136** and process fan **138** can be configured as a single fan or multiple fans, including a fan array, such as, for example, FANWALL® Systems provided by Nortek Air Solutions of O'Fallon, Missouri. Although not shown in the figures, example conditioning systems in accordance with this disclosure can include one or more filters disposed at a variety of locations in one or both of scavenger plenum **104** and process plenum **106**.
(34) In the example of FIG. **1**, scavenger fan **136** is arranged inside scavenger plenum **104** downstream of LAMEE**2** **110**. In this position, at least some of the heat generated by scavenger fan **136** is exhausted out of scavenger plenum **104** through scavenger outlet **122**, which is just downstream of scavenger fan **136**. Process fan **138** is arranged inside process plenum **106** upstream of LAHX**1** **112**. In this position, some heat generated by process fan **138** can be removed by LAHX**1** **112**. In other examples, scavenger fan **136** can be located at different positions within/along scavenger plenum **104** and process fan **138** can be located at different positions within/along process plenum **106**.
(35) In the example of FIG. **1**, conditioning system **100** includes first fluid circuit **116** and second fluid circuit **118**. Fluid circuits employed in examples according to this disclosure, including first and second fluid circuits **116** and **118** can include a number of different interconnected conduits or fluid flow pathways, as well as other cooling fluid related components, including, for example, valves, pumps, tanks or other storage vessels, etc. Each of first and second fluid circuits **116** and **118** can be thought of as including multiple interconnected fluid flow branches or could also be characterized as including multiple fluid circuits.
(36) First and second fluid circuits **116** and **118** are structured and configured to transport one or more cooling fluids (or more generally “heat transfer” fluids) among the components of system **100**. In the example of FIG. **1**, first fluid circuit **116** transports a first cooling fluid among LAMEE**1** **108** and LAHX**2** **114**. Second fluid circuit **118** transports a second cooling fluid among LAMEE**2** **110** and LAHX **112**. As noted above, in one example, first fluid circuit **116** transports a salt solution liquid desiccant among LAMEE**1** **108** and LAHX**2** **114** and second fluid circuit **118** transports water among LAMEE**2** **110** and LAHX **112**.
(37) Conditioning system **100** also includes system controller **150**. System controller **150** can include hardware, software, and combinations thereof to implement the functions attributed to the controller herein. System controller **150** can be an analog, digital, or combination analog and digital controller including a number of components. As examples, controller **150** can include ICB(s), PCB(s), processor(s), data storage devices, switches, relays, etcetera. Examples of processors can include any one or more of a microprocessor, a controller, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), or equivalent discrete or integrated logic circuitry.
(38) Storage devices, in some examples, are described as a computer-readable storage medium. In some examples, storage devices include a temporary memory, meaning that a primary purpose of one or more storage devices is not long-term storage. Storage devices are, in some examples, described as a volatile memory, meaning that storage devices do not maintain stored contents when the computer is turned off. Examples of volatile memories include random access memories (RAM), dynamic random access memories (DRAM), static random access memories (SRAM), and other forms of volatile memories known in the art. The data storage devices can be used to store program instructions for execution by processor(s) of controller **150**. The storage devices, for example, are used by software, applications, algorithms, as examples, running on and/or executed by controller **150**. The storage devices can include short-term and/or long-term memory, and can be volatile and/or non-volatile. Examples of non-volatile storage elements include magnetic hard discs, optical discs, floppy discs, flash memories, or forms of electrically programmable memories (EPROM) or electrically erasable and programmable (EEPROM) memories.

(39) System controller **150** can be configured to communicate with conditioning system **100** and components thereof via various wired or wireless communications technologies and components using various public and/or proprietary standards and/or protocols. For example, a power and/or communications network of some kind may be employed to facilitate communication and control between controller **150** and conditioning system **100**. In one example, system controller **150** may communicate with conditioning system **100** via a private or public local area network (LAN), which can include wired and/or wireless elements functioning in accordance with one or more standards and/or via one or more transport mediums. In one example, system **100** can be configured to use wireless communications according to one of the 802.11 or Bluetooth specification sets, or another standard or proprietary wireless communication protocol. Data transmitted to and from components of system **100**, including controller **150**, can be formatted in accordance with a variety of different communications protocols. For example, all or a portion of the communications can be via a packet-based, Internet Protocol (IP) network that communicates data in Transmission Control Protocol/Internet Protocol (TCP/IP) packets, over, for example, Category 5, Ethernet cables or over an 802.11 or Bluetooth wireless connection.
(40) System controller **150** can include one or more programs, circuits, algorithms or other mechanisms for controlling the operation of conditioning system **100**. For example, system controller **150** can be configured to modulate the speed of scavenger and process fans **136** and **138** and/or control actuation of valves, pumps, etc. in one or both of first fluid circuit **116** and second fluid circuit **118**. System controller **150** can also be configured to operate system **100** in multiple conditioning (for example, cooling) modes. For example, system controller **150** can also be configured to operate system **100** in an evaporative mode in which LAMEE**1** **108** is deactivated, damper **124** is closed, a bypass damper (in scavenger plenum **104** between LAMEE**1** **108** and LAMEE**2** **110**) is opened, and cooling fluid is circulated through a run-around loop defined by first fluid circuit **116** from the outlet of LAHX**1** **112** to the inlet of LAMEE**2** **110**, through LAMEE**2** **110**, from the outlet of LAMEE**2** **110** to the inlet of LAHX**1** **112**, and through LAHX**1** **112** back to the outlet thereof. Additionally, system controller **150** can also be configured to operate system **100** in a desiccant enhanced evaporation mode in which LAMEE**1** **108** is activated, damper **124** is opened, the bypass damper is closed, and cooling fluid is circulated by first fluid circuit **116** among all of LAMEE**1** **108** and LAHX**1** **112**.
(41) Although not shown in detail in the example of FIG. **1**, conditioning system **100** can also include one or more components to recover the fluid flowing through LAHX**1** **112** before returning to LAMEE**2** **110** and/or one or more components to regenerate the liquid desiccant flowing through LAMEE**1** **108**. In the case of regeneration of liquid desiccant flowing through LAMEE**1** **108**, in some examples, the regeneration circuit and components can be configured to regenerate less than 100% of the desiccant in each cycle through LAMEE**1** and LAHX**2**.
(42) In some examples according to this disclosure, an important feature/advantage of employing LAMEE**1** (versus some other type of liquid desiccant device) is the relatively high desiccant flow rate that is possible through such example LAMEEs in accordance with this disclosure. Due to the high flow rates through the desiccant dryer LAMEE, even though the desiccant may pick up heat in LAMEE**1** (in addition to moisture) the flow rates are such that the increase in temperature is tolerable without additional desiccant cooling such as requiring an additional cooling flowing through the same exchanger to cool the desiccant. The control of desiccant temperature is important in such systems, because, for a given desiccant salt concentration, the capacity of the desiccant to absorb moisture degrades as the desiccant temperature increases. Maintaining relatively high flow rates through the desiccant dryer LAMEE is assisted by only regenerating a portion of the total flow between LAMEE**1** and LAHX**2**. Examples of such components or systems are described in more detail with reference to the examples of FIGS. **2** and **4**.
(43) FIG. **2** depicts another example conditioning system **200** in accordance with this disclosure. As is apparent from FIG. **2**, conditioning system **200** shares many of the components and functions

of example conditioning system **100** of FIG. **1**. For example, conditioning system **200** includes system cabinet **102**, scavenger plenum **104**, process plenum **106**, LAMEE**1 108**, LAMEE**2 110**, LAHX**1 112**, and LAHX**2 114**. Scavenger plenum **104** includes inlet **120** and outlet **122**, and dampers **124** and **126**, which are associated and generally collocated with each of inlet **116** and outlet **118**. Process plenum **106** includes inlet **128**, with which is associated and collocated damper **130**, and outlet **132**, which is associated and collocated damper **134**. Conditioning system **200** also includes scavenger fan **136**, process fan **138**, and system controller **150**. Conditioning system **200** includes a liquid desiccant regeneration system, which is configured to regenerate desiccant leaving LAMEE**1 108**, which has been diluted by water from the scavenger air, and, in some cases, to supply the water removed from the desiccant to other components, including, for example, LAMEE**2 110**.
(44) In addition to the components in common with conditioning system **100**, conditioning system **200** includes recovery coil **202**, first storage tank **204** and first pump **206**, and second storage tank **208** and second pump **210**. Recovery coil **202** can include a number of different types of devices configured to use the air flowing out of LAMEE**2 110** in scavenger plenum **104** to cool down the fluid returning from LAHX**1 112** to LAMEE**2**. In one example, recovery coil **202** is one of a number of different types of LAHX devices.
(45) The fluid exiting LAHX**1 112** will be at an increased-temperature or "heated," because the rejected heat from the process air has been picked up by the fluid. The fluid can therefore be transported to recovery coil **202** in scavenger plenum **104**, which cools the fluid before it returns to LAMEE**2 110**. Recovery coil **202** can cool the fluid using the cooling potential of the scavenger air. The scavenger air exiting LAMEE**2 110** can be relatively cool and additional sensible heat from the cooling fluid can therefore be rejected into the scavenger air. One reason for the amount of energy still available in the scavenger air after going through LAMEE**2 110** is that LAMEE**2** cools the water or other fluid by increasing the humidity of the scavenger air versus substantially increasing the temperature of the air. In this sense, system **200** uses the latent heat transfer capacity of the scavenger air to cool a cooling fluid (for example, water) that is used to sensibly cool the process air and uses the sensible heat transfer capacity of the scavenger air to cool the fluid after it has picked up heat from the process air.
(46) Therefore, one advantage of conditioning system **200** is the ability to use the scavenger air as a working fluid to cool down and recover the cooling fluid flowing through LAMEE**2 110**. Recovery coil **202** or an equivalent device can be relatively inexpensive, simple in construction and maintenance, thus potentially simplifying and reducing the cost and complexity of at least some example conditioning systems and methods in accordance with this disclosure. Moreover, recovery coil **202** may provide a number of advantages related to water usage efficiency over systems not including such a component. For example, inclusion of recovery coil **202** may make a true economizer operating mode possible in which no evaporative conditioning takes place and fluid is transported in a run around loop between recovery coil **202** and LAHX**1 112**. Additionally, the recovery coil **202** can increase the water efficiency of evaporative modes by increasing the temperature of the scavenger exhaust air.
(47) In the example of conditioning system **200** of FIG. **2**, first storage tank **204** and first pump **206** are included in and connected to first fluid circuit **212**. First fluid circuit **212** can be similar in structure and function to first fluid circuit **116** of FIG. **1**, except that first fluid circuit **212** includes tank **204** and pump **206** and associated couplings to incorporate these components into the circuit. Second storage tank **208** and second pump **210** are included in and connected to second fluid circuit **214**. Second fluid circuit **214** can be similar in structure and function to second fluid circuit **118** of FIG. **1**, except that second fluid circuit **214** includes tank **208** and pump **210** and associated couplings to incorporate these components into the circuit.
(48) Storage tank **204** can be employed to store fluid cooled by LAMEE**2 110**. Although not shown in FIG. **2**, tank **204** can include a make-up valve and a drain valve to maintain the fluid level and

hardness level inside the tank. Tank **204** can include one or more temperature sensors in or around the tank to monitor a temperature of the fluid stored therein. In an example, the control scheme for conditioning system **200** can be based, in part, on a measured temperature of the fluid in tank **204** compared to a set point temperature. In an example, the set point temperature can be pre-determined based on an estimated cooling load from the enclosed space or a temperature required by the equipment of occupants of the enclosed space (for example, computing, networking, etc. equipment in a data center). The set point water temperature can also vary during operation of conditioning system **100**, based in part on conditions in the enclosed space (for example, operation of the data center like periodic processing or data storage load variations).

(49) Pump **206**, which can be controlled by system controller **150**, pumps the cooled fluid from storage tank **204** into LAHX**1 112**, by which LAHX**1 112** cools the process air supplied to the enclosed space. After the fluid provides cooling to the process air, the fluid can be recirculated back to LAMEE**2 110** (including through recovery coil **202**).

(50) Fluid circuit **212** can include a number of different interconnected conduits or fluid flow pathways, as well as other cooling fluid related components. Fluid circuit **212** can be thought of as including multiple interconnected fluid flow branches or could also be characterized as including multiple fluid circuits. In any event, fluid circuit **212** is structured and configured to transport one or more cooling fluids (or more generally "heat transfer" fluids) among the cooling components of system **200**. In the example of FIG. **2**, fluid circuit **212** transports cooling fluid, for example, water among LAMEE**2 110**, LAHX**1 112**, and recovery coil **202**, stores the fluid in tank **204** and transports the fluid to LAHX**1 112** from tank **204** using pump **206**.

(51) Storage tank **208** can be employed to store fluid that is used by LAMEE**1 108** to dehumidify the scavenger air and to thereby lower the enthalpy/wet bulb temperature of the scavenger air to boost the cooling capacity of the evaporative cooler LAMEE**2 110**. Tank **208** can include one or more temperature sensors in or around the tank to monitor a temperature of the fluid stored therein. In an example, the control scheme for conditioning system **200** can be based, in part, on a measured temperature of the fluid in tank **208** compared to a set point temperature. In an example, the set point temperature can be pre-determined based on, inter alia, an estimated cooling load from the enclosed space. The set point temperature for the fluid flowing through LAMEE**1 108** can also vary during operation of conditioning system **200**, based in part on conditions in the enclosed space (for example, operation of the data center like periodic processing or data storage load variations). In an example, the temperature of the fluid entering LAMEE**1 108** can be controlled by modulating the capacity of LAHX**2 114**.

(52) Pump **210**, which can be controlled by system controller **150**, pumps the fluid from storage tank **208** to LAHX**2 114**, which cools the fluid using outdoor air and returns the cooled fluid to the fluid inlet of LAMEE**1 108**. Fluid circuit **214** can include a number of different interconnected conduits or fluid flow pathways, as well as other cooling fluid related components. Fluid circuit **214** can be thought of as including multiple interconnected fluid flow branches or could also be characterized as including multiple fluid circuits. In any event, fluid circuit **214** is structured and configured to transport one or more fluids among the select components of system **200**. In the example of FIG. **2**, fluid circuit **214** transports a fluid, for example, a liquid desiccant among LAMEE**1 108** and LAHX**2 114**, stores the fluid in tank **208** and transports the fluid to LAHX**2 114** from tank **208** using pump **210**.

(53) System controller **150** can be structured and operate in association with conditioning system **200** in a manner similar to that described with reference to conditioning system **100** of FIG. **1**. For example, controller **150** can be communicatively connected to system **200**, can control operation of components thereof, and can operate the system in multiple modes, including, for example, modes similar to the evaporation mode and the desiccant enhanced evaporation mode described above with reference to the example of FIG. **1**. Additionally, system controller **150** can operate system **200** in a true economizer mode by transmitting a cooling fluid in a runaround loop between

recovery coil **202** and LAHX**1** **112**. In this true economizer mode, LAMEE**1** **108** and LAMEE**2** **110** (or another evaporative cooler in place of LAMEE**2**) are deactivated and the scavenger air sensibly cools the cooling fluid and the cooling fluid sensibly cools the process air.

(54) FIG. **3** is a psychometric process diagram for a theoretical system substantially similar to example system **200** of FIG. **2**. The psychometric process diagram illustrates the conditions of a modeled conditioning system and, in particular, conditions of the working fluid(s) thereof at different components of the system and/or at different points during operation. The process diagram depicted in FIG. **3** was created using various numerical, analytical, algorithmic, etc. methods, tools, etc. to estimate the physical characteristics of a system in accordance with this disclosure when operated under certain initial conditions.

(55) The example modeled system is operated at ambient conditions including outdoor air dry bulb temperature of approximately 32.2 degrees Celsius, outdoor air wet bulb temperature of 29.4 degrees Celsius and relative humidity of 81.6%. Additionally, the altitude of the modeled system is sea level (0 meters), the barometric pressure is approximately 760 mm Hg, and the atmospheric pressure is approximately 101.325 kPa. The liquid desiccant employed in LAMEE**1** is a lithium chloride solution with a salt concentration of approximately 38% and a target fluid inlet temperature of 35 degrees Celsius. The target set-point temperature for the process air supplied to the enclosed space from the outlet of the process plenum is approximately 30 degrees Celsius. The characteristic values associated with the process diagram of FIG. **3** are as follows:

(56) TABLE-US-00001 1. Air Condition and Flow Rate at Scavenger Inlet 120 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14.159 32.222 29.444 81.6 25.23 0.900 96.906 28.667 1.1394 29.4898 28.037 Energy Change of Air across LAMEE1 108 Start Total Sensible Latent Moisture Sensible Enthalpy/ Point Energy Energy Energy Difference Heat Humidity Ratio Name (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) Inlet 120 −365,991 57,615 −423,606 −595.7 −0.157 N/A 2. Air Condition Leaving LAMEE1 108 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 35.500 24.867 42.4 15.50 0.896 75.384 20.772 1.1336 18.3994 17.303 Energy Chang of Air across LAMEE2 110 Start Total Sensible Latent Moisture Sensible Enthalpy/ Point Energy Energy Energy Difference Heat Humidity Ratio Name (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) LAMEE1 197,590 −81,791 279,381 391.9 −0.414 N/A 3. Air Condition Leaving LAMEE2 110 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu.m) (mm Hg) (g/cu .Math. m) 14,159 30.900 27.425 76.8 21.90 0.891 87.003 26.339 1.1465 25.7358 24.571 4. Air Condition Leaving Recovery Coil 202 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 32.300 27.748 70.9 21.90 0.895 88.467 26.339 1.1413 25.7358 24.458 Energy Chang of Air across Recovery Coil 202 Start Total Total Sensible Latent Moisture Sensible Enthalpy/ Point Heating Energy Energy Energy Difference Heat Humidity Ratio Name (kW) (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) LAMEE2 24.9 24,892 24,892 0 0.0 1.000 N/A 5. Fluid Outlet of LAMEE2 110 Temperature (° C.) 27.400

(57) Referring to the psychometric process diagram of FIG. **3**, the scavenger air, which in this example is outdoor air, enters the cooling system scavenger plenum via a scavenger inlet at a dry bulb temperature of 32.2 degrees Celsius, a wet bulb temperature of 29.4 degrees Celsius and has a relative humidity of 81.6%. After passing through LAMEE**1**, the enthalpy of the scavenger air has been markedly reduced and the scavenger air is at a dry bulb temperature of approximately 35.5

degrees Celsius, a wet bulb temperature of 24.9 degrees Celsius and has a relative humidity of 42.4%. After passing through LAMEE**2**, the scavenger air is at a dry bulb temperature of about 31 degrees Celsius, at a wet bulb temperature of 27.4 degrees Celsius, and has a relatively humidity of 76.8%.

(58) Additionally, the process diagram of FIG. **3** illustrates that as the scavenger air passes through the recovery coil, the air sensibly cools the fluid flowing through the recovery coil and thus the scavenger air humidity ratio remains nearly unchanged, while the dry bulb temperature is increased as the scavenger air is sensibly heated by the fluid being circulated through the recovery coil. Finally, the temperature of the cooling fluid supplied from the outlet of LAMEE**2** in the scavenger plenum to the inlet of LAHX**1** in the process plenum is approximately 27.4 degrees Celsius, which, in this example, is sufficient for LAHX**1** to sensibly cool the process air to a target set-point temperature for the enclosed space of approximately 30 degrees Celsius.

(59) A target temperature of the fluid at the fluid outlet of LAMEE**2 110** may be determined using the target set-point temperature for the enclosed space and the efficiency of LAHX**1 112**. The target set-point temperature for the enclosed space may be a known, constant, which is prescribed by desired conditions in the space. For example, in a data center, the target set-point temperature may be a temperature at or below which the computer, networking, data storage, etc. components in the data center need to be maintained for proper operation. Similarly, the efficiency of LAHX**1 112** will be a value or range that is known and that is prescribed by the particular cooling component employed as LAHX**1 112**. Thus, the temperature of the fluid at the fluid outlet of LAMEE**2 110**, T.sub.LAMEE2_fluid_outlet, can be determined by subtracting a known constant, A, which accounts for the inefficiency of LAHX**1 112**, from the target set-point temperature of the space, T.sub.space, as follows:

$$T\text{.sub.LAMEE2\_fluid\_outlet}=T\text{.sub.space}-A \qquad (1)$$

(60) In the foregoing formula, “A” is sometimes referred to as the approach temperature, i.e. how close the air temperature, T.sub.space, coming out of the coil approaches the inlet water temperature, T.sub.LAMEE2_fluid_outlet. This term can be used at the design stage. However, in operation, the system would typically use a feedback control loop to maintain the leaving air temperature, T.sub.space. The water temperature would be, for example, dynamically modulated to hold T.sub.space at a target value.

(61) Referring again to FIG. **2**, conditioning system **200** includes a liquid desiccant regeneration system, which is fluidically connected to LAMEE**1 108** via second fluid circuit **214**. The liquid desiccant regeneration system can take a number of different specific forms and is generally configured to regenerate diluted desiccant leaving LAMEE**1 108** and, in some cases, to supply the water removed from the desiccant to other components, including, for example, LAMEE**2 110**. Thus, desiccant at a target concentration can be returned to LAMEE**1 108** for use thereby/therein and water removed from the scavenger air by LAMEE**1** can be supplied to a component that employs water to some useful effect(s) like replacing/supplying the water consumed in LAMEE**2 110**.

(62) In general, example liquid desiccant regeneration systems can include thermally driven brine concentration systems. For example, a vacuum membrane distillation system could be employed, a byproduct of which is distilled water. In one example, a vacuum membrane distillation system from memsys GmbH of Germany. Other types of regenerations systems that are electrically or mechanically driven can also be used in examples according to this disclosure.

(63) Liquid desiccant regeneration systems can be employed in any examples in accordance with this disclosure, both to reconstitute a liquid desiccant used in a dehumidifying LAMEE and also to extract water removed from the scavenger air for some useful effect elsewhere in the same or a different system. FIG. **4** depicts another example conditioning system **400**. Conditioning system **400** shares many of the components and functions of example conditioning system **200** of FIG. **2**, and adds pre-cooler **402**, pump **404** and valve **406**, which are incorporated into and interconnected

with the system via first fluid circuit **408**. Thus, example conditioning system **400** includes LAMEE**1 108** to lower the enthalpy/wet bulb temperature of the incoming scavenger air (for example, outdoor air) using a liquid desiccant, pre-cooler **402** to sensibly cool the dehumidified scavenger air from LAMEE**1** before it flows through/by LAMEE**2 110**, LAMEE**2 110** to cool a fluid for use by LAHX**1 112** to directly and sensibly cool the process return air to be supplied back to the enclosed space, and recovery coil **202** to cool the fluid flowing out of LAHX**1 112** before it is returned to the inlet of LAMEE**2**. Conditioning system **400** also includes a liquid desiccant regeneration system, which is configured to regenerate desiccant leaving LAMEE**1 108**, which has been diluted by water from the scavenger air, and, in some cases, to supply the water removed from the desiccant to other components, including, for example, LAMEE**2 110**.
(64) In FIG. **4**, conditioning system **400** includes system cabinet **102**, scavenger plenum **104**, process plenum **106**, LAMEE**1 108**, LAMEE**2 110**, LAHX**1 112**, LAHX**2 114** and recovery coil **202**. Scavenger plenum **104** includes inlet **120** and outlet **122**, and associated and generally collocated with each of inlet **120** and outlet **122** are dampers **124** and **126**, respectively. Process plenum **106** includes inlet **128**, with which is associated and collocated with damper **130**, and outlet **132**, which is associated and collocated with damper **134**. Conditioning system **400** also includes scavenger fan **136**, process fan **138**, system controller **150**, tanks **204** and **208** and associated pumps **206** and **210**, and second fluid circuit **214**.
(65) Pre-cooler **402** of conditioning system **400** is arranged in scavenger plenum **104** between LAMEE**1 108** and LAMEE**2 110**. Pre-cooler **402** can be, for example, a cooling coil that is configured to condition the scavenger air and/or the fluid flowing through the pre-cooler before it enters LAMEE**2 110**. In some examples, a filter (not shown) can be arranged inside scavenger plenum **104** and/or process plenum **106** near the air inlet.
(66) In the example of FIG. **4**, a branch of first fluid circuit **408** can transport water (or another heat transfer fluid) from tank **204** to the inlet of pre-cooler **402**. The cooling fluid flowing through pre-cooler **402** is transported via fluid circuit **408** from the outlet of the pre-cooler to the inlet of LAMEE**2 110** (and, in some cases, mixed with fluid exiting recovery coil **202**).
(67) First fluid circuit **408** of system **400** also includes valve **406**. A branch **408***a* of first fluid circuit **408** transports cooling fluid cooled by recovery coil **202** out of the fluid outlet of the recovery coil to valve **406**. Depending upon the state of valve **406**, the fluid flowing through branch **408***a* either can flow through branch **408***b* to the inlet of LAMEE**2 110** or can flow through branch **408***c* into tank **204**. Branch **408***d* of fluid circuit **408** transports fluid from the outlet of pre-cooler **402** and intermixes with the fluid flowing through branch **408***b* (from valve **406**), before flowing to the inlet of LAMEE**2 110**. Branch **408***e* transports fluid from tank **204** to the fluid inlet of LAHX**1 112** in process plenum **106**. Finally, branch **408***f* transports fluid from the outlet of LAHX**1 112** in process plenum **106** to the inlet of recovery coil **202** in scavenger plenum **104**.
(68) In at least some cases, pre-cooler **402** can be effective when the temperature of the water entering the pre-cooler **402** is lower than the entering air (air leaving LAMEE**1** if this device is operating and not bypassed) dry bulb temperature. Conditioning system **400** can be used in typical summer conditions as well as extreme summer conditions when the outdoor air can be very hot and humid. Pre-cooler **402** can function to depress the scavenger air dry bulb temperature, thus pre-cooling the scavenger air passing through the pre-cooler and heating the water in the pre-cooler **402**. The scavenger air and the water can then pass through LAMEE**2 110**, as described above, in which case evaporation occurs and water (or other fluid) or both the air and water can be cooled to a temperature approaching the wet bulb temperature of the scavenger air leaving the pre-cooler, which is lower than the wet bulb temperature entering the pre-cooler. After passing through LAMEE**2 110**, the scavenger air can then pass through recovery coil **202** and thereby cool the heated fluid received by recovery coil **202** from LAHX**1 112**.
(69) Conditioning system **400** can allow for a plurality of operating modes and selection of the mode can depend, for example, on the outdoor air conditions and a cooling load for the system.

When the outdoor air is relatively cold (for example, at or below a threshold temperature), conditioning system **400** can operate in a first mode, an economizer mode. In this first example mode of operation, LAMEE**1 108**, pre-cooler **402** and LAMEE**2 110** are all deactivated and/or bypassed from air and/or fluid flow. Recovery coil **202** in scavenger plenum **104** and LAHX**1 112** in process plenum **106** are coupled such that the cooling fluid, for example, water circulates through the recovery coil and LAHX**1** in a closed loop.
(70) In a second operating mode, which can also be referred to as an adiabatic mode, the cooling fluid, for example, water continues to travel in a closed loop through recovery coil **202** in scavenger plenum **104** and LAHX**1 112** in process plenum **106**. LAMEE**2 110** is engaged to adiabatically cool the incoming scavenger air before it goes through the recovery coil. In one example employing this or a similar adiabatic mode, water or another heat transfer fluid is pumped through LAMEE**2 110** in a closed circuit, independent of the water or other fluid circuit transporting water among recovery coil **202** and LAHX**1 112**. LAMEE**1 108** and pre-cooler **402** can be deactivated and/or bypassed from air and/or fluid flow in this second example mode of operation. LAMEE**1** may also be actuated to pre-dry the air before it is adiabatically cooled in LAMEE**2**.
(71) In a third operating mode, which can also be referred to as an evaporation mode, the water or other fluid flowing out of the outlet of recovery coil **202** is directed into the fluid inlet of LAMEE**2 110**, for example by activation or deactivation of valve **406**. LAMEE**2 110** cools the water to a set point temperature. The water flowing from the fluid outlet of LAMEE**2 110** is transported to the fluid inlet of LAHX**1 112** (for example, via tank**1 204**). In this mode, LAMEE**2 110**, recovery coil **202** and LAHX**1 112** are all in the process water (or other fluid) circuit, while LAMEE**1 108** and pre-cooler **402** are deactivated and/or bypassed from air and/or fluid flow in this second example mode of operation.
(72) In a fourth operating mode, which can also be referred to as an enhanced or super evaporation mode, LAMEE**1 108** and/or pre-cooler **402** are activated to lower the enthalpy of the scavenger air stream. Pre-cooler **402** may use some of the cold process water in tank**1 204**, or be supplied by another cold water source. In some examples, pre-cooler **402** and LAMEE**1 108** may be staged on separately/sequentially, defining additional modes of operation.
(73) FIG. **5** is a psychometric process diagram for a theoretical system substantially similar to example system **400** of FIG. **4**. The psychometric process diagram illustrates the conditions of the example modeled system and, in particular, conditions of the working fluid(s) thereof at different components of the system and/or at different points during operation. The process diagram depicted in FIG. **5** was created using various numerical, analytical, algorithmic, etc. methods, tools, etc. to estimate the physical characteristics of a system in accordance with this disclosure when operated under certain initial conditions.
(74) The example modeled system is operated at ambient conditions including outdoor air dry bulb temperature of approximately 30.7 degrees Celsius, outdoor air wet bulb temperature of 27.7 degrees Celsius and relative humidity of 80%. Additionally, the altitude of the modeled system is 16 meters, the barometric pressure is approximately 758.56 mm Hg, and the atmospheric pressure is approximately 101.133 kPa. The liquid desiccant employed in LAMEE**1** is a lithium chloride solution with a salt concentration of approximately 32% and a target fluid inlet temperature of 35 degrees Celsius. The target set-point temperature for the process air supplied to the enclosed space from the outlet of the process plenum is 85 degrees Fahrenheit. The characteristic values associated with the process diagram of FIG. **5** are as follows:
(75) TABLE-US-00002 1. Air Condition and Flow Rate at Scavenger Inlet 120 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 30.667 27.722 80.0 22.60 0.893 88.549 26.822 1.1448 26.4790 25.300 2. Air Condition Leaving LAMEE1 108 Air Flow Dry Wet

Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 34.900 26.001 49.8 17.70 0.899 80.410 22.861 1.1322 20.9035 19.692 Energy Change of Air across LAMEE1 108 Start Total Sensible Latent Moisture Sensible Enthalpy/Humidity Point Energy Energy Energy Difference Heat Ratio Name (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) Inlet 120 −138,411 74,706 −213,117 −300.0 −0.540 N/A 3. Air Condition Leaving Pre-cooler 402 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 28.400 24.355 72.0 17.70 0.880 73.664 22.861 1.1566 20.9035 20.116 Energy Chang of Air across Pre-cooler 402 Start Total Total Sensible Latent Moisture Sensible Enthalpy/Humidity Point Cooling Energy Energy Energy Difference Heat Ratio Name (kW) (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) LAMEE1 −114.7 −114,711 −114,711 0 0.0 1.000 N/A 4. Air Condition Leaving LAMEE2 110 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 29.300 27.190 85.1 22.20 0.889 86.098 26.533 1.1502 26.0326 24.980 Energy Chang of Air across LAMEE2 110 Start Total Sensible Latent Moisture Sensible Enthalpy/Humidity Point Energy Energy Energy Difference Heat Ratio Name (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) Pre-cooler 211,440 16,011 195,429 275.6 0.076 N/A 5. Air Condition Leaving Recovery Coil 202 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/kg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 35.500 28.600 60.0 22.20 0.907 92.583 26.533 1.1271 26.0326 24.479 Energy Chang of Air across Recovery Coil 202 Start Total Total Sensible Latent Moisture Sensible Enthalpy/Humidity Point Heating Energy Energy Energy Difference Heat Ratio Name (kW) (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) LAMEE2 110.3 110,298 110,298 0 0.0 1.000 N/A 6. Fluid Outlet of LAMEE2 110 Temperature (° C.) 26.600

(76) Referring to the psychometric process diagram of FIG. **5**, the scavenger air, which in this example is outdoor air, enters the conditioning system scavenger plenum via a scavenger inlet at a dry bulb temperature of 30.7 degrees Celsius, a wet bulb temperature of 27.7 degrees Celsius and has a relative humidity of 80%. After passing through LAMEE**1**, the enthalpy of the scavenger air has been markedly reduced and the scavenger air is at a dry bulb temperature of approximately 34.9 degrees Celsius, a wet bulb temperature of 26 degrees Celsius and has a relative humidity of 49.8%. After passing through the pre-cooler, the scavenger air has a dry bulb temperature of 28.4 degrees Celsius, a wet bulb temperature of 24.4 degrees Celsius and a relative humidity of 72%. After passing through LAMEE**2**, the scavenger air is at a dry bulb temperature of about 29.3 degrees Celsius, at a wet bulb temperature of 27.2 degrees Celsius, and has a relatively humidity of 85.1%.

(77) Additionally, the process diagram of FIG. **5** illustrates that as the scavenger air passes through the recovery coil, the air sensibly cools the fluid flowing through the recovery coil and thus the scavenger air temperature is increased as the scavenger air is heated by the fluid being circulated through the recovery coil. Finally, the temperature of the cooling fluid supplied from the outlet of LAMEE**2** in the scavenger plenum to the inlet of LAHX**1** in the process plenum is approximately 26.6 degrees Celsius, which, in this example, is sufficient for LAHX**1** to directly and sensibly cool the process air to a target set-point temperature for the enclosed space of approximately 30 degrees Celsius.

(78) FIG. **6** is a psychometric process diagram for a theoretical system with the same components and arrangements thereof as the system modeled to produce the process diagram of FIG. **5**, except the pre-cooler and the recovery coil have lower capacities/conditioning effectiveness. The

psychometric process diagram of FIG. **6** illustrates the conditions of the example modeled system and, in particular, conditions of the working fluid(s) thereof at different components of the system and/or at different points during operation. The process diagram depicted in FIG. **6** was created using various numerical, analytical, algorithmic, etc. methods, tools, etc. to estimate the physical characteristics of a system in accordance with this disclosure when operated under certain initial conditions.

(79) The example modeled system is operated at ambient conditions including outdoor air dry bulb temperature of approximately 32.2 degrees Celsius, outdoor air wet bulb temperature of 29.4 degrees Celsius and relative humidity of 81.5%. Additionally, the altitude of the modeled system is 16 meters, the barometric pressure is approximately 758.56 mm Hg, and the atmospheric pressure is approximately 101.133 kPa. The liquid desiccant employed in LAMEE**1** is a lithium chloride solution with a salt concentration of approximately 38% and a target fluid inlet temperature of approximately 33.9 degrees Celsius. The target set-point temperature for the process air supplied to the enclosed space from the outlet of the process plenum is approximately 28.7 degrees Celsius. The characteristic values associated with the process diagram of FIG. **6** are as follows:

(80) TABLE-US-00003 1. Air Condition and Flow Rate at Scavenger Inlet 120 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) Bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/jg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 32.200 29.400 81.5 25.20 0.901 96.814 28.617 1.1373 29.4044 27.957 2. Air Condition Leaving LAMEE1 108 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) Bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/jg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14.159 35.500 24.843 42.3 15.50 0.897 75.385 20.744 1.1315 18.3679 17.270 Energy Change of Air across LAMEE1 108 Start Total Sensible Energy Moisture Sensible Enthalpy/ Point Energy Energy (W) Difference Heat Humidity Ratio Name (W) (W) Latent (kg/hr) Ratio (kJ/kg/g/kg) Inlet 120 −364,416 58,008 −422,424 −594.0 −0.159 N/A 3. Air Condition Leaving Pre-cooler 402 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) Bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/jg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 28.600 23.009 62.5 15.50 0.877 68.253 20.744 1.1574 18.3679 17.665 Energy Change of Air across Pre-cooler 402 Start Total Total Sensible Latent Moisture Sensible Enthalpy/ Point Cooling Energy Energy Energy Difference Heat Humidity Ratio Name (kW) (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) LAMEE1 −121.3 −121,290 121,290 0 0.0 1.000 N/A 4. Air Condition Leaving LAMEE2 110 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) Bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/jg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 28.700 26.210 82.3 20.70 0.885 81.638 25.389 1.1535 24.3278 23.393 Energy Change of Air across LAMEE2 110 Start Total Sensible Energy Moisture Sensible Enthalpy/ Point Energy Energy Latent Difference Heat Humidity Ratio Name (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) Pre- 227,637 1,774 225,863 318.4 0.008 N/A cooler 5. Air Condition Leaving Recovery Coil 202 Air Flow Dry Wet Relative Humidity Specific Dew Density Vapor Absolute (Standard) Bulb Bulb Humidity Ratio Volume Enthalpy Point (kg/ Pressure Humidity (L/s) (° C.) (° C.) (%) (g/kg) (cu .Math. m/kg) (kJ/jg) (° C.) cu .Math. m) (mm Hg) (g/cu .Math. m) 14,159 35.500 27.812 56.1 20.70 0.905 88.733 25.389 1.1281 24.3278 22.878 Energy Change of Air across Recovery Coil 202 Start Total Total Sensible Latent Moisture Sensible Enthalpy/ Point Heating Energy Energy Energy Difference Heat Humidity Ratio Name (kW) (W) (W) (W) (kg/hr) Ratio (kJ/kg/g/kg) LAMEE2 120.6 120,650 120,650 0 0.0 1.000 N/A 6. Fluid Outlet of LAMEE2 110 Temperature (° C.) 25.700

(81) Referring to the psychometric process diagram of FIG. **6**, the scavenger air, which in this example is outdoor air, enters the conditioning system scavenger plenum via a scavenger inlet at a

dry bulb temperature of 32.2 degrees Celsius, a wet bulb temperature of 29.4 degrees Celsius and has a relative humidity of 81.5%. After passing through LAMEE**1**, the enthalpy of the scavenger air has been markedly reduced and the scavenger air is at a dry bulb temperature of approximately 35.5 degrees Celsius, a wet bulb temperature of 24.8 degrees Celsius and has a relative humidity of 42.3%. After passing through the pre-cooler, the scavenger air has a dry bulb temperature of 28.6 degrees Celsius, a wet bulb temperature of approximately 23 degrees Celsius and a relative humidity of 62.5%. After passing through LAMEE**2**, the scavenger air is at a dry bulb temperature of about 28.7 degrees Celsius, at a wet bulb temperature of 26.2 degrees Celsius, and has a relatively humidity of 82.3%.
(82) Additionally, the process diagram of FIG. **6** illustrates that as the scavenger air passes through the recovery coil, the air sensibly cools the fluid flowing through the recovery coil and thus the scavenger air temperature is increased as the scavenger air is heated by the fluid being circulated through the recovery coil. Finally, the temperature of the cooling fluid supplied from the outlet of LAMEE**2** in the scavenger plenum to the inlet of LAHX**1** in the process plenum is approximately 25.7 degrees Celsius, which, in this example, is sufficient for LAHX**1** to directly and sensibly cool the process air to a target set-point temperature for the enclosed space of approximately 28.7 degrees Celsius.
(83) Referring again to FIG. **4**, conditioning system **400** includes a liquid desiccant regeneration system, which is fluidically connected to LAMEE**1 108** via second fluid circuit **214**. The liquid desiccant regeneration system can take a number of different specific forms and is generally configured to regenerate diluted desiccant leaving LAMEE**1 108** and, in some cases, to supply the water removed from the desiccant to other components, including, for example, LAMEE**2 110**. Thus, desiccant at a target concentration can be returned to LAMEE**1 108** for use thereby/therein and water removed from the scavenger air by LAMEE**1** can be supplied to a component that employs water to some useful effect(s) like replacing/supplying the water consumed in LAMEE**2 110**.
(84) In general, example liquid desiccant regeneration systems can include thermally driven brine concentration systems. For example, a vacuum membrane distillation system could be employed, a byproduct of which is distilled water. In one example, a vacuum membrane distillation system from memsys GmbH of Germany. Liquid desiccant regeneration systems can be employed in any examples in accordance with this disclosure, both to reconstitute a liquid desiccant used in a dehumidifying LAMEE and also to extract water removed from the scavenger air for some useful effect elsewhere in the same or a different system.
(85) FIG. **7** depicts an example liquid desiccant regeneration system connected to a conditioning system in accordance with this disclosure. The regeneration system including a desiccant regenerator **700** is fluidically coupled to LAMEE**1 108** and LAMEE**2 110**. The system of FIG. **7** can thus be employed with and generally connected to any example conditioning systems in accordance with this disclosure, including the examples of FIGS. **1**, **2**, **4** and **9-13**.
(86) Regenerator **700** is generally configured to modulate and maintain the liquid desiccant flowing through LAMEE**1** at a target relative concentration (for example, water to salt), including, for example, delivering a lithium chloride liquid desiccant to the fluid inlet of LAMEE**1** at a concentration in a range from approximately 32% lithium chloride to approximately 38% lithium chloride. Additionally, regenerator **700** can extract water from the diluted desiccant flowing out of LAMEE**1** and supply this water to LAMEE**2**. As noted above, the water collection rate/capacity of dryer LAMEE**1** in examples according to this disclosure may exceed the evaporation rate of the evaporative cooler LAMEE**2**. As such, in at least some examples and operating conditions, the water removed from the scavenger air by LAMEE**1** (in addition to markedly reducing the enthalpy of the scavenger air and thereby boosting the cooling capacity of LAMEE**2**) can be collected in quantities sufficient to completely supply the fluid necessary to drive operation of LAMEE**2**.
(87) FIG. **7** depicts a portion of an example conditioning system including LAMEE**1 108** and

LAMEE**2 110** disposed in scavenger plenum **104**. The fluid tanks **204** and **208** and associated pumps are fluidically interconnected with LAMEE**1 108** and LAMEE**2 110** and regenerator **700** by one or more fluid circuits, including, for example, first and second fluid circuits **702** and **704**. As explained above, LAMEE**1 108** is configured to remove water from the scavenger air flowing through scavenger plenum **104**. The water extracted from the scavenger air by LAMEE**1 108** dilutes the liquid desiccant flowing through LAMEE**1**. In the example of FIG. **7**, The diluted desiccant flows out of the fluid outlet of LAMEE**1 108** and into tank **208**, where the diluted desiccant intermixes with concentrated desiccant supplied by regenerator **700** and from which liquid desiccant flows to the fluid inlet of LAMEE**1 108** and flows into regenerator **700** via modulating transfer valve **706**.
(88) In this example, valve **706** can be controlled to modulate the flow rate of desiccant out of tank **208** and thereby divert an amount of desiccant to regenerator **700** necessary to maintain the intermixed desiccant in tank **208** at a target or within a threshold range of desiccant concentration, including, for example, maintaining the desiccant in tank **208** at a concentration in a range from approximately 32% lithium chloride to approximately 38% lithium chloride. In one example, transfer valve **706** is controlled to deliver approximately 250 gallons per minute (gpm) to the fluid inlet of LAMEE**1 108** and to deliver approximately 12 gpm to regenerator **700**. As the humidity of the scavenger air flowing into LAMEE**1 108** rises, the amount of desiccant diverted into regenerator **700** can be increased by controlling transfer valve **706**. In some examples, transfer valve **706** can be controlled by system controller **150** described with reference to the examples of FIGS. **1**, **2** and **4**.
(89) The dehumidification capacity of LAMEE**1 108** can depend on a flow rate, a temperature, and a concentration of the liquid desiccant passing there through. In some cases, an example conditioning system in accordance with this disclosure can operate with a set point temperature and a set point concentration of the liquid desiccant flowing into LAMEE**1 108**. Additionally, in some examples, the flow rate of the desiccant through LAMEE**1 108** can be constant. The load on the LAMEE**1 108** can vary as the conditions of the air stream passing through scavenger plenum **104** vary. For example, if the air stream increases in humidity, the load on the LAMEE**1 108** can increase. As a result, the liquid desiccant exiting LAMEE**1 108** can require more regeneration, relative to if LAMEE**1** receives a relatively lower humidity air stream. The regeneration system can therefore be configured such that as additional regeneration of the desiccant is required, the flow rate of liquid desiccant to regenerator **700** can be increased via the modulating valve **706**. To achieve selective modulation of desiccant flow rate and concentration, for example intermixed in tank**2 208**, the regeneration system can be configured such that the flow of liquid desiccant to the LAHX**2 114** can be relatively constant and the flow of liquid desiccant through the modulating valve **706** can be variable.
(90) Regenerator **700** can be a thermally driven brine concentration device/system. In one example, regenerator **700** is a vacuum multi-effect membrane distillation device, which is configured to employ heat to distill the desiccant solution flowing there through. In one example, regenerator **700** can distill 3 liters of water per kW hr of heat input at approximately 80 degrees Celsius. It may be possible, in some cases, to use heat removed from the enclosed space to drive regenerator **700**, including, for example, using heat removed from servers and other equipment in a data center to drive the regenerator. However, the heat input requirements to distill the liquid desiccant may be greater than can be typically removed from such equipment in a data center and, as such, in some cases, an additional heat/energy source may be needed to drive distillation of the desiccant by regenerator **700**. Regenerator **700** can also include other types of devices, including, for example, electro dialysis, reverse osmosis (RO) filtration, a gas boiler with condenser, a vacuum assisted, multi-stage flash, or other membrane distillation devices other than a vacuum multi-effect membrane distillation device.
(91) In operation, the desiccant exiting tank **208** can be transported to regenerator **700** via second

fluid circuit **704**. Regenerator **700** can separate water from the desiccant such that a concentrated desiccant supply can be transported back to tank **208** via second fluid circuit **704** and a supply of distilled water can be transported from regenerator to various components/locations via first fluid circuit **702**.
(92) In one example, the distilled water can be transported to tank **204** for evaporative cooler LAMEE**2 110**. Thus the water in the air stream passing through scavenger plenum **104** can be absorbed by the desiccant in the desiccant dryer LAMEE**1 108**, separated from the desiccant in regenerator **700**, and then used as the cooling fluid for the evaporative cooler LAMEEs **110**. This can result in a significant reduction or elimination of water for operation of an evaporative cooler LAMEE or other type of evaporative cooler.
(93) As described above, one feature of example conditioning systems in accordance with this disclosure is the ability to sensibly cool the liquid desiccant employed in LAMEE**1 108** using only outdoor air. FIG. **8** depicts an example LAHX **800** that cools the liquid desiccant employed in LAMEE**1 108**. LAHX **800** is fluidically connected to LAMEE**1 108** by a fluid circuit **802** in a manner similar to LAHX**2 114** of the examples of FIGS. **1**, **2**, **4** and **9-13**.
(94) As described above with reference to FIG. **7**, after the liquid desiccant exits the LAMEE**1 108**, the liquid desiccant can be discharged into a tank **208**, onto the regeneration system and from the regeneration system to LAHX **800**. LAHX **800** can be configured to reduce a temperature of the desiccant prior to passing the desiccant into LAMEE**1 108**. LAHX **800** and regenerator **700**, in combination, can thus decrease a temperature and increase a concentration of the liquid desiccant prior to circulating the desiccant through the desiccant dryer LAMEE**1 108** in scavenger plenum **104**. Both capabilities can be important in order for the desiccant to effectively remove moisture from the air stream passing through LAMEE**1 108**.
(95) LAHX **800** can include any type of device suitable for cooling the liquid desiccant. In one example, LAHX **800** is configured to cool the liquid desiccant employed in LAMEE**1 108** using outdoor air only. In one example, LAHX **800** is a polymer fluid cooler (with or without evaporative cooling capability), a plate exchanger, or other suitable heat exchangers. As schematically depicted, LAHX **800** can be located external to and separate from scavenger plenum **104** and/or other components of the conditioning system. In another example, however, LAHX **800** could be collocated in a common cabinet with other components of the system and outdoor air could be ducted through the LAHX.
(96) The design of example regeneration systems in combination with desiccant dryer LAMEE**1 108** can facilitate operation of conditioning systems in accordance with this disclosure with little to no external water consumption. LAMEE**1 108** can remove the water from the air stream and use that water (which is separated from the desiccant for regeneration of the desiccant) as the cooling fluid for one or more coolers in the conditioning system. The recovered water can be stored in a tank and can be used as needed. Operation of evaporative coolers, like LAMEE**2 110**, can commonly require a significant amount of water. Example conditioning systems having such desiccant regeneration/water extraction can eliminate or markedly decrease the external water needed to operate the system, which, in turn, can decrease costs, complexity, and externalities of the system.
(97) The design of example regeneration systems in combination with desiccant dryer LAMEE**1 108** can also improve operation of evaporative cooler LAMEE**2 110** (or other evaporative cooling device) since water can be collected directly from the atmosphere. Such water recovered from the liquid desiccant in the regenerator is often considered relatively high quality water, which can be ideal for many cooling applications, including evaporative coolers. Such high quality water can increase the lifespan of the media in LAMEE**2 110** and can decrease required maintenance on the cooler. In contrast, if the water supplied to the LAMEE**2 110** is potable water from wells or surface water sources, in some cases, mineral build up or scaling can occur, which may require the conditioning system or portions thereof to include management of mineral concentrations or other

water treatment units.

(98) FIGS. **9** and **10** depict two other example conditioning systems **900** and **1000**. Conditioning systems **900** and **1000** share many of the components and functions of example conditioning systems **100**, **200** and **400** of FIGS. **1**, **2** and **4**, and each adds a mechanical cooling system to the fluid circuit to provide cooling to the water (or other fluid) stored in tank **204**. The mechanical cooling system included in conditioning system **900** of FIG. **9** includes a water-cooled condenser, while the mechanical cooling system included in conditioning system **1000** of FIG. **10** includes an air-cooled condenser.

(99) In FIG. **9**, conditioning system **900** includes system cabinet **102**, scavenger plenum **104**, process plenum **106**, LAMEE**1 108**, pre-cooler **402**, LAMEE**2 110**, recovery coil **202**, LAHX**1 112**, LAHX**2 114**, and DX unit **902**. Scavenger plenum **104** includes inlet **120** and outlet **122** and associated and generally collocated dampers **124** and **126**, respectively. Process plenum **106** includes inlet **128**, with which is associated and collocated damper **130**, and outlet **132**, which is associated and collocated damper **134**. Conditioning system **900** also includes scavenger fan **136**, process fan **138**, valve **406**, system controller **150** and tanks **204** and **208**. Pumps to facilitate transport of cooling fluid through system **900** have been omitted from FIG. **9**, but the appropriate number and arrangement of such pumps could be included in this and other conditioning systems in accordance with this disclosure.

(100) In FIG. **9**, conditioning system **900** includes DX or direct expansion unit **902**. A conditioning system having pre-cooler **402**, as shown in FIG. **9**, in combination with a DX unit **902** can be used, for example, in extreme outdoor air conditions. If the temperature in tank **204** is higher than a target set point temperature (to cover 100% of the load), DX unit **902** can cool the water to the target set point temperature. Thus, DX unit **902** can provide additional cooling of the water (or other fluid) leaving tank **204** so that the water can be sufficiently cool to cover the heating/cooling load for the enclosed space.

(101) DX unit **902** includes evaporator **904**, compressor **906**, condenser **908** and expansion valve **910**. DX unit **902** is configured to cool the water in tank **204** using, for example, a condensed refrigerant liquid. In operation, DX unit **902** cools the water or other fluid in tank **204** by passing the condensed refrigerant through one side of a first heat exchanger, evaporator **904**, which cools the water flowing through the other side of evaporator **904**. In evaporator **904**, the refrigerant expands as it absorbs heat, eventually converting to a gas. DX unit **902** then pumps the refrigerant to compressor **906**, which compresses the gas refrigerant and passes it through another heat exchanger, condenser **908**. The heat that is absorbed by the refrigerant can be exhausted, and the cooled, compressed refrigerant is once again in liquid form. DX unit **902** then pumps (or otherwise transports) the cooled refrigerant liquid back to evaporator **904** through expansion valve **910** and the cycle begins again.

(102) In the example of FIG. **9**, condenser **908** is a water-cooled condenser. Condenser **908** is a heat exchanger through which flows the refrigerant of DX unit **902** and the water (or other fluid) of LAMEE**2 110**. The water is cooled in LAMEE**2 110**, as described with reference to other examples. The cooled water from LAMEE**2 110** is transported by the fluid circuit of conditioning system **900** to and flows through condenser **908**. The cooled water cools the compressed refrigerant flowing through the other side of compressor **908** and the cooled refrigerant flows back to evaporator **904** through expansion valve **910**. The water exiting condenser **908** is conveyed to the inlet of LAMEE**2 110**, for example, after mixing with water from pre-cooler **402**, which is also conveyed to the inlet of the LAMEE**2 110**.

(103) As with at least some other examples in accordance with this disclosure, conditioning system **900** can be operated in multiple modes depending upon various factors, including the heat load from the enclosed space and/or the outdoor air (or incoming scavenger air) conditions. For example, system controller **150** can be configured to control elements of system **900** (and other example systems in accordance with this disclosure) to operate differently in different modes.

System controller **150** can be configured to operate system **900** in an economizer mode and evaporation mode, as well as other modes. In the economizer mode, generally, there is sufficient cooling capacity in the outdoor air entering the system that LAMEE**2 110** (or pre-cooler **402** with a slightly modified fluid circuit) can cool the water or other fluid with the scavenger air without cooling by LAMEE**1 108** being required. In the evaporation mode, for example, pre-cooler **402**, LAMEE**1 108**, LAMEE**2 110** and recovery coil **202** may all be activated and used to cool the water flowing through the system using the scavenger air passing through scavenger plenum **104**.
(104) In one example, system controller **150** is configured to cause conditioning system **900** to operate in the evaporation mode. In this mode, for example, outdoor scavenger air is drawn into and through scavenger plenum **104** by fan **136**. The outdoor air passes through LAMEE**1 108**, by which the enthalpy of the outdoor/scavenger air is reduced. The outdoor air passes through and is cooled by pre-cooler **402** using fluid delivered to the inlet of the pre-cooler by a fluid circuit from tank**1 204**. The cooled outdoor air then flows through and evaporatively cools the fluid flowing through LAMEE**2 110**. The cooling fluid is delivered to LAMEE**2 110** by the fluid circuit from the outlet of water-side of condenser **908** and from the outlet of pre-cooler **402**. The scavenger air passes LAMEE**2 110** and flows through recovery coil **202**. Recovery coil **202** receives fluid from the outlet of LAHX**1 112** and the scavenger air cools the heated fluid received from LAHX**1**. Fan **136** then exhausts the scavenger air out of outlet **122** of scavenger plenum **104**.
(105) The water or other evaporative cooling fluid cooled by LAMEE**2 110** is transported by the fluid circuit to tank**1 204**, which stores the water. As described above, DX unit **902** can be activated to cool the water or other fluid stored in tank**1 204** to keep the fluid at a target set point temperature. From tank**1 204**, the water is transported to the inlet of pre-cooler **402** and to the inlet of the water-side of evaporator **904**. The water is transported from the outlet of the water-side of evaporator **904** to LAHX**1 112**. LAHX**1 112** cools the heated process air returned to process plenum **106** from the enclosed space using the water cooled by LAMEE**2 110** and DX unit **902**.
(106) Still in the evaporation mode, the water flows from the outlet of LAHX**1 112** in process plenum **106** to the inlet of recovery coil **202** in scavenger plenum **104**. System controller **150** can, in the evaporation mode, activate or not activate valve **406** (depending upon the default state of the valve) to cause the water from the outlet of recovery coil **202** to flow into the water-side of condenser **908**. The water exits condenser **908** and returns to the inlet of LAMEE**2 110**.
(107) System controller **150** can also be configured to cause conditioning system **900** to operate in the economizer mode. For example, in the economizer mode, system controller **150** can cause pre-cooler **402**, LAMEE**1 108** and, in some cases, DX unit **902** to be deactivated and/or cause the scavenger air to bypass the pre-cooler **402** and the LAMEE**1 108**. In this mode, LAMEE**2 110** cools the water using the scavenger air and transports the water to LAHX**1 112** via valve **406**, tank**1 204**, and the water-side of evaporator **904**.
(108) FIG. **10** depicts another example conditioning system **1000**. The primary substantive difference between conditioning system **900** of FIG. **9** and conditioning system **1000** of FIG. **10** is that DX unit **902** of conditioning system **900** includes a water-cooled condenser **908**, while DX unit **1002** of conditioning system **1000** includes an air-cooled condenser **1008**. DX unit **1002** can be employed in system **1000** to maintain cooling fluid stored in tank **204** at a target set point temperature.
(109) In FIG. **10**, DX unit **1002** includes evaporator **1004**, compressor **1006**, air-cooled condenser **1008**, and expansion valve **1010**. Air-cooled condenser **1008** is arranged in scavenger plenum **104** downstream of recovery coil **202** and, in some examples, downstream of fan **136**, close to outlet **122** of scavenger plenum **104**. Compressed refrigerant is transported by the fluid circuit of DX unit **1002** from compressor **1006** to condenser **1008**. The scavenger air flowing through scavenger plenum **104** passes through and cools the refrigerant flowing through condenser **1008**.
(110) Although the condenser **1008** is shown inside the plenum **104** in FIG. **10**, the condenser **1008** can be located outside of the plenum **104** and outside of the cabinet **102**. The condenser **1008** can

be located external to the cabinet **102** and can be used, for example, in climates typically having mild outdoor air conditions. Condenser **1008** can use outdoor air, which in some cases can be at a lower temperature than scavenger air passing through the condenser in plenum **104** as shown in FIG. **10**. If condenser **1008** is located external to cabinet **102**, it is recognized that additional components may be included with the condenser, for example, one or more fans.

(111) Conditioning systems **900** and **1000** can include multiple cooling fluids and associated cooling fluid circuits. For example, the refrigerant flowing through DX unit **1002** can be a first cooling fluid and the conduits and other components for conveying the refrigerant can be a first or a first portion of a fluid circuit. The second cooling fluid flowing through pre-cooler **402**, LAMEE**2** **110**, LAHX**1** **112** and recovery coil **202** can be water or predominantly water. A separate or a portion of a larger fluid cooling circuit (for example, conduits, valves, pumps, filters, etcetera) can be employed to transport the water among the various components in conditioning systems **900** and **1000**. The two cooling fluid circuits or two portions of one circuit can be fluidically isolated from one another such that the first and second cooling fluids do not intermix.

(112) FIG. **11** depicts another example conditioning system **1100**. Conditioning system **1100** shares many of the components and functions of example conditioning systems **900** and **1000** of FIGS. **9** and **10**, except that system **1100** employs a mechanical cooling system **1102** to supplement cooling of the process air flowing through process plenum **106**. Mechanical cooling system **1102** includes an air-cooled condenser **1108**, but, in another example, a water-cooled condenser could be employed in conditioning system **1100**.

(113) Mechanical cooling of the process air can function to provide needed cooling in certain outdoor or other conditions. Additionally, if the water cooling system or components thereof, for example, pre-cooler **402**, LAMEE**2** **110**, LAHX**1** **112**, and/or recovery coil **202**, malfunction or go offline for some reason, mechanical cooling system **1102** may be employed to provide some or all the required cooling of the heated process air received from the enclosed space to the target supply air temperature.

(114) In FIG. **11**, conditioning system **1100** includes system cabinet **102**, scavenger plenum **104**, process plenum **106**, LAMEE**1** **108**, pre-cooler **402**, LAMEE**2** **110**, recovery coil **202**, LAHX**1** **112**, LAHX**2** **114**, and mechanical cooling system **1102**. Scavenger plenum **104** includes inlet **120** and outlet **122** and associated and generally collocated dampers **122** and **124**, respectively. Process plenum **106** includes inlet **128**, with which is associated and collocated damper **130**, and outlet **132**, which is associated and collocated damper **134**. Conditioning system **1100** also includes scavenger fan **136**, process fan **138**, valve **406**, system controller **150** and tank**1** **204** and tank**2** **208**. Pumps to facilitate transport of cooling fluid through system **1100** have been omitted from FIG. **11**, but the appropriate number and arrangement of such pumps could be included in this and other conditioning systems in accordance with this disclosure.

(115) Conditioning system **1100** includes DX unit **1102** (or some other similar mechanical cooling system). DX unit **1102** includes DX coil **1104**, compressor **1106**, condenser **1108** and expansion valve **1110**. DX coil **1104** is arranged downstream of LAHX**1** **110** in process plenum **106**. DX unit **1102** is configured to cool the process air flowing through process plenum **106** using, for example, a condensed refrigerant liquid. In operation, DX unit **1102** cools the process air by passing the condensed refrigerant through the coil, which cools the process air and causes the refrigerant to expand as it absorbs heat, eventually converting to a gas. DX unit **1102** then pumps the refrigerant to compressor **1106**, which compresses the gas refrigerant and passes it through another heat exchanger, condenser **1108** arranged in scavenger plenum **104**. The scavenger air cools the refrigerant flowing through condenser **1108**, after which the cooled, compressed refrigerant is once again in liquid form. DX unit **1102** then pumps (or otherwise transports) the cooled refrigerant liquid back to DX coil **1104** through expansion valve **1110** and the cycle begins again.

(116) As with at least some other examples in accordance with this disclosure, conditioning system **1100** can be operated in multiple modes depending upon various factors, including the heat load

from the enclosed space and/or the outdoor air (or incoming scavenger air) conditions. For example, system controller **150** can be configured to control elements of system **1100** (and other example systems in accordance with this disclosure) to operate differently in different modes. System controller **150** can be configured to operate system **1100** in an economizer mode and evaporation mode, as well as other modes. For example, in the economizer mode, generally, there is sufficient cooling capacity in the outdoor air entering the system that LAMEE**2 110** can cool the water or other fluid with the scavenger air without conditioning by LAMEE**1 108** being required. In this mode, for example, system controller **150** can cause LAMEE**1 108**, pre-cooler **402**, and, in some cases, DX unit **1102** to be deactivated and/or cause the scavenger air to bypass the pre-cooler and LAMEE**1**. In this mode, as described with reference to other examples in accordance with this disclosure, LAMEE**2 110** cools the water using the scavenger air and transports the water to LAHX**1 112** via valve **406** and tank **204**. In the evaporation mode, for example, LAMEE**1 108**, pre-cooler **402**, LAMEE**2 110** and recovery coil **202** may all be activated and used to cool the water (or other heat transfer fluid) flowing to and employed by LAHX**1 112** to cool the process air. Additionally, in an evaporation plus DX mode, DX unit **1102** may be activated and used to provide supplemental cooling to the process air cooled by LAHX**1 112**.

(117) In one example, system controller **150** is configured to cause conditioning system **1100** to operate in the evaporation mode. In this mode, for example, outdoor scavenger air is drawn into and through scavenger plenum **104** by fan **136**. The outdoor air passes through LAMEE**1 108**, by which the enthalpy of the outdoor/scavenger air is reduced. The outdoor air then passes through and is cooled by pre-cooler **402** using fluid delivered to the inlet of the pre-cooler by a fluid circuit from tank**1 204**. The cooled outdoor air then flows through and evaporatively cools the fluid flowing through LAMEE**2 110**. The scavenger air passes LAMEE**2 110** and flows through recovery coil **202**. Recovery coil **202** receives fluid from the outlet of LAHX**1 112** and the scavenger air cools the heated fluid received from LAHX**1 112**. Fan **136** then exhausts the scavenger air out of outlet **122** of scavenger plenum **104**.

(118) The water or other evaporative cooling fluid cooled by LAMEE**1 108** is transported by the fluid circuit to tank**1 204**, which stores the water. From tank**1 204**, the water is transported to the inlet of pre-cooler **402** and to the inlet of LAHX**1 112**. LAHX**1 112** directly and sensibly cools the heated process air returned to process plenum **106** from the enclosed space using the water cooled by LAMEE**2 110**.

(119) Still in the evaporation mode, the water flows from the outlet of LAHX**1 112** in process plenum **106** to the inlet of recovery coil **202** in scavenger plenum **104**. System controller **150** can, in the evaporation mode, activate or not activate valve **406** (depending upon the default state of the valve) to cause the water from the outlet of recovery coil **202** to flow into tank **204**.

(120) In the evaporation plus DX mode, system controller **150** activates DX unit **1102**. In this mode, LAHX**1 112** cools the process air using the cooled water or other fluid from tank **204**. Additionally, the process air passes LAHX**1 112** and is cooled further by DX coil **1104** arranged in process plenum **106** downstream of LAHX**1 112**. In this case, DX coil **1104** may cool the process air to the target supply temperature before the air is supplied to the enclosed space.

(121) System controller **150** can also be configured to cause conditioning system **1100** to operate in the economizer mode. For example, in the economizer mode, system controller **150** can cause LAMEE**1 108**, pre-cooler **402**, and, in some cases, DX unit **1102** to be deactivated and/or cause the scavenger air to bypass the pre-cooler and LAMEE**1**. In this mode, as described with reference to other examples in accordance with this disclosure, LAMEE**2 110** cools the water using the scavenger air and transports the water to LAHX**1 112** via valve **406** and tank **204**.

(122) FIG. **12** depicts another example conditioning system **1200** including a liquid-to-liquid heat exchanger (LLHX) **1202**. Conditioning system **1200** has many components and functions in common with the above-described examples. For example, in FIG. **12**, conditioning system **1200** includes system cabinet **102**, scavenger plenum **104**, process plenum **106**, LAMEE**1 108**, LAMEE**2**

110, LAHX**1 112** and LAHX**2 114**. Scavenger plenum **104** includes inlet **120**, outlet **122** and associated and generally collocated therewith are dampers **124** and **126**, respectively. Process plenum **106** includes inlet **128**, with which is associated and collocated damper **130**, and outlet **132**, which is associated and collocated damper **134**. Conditioning system **1200** also includes scavenger fan **136**, process fan **138**, system controller **150** and tanks **204** and **208**. Pumps to facilitate transport of cooling fluids through system **1200** have been omitted from FIG. **12**, but the appropriate number and arrangement of such pumps could be included in this and other conditioning systems in accordance with this disclosure.

(123) In the example of FIG. **12**, conditioning system LLHX **1202**, which is configured and arranged to use the water or other first cooling fluid coming from LAMEE**2 110**, via a first fluid circuit **1204** and tank**1 204**, to cool a second cooling fluid flowing through the LLHX **1202**, LAHX**1 112** and recovery coil **202** via second fluid circuit **1206**. Employing LLHX **1202** in conditioning system **1200** can have a number of advantages, including, for example, reducing the risk of freezing in the fluid circuit **1206** in a winter/economizer mode, because the second cooling fluid can be glycol or another fluid with anti-freeze properties.

(124) Water cooled by LAMEE**2 110** is transported via fluid circuit **1204** from the outlet of LAMEE**2** to tank**1 204**. The cooled water leaves tank **204** and enters the first side of LLHX **1202** (for example, the water side of the LLHX). The second fluid can enter the LLHX **1202** through an input line of fluid circuit **1206** and exit and be transported via another portion of circuit **1206** to LAHX**1 112**. The coolant can be any suitable heat transfer fluid, and, in some cases, can include anti-freeze to minimize the risk of the coolant freezing in the winter. The cooled water flowing through the water side of LLHX **1202** cools the second cooling fluid flowing through the second side of the LLHX. The cooled second cooling fluid is then transported to LAHX**1 112**, which uses the second cooling fluid to cool the heated process air received in process plenum **106** from the enclosed space. LAHX**1 112**, as described with other examples, can be configured to cool the process air to a target supply air temperature.

(125) After being used to cool the process air, the higher-temperature (also referred to as heated) coolant can be transported via fluid circuit **1206** from an outlet of LAHX **112** in process plenum **106** to the inlet of recovery coil **202** in scavenger plenum **104**. The scavenger air flowing through scavenger plenum **106** cools the heated second cooling fluid, after which the second cooling fluid recirculates back to the second side of LLHX **1202**.

(126) LLHX **1202** can be located physically in system cabinet **102**, but outside of plenums **104** and **106**. In some examples, LLHX **1202** may be located in either scavenger plenum **104** or process plenum **106**. Additionally, LLHX **1202** can be located separate from system cabinet **102** and plenums **104** and **106**, in which case pumps or other mechanisms may be employed to transport cooling fluids among the LLHX and the other components of conditioning system **1200**.

(127) Although not shown in the example of FIG. **12**, conditioning system **1200** could also include a mechanical cooling system like a DX unit to provide cooling to the water or other cooling fluid stored in tank**1 204** or to the second cooling fluid circulating between the LLHX **1202**, LAHX**1 112**, and recovery coil **202**. Such a DX unit can be coupled to and function in concert with conditioning system **1200** in a manner similar to that described with reference to conditioning system **1100** of FIG. **11**. Additionally, in examples according to this disclosure, conditioning system **1200** may be configured with LLHX, with or without an additional mechanical cooling system, and without pre-cooler **402**.

(128) System controller **150** can be configured to control operation of conditioning system **1200** in multiple modes. A first or evaporation mode is described above, in which all of the components of conditioning system are active and providing cooling.

(129) Additionally, system controller **150** can operate conditioning system **1200** in an economizer mode. In the economizer mode, for example, system controller **150** can cause LAMEE**1 108**, pre-cooler **402** and/or LAMEE**2 110** to be deactivated and/or bypassed from air and/or fluid flow. In

this mode, LLHX **1202** is generally inactive and the second cooling fluid is circulated via second fluid circuit **1206** in a run-around loop between LAHX**1 112** and recovery coil **202**. Recovery coil **202** cools the second cooling fluid using the scavenger air and transports the second fluid to LAHX**1 112**, which uses the cooled second fluid to cool the heated process air received from the enclosed space.

(130) Conditioning system **1200** includes multiple cooling fluids and associated cooling fluid circuits **1204** and **1206**. The first cooling fluid, for example, water or predominantly water flows through LAMEE**2 110**, pre-cooler **402** and LLHX **1202** (at least in evaporation mode in which the LAMEE is activated to provide evaporative cooling). The second cooling fluid, for example, glycol flows through LAHX**1 112**, recovery coil **202** and LLHX **1202**, the second cooling fluid being used in both the evaporation and the economizer modes of operation.

(131) FIG. **13** depicts another example conditioning system **1300** in accordance with this disclosure. In some examples, the scavenger air circuit and the process air circuit, instead of being commonly housed/packaged and collocated, may be separated by some distance. Example conditioning system **1300** of FIG. **13** is substantially the same as conditioning system **400** of FIG. **4**, except that conditioning system **1300** does not include a system cabinet **102** housing the scavenger and process air circuits (and, in some cases, the fluid circuit(s)). In the example of FIG. **13**, instead, scavenger plenum **104** and the associated components and process plenum **106** and the associated components are separately located and separated from one another by some distance. Although this example, in terms of componentry and functionality, is modeled after the example of FIG. **4**, other example conditioning systems in accordance with this disclosure could also be so arranged and configured. For example, any of conditioning systems **100**, **200**, **900**, **1000**, **1100**, and **1200** could also include scavenger and process air circuits (for example, plenum, cooling components, fluid circuits or portions thereof, etcetera) that are separate and located at a distance from one another.

(132) FIG. **14** is a flowchart depicting an example method **1400** of operating a conditioning system in accordance with this disclosure. In FIG. **14**, method **1400** includes directing a first air stream through a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside a first plenum (**1402**), directing the first air stream through a second LAMEE (LAMEE**2**) arranged inside the first plenum downstream of LAMEE**1** (**1404**), directing a first cooling fluid through a first liquid-to-air heat exchanger (LAHX**1**) arranged inside a second plenum (**1406**), and directing the liquid desiccant through a second LAHX (LAHX**2**) in fluid communication with LAMEE**1** (**1408**).

(133) In the example method of FIG. **14**, LAMEE**1** configured to use a liquid desiccant to lower an enthalpy of the first air stream flowing through the first plenum. LAMEE**2** is configured to use the first air stream to evaporatively cool water flowing through LAMEE**2**. The second plenum is configured to direct a second air stream from a second inlet to a second outlet. Additionally, the second inlet receives heated air from an enclosed space (being conditioned in whole or in part by the system) and the second outlet supplies cooled air to the space. LAHX**1** is configured to directly and sensibly cool the second air stream using the first cooling fluid. LAHX**2** is configured to cool the liquid desiccant using outdoor air.

(134) Example method **1400** of FIG. **14** illustrates generally the manner in which examples according to this disclosure function to condition the air in an enclosed space. The functions of the method of FIG. **14** can be carried out by a variety of conditioning systems in accordance with this disclosure. For example, the functions of method **1400** can be carried out by conditioning system **100**, **200**, **400**, **900**, **1000**, **1100**, **1200** and/or **1300**, the components and functions of which are described above with reference to FIGS. **1-13**.

(135) FIG. **15** shows an example conditioning system **300** that can be similar to other example systems described and including an alternative design for the fluid circuits for regeneration. Only a portion of the system **1500** is shown in FIG. **15** for simplicity and it is recognized that additional components can be included. For example, only a portion of plenum **104** is shown in FIG. **15**, but it

is recognized that the plenum **104** can include some or all of the additional components shown and described above in reference to other examples.

(136) LAMEE**1** **108** can be structured and operate in a similar manner as described in the above examples. The dilute desiccant exiting LAMEE**1** **108** at an outlet **1510** can be split into two flow paths-a first flow path to tank **208** or a second flow path directly to regenerator **700** (via a desiccant circuit **1520**). Regenerator **700** can operate similar to the regenerators described above. The desiccant entering regenerator **700** at an inlet **1530** can be at a first concentration C**1**. The concentrated desiccant exiting the regenerator **700** at an outlet **1540** can be at a third concentration C**3** and can be transported to the tank **208** for mixing with the desiccant already in the tank. As such, the desiccant in the tank **208** can be at a second concentration C**2** that is greater than the first concentration C**1** and less than the third concentration C**3**.

(137) In contrast examples depicted and described above, instead of the dilute desiccant (at the concentration C**1**) mixing with the desiccant in the tank and then flowing to the regenerator (at the second concentration C**2**), the dilute desiccant exiting LAMEE**1** **108** in FIG. **15** is transported directly to the regenerator **700** at the first concentration C**1**. All of the desiccant exiting the tank **208** at the second concentration C**2** is circulated through LAHX**2** **114** and back through LAMEE**1**, rather than selectively directing a portion of the desiccant at the second concentration C**2** to the regenerator **700**. Thus in the design of FIG. **15** the split of the desiccant flow path is at the outlet **1510** of LAMEE**1** **108**, rather than at an outlet of the tank **208**.

NOTES & EXAMPLES

(138) The present application provides for the following exemplary embodiments or examples, the numbering of which is not to be construed as designating levels of importance:

(139) Example 1 provides a system for controlling conditions in an enclosed space, the system comprising: a first plenum configured to direct a first air stream from a first inlet to a first outlet; a second plenum configured to direct a second air stream from a second inlet to a second outlet, the second inlet receiving heated air from the space and the second outlet supplying cooled air to the space; a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside the first plenum, LAMEE**1** configured to use a liquid desiccant to lower an enthalpy of the first air stream; a second LAMEE (LAMEE**2**) arranged inside the first plenum downstream of LAMEE**1**, LAMEE**2** configured to use the first air stream to evaporatively cool water flowing through LAMEE**2**; a first liquid-to-air heat exchanger (LAHX**1**) arranged inside the second plenum, LAHX**1** configured to directly and sensibly cool the second air stream using a first cooling fluid; and a second LAHX (LAHX**2**) in fluid communication with LAMEE**1**, LAHX**2** being configured to receive the liquid desiccant from LAMEE**1** and cool the liquid desiccant using outdoor air.

(140) Example 2 provides the system of Example 1 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom.

(141) Example 3 provides the system of Example 1 and/or Example 2 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom and wherein at least a portion of the water flowing through LAMEE**2** comprises the water removed from the first air stream by LAMEE**1**.

(142) Example 4 provides the system of any of Examples 1-3 and optionally further comprising a pre-cooler coil arranged inside the scavenger plenum upstream of LAMEE**2**, the pre-cooler coil configured to condition the scavenger air prior to the scavenger air entering LAMEE**2**.

(143) Example 5 provides the system of Example 4 and optionally wherein the pre-cooler coil is configured to receive at least a portion of the water cooled by LAMEE**2** to condition the scavenger air.

(144) Example 6 provides the system of Example 4 and optionally further comprising a fluid storage tank to store the water received from a fluid outlet of LAMEE**2**.

(145) Example 7 provides the system of Example 6 and optionally further comprising a mechanical cooling system configured to cool the water in the storage tank using a first cooling fluid.

(146) Example 8 provides the system of Example 6 and optionally further comprising a liquid-to-liquid heat exchanger (LLHX) configured to cool the water in the storage tank using a first cooling fluid.
(147) Example 9 provides the system of Example 8 and optionally further comprising a third LAHX (LAHX**3**), LAHX**3** arranged inside of the first plenum downstream of LAMEE**2** and configured to cool at least one of the water and the first cooling fluid using the scavenger air.
(148) Example 10 provides the system of Example 9 and optionally further comprising: a first fluid circuit configured to transport the water from a fluid outlet of LAMEE**2**, through the LLHX and return the water to a fluid inlet of LAMEE**2**; and a second fluid circuit fluidically isolated from the first fluid circuit, the second fluid circuit configured to transport the first cooling fluid from an outlet of LAHX**3** through the LLHX to an inlet of LAHX**1**, and return the first cooling fluid from the fluid outlet of LAHX**1** to a fluid inlet of LAHX**3**.
(149) Example 11 provides the system of any of Examples 1-10 and optionally further comprising a direct exchange (DX) coil arranged inside the process plenum downstream of LAHX**1**, the DX coil being configured to cool the process air using a second cooling fluid flowing there through.
(150) Example 12 provides the system of any of Examples 1-11 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water and heat therefrom, a temperature of the liquid desiccant at a fluid inlet of LAMEE**1** being lower than a temperature of the liquid desiccant at a fluid outlet of LAMEE**1**.
(151) Example 13 provides a system for controlling conditions in an enclosed space, the system comprising: a scavenger plenum configured to direct scavenger air from a scavenger inlet to a scavenger outlet; a process plenum configured to direct process air from a process inlet to a process outlet, the process inlet receiving heated air from the space and the process outlet supplying cooled air to the space; a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside the scavenger plenum, LAMEE**1** configured to use a first fluid flowing through LAMEE**1** to reduce a humidity of the scavenger air, a first concentration of water in the scavenger air at an air inlet of LAMEE**1** being higher than a second concentration of water in the scavenger air at an air outlet of LAMEE**1**; an evaporative cooler arranged inside the scavenger plenum downstream of LAMEE**1**, the evaporative cooler configured to use the scavenger air to evaporatively cool a second fluid flowing there through, a temperature of the second fluid at a fluid outlet of the evaporative cooler being lower than a temperature of the second fluid at a fluid inlet of the evaporative cooler; a first liquid-to-air heat exchanger (LAHX**1**) arranged inside the process plenum, LAHX**1** configured to directly and sensibly cool the process air being directed through the process plenum using a third fluid flowing through LAHX**1**; and a second LAHX (LAHX**2**), LAHX**2** in fluid communication with LAMEE**1** and configured to receive and cool the first fluid using outdoor air.
(152) Example 14 provides the system of Example 13 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom.
(153) Example 15 provides the system of Example 13 and/or Example 14 and optionally wherein the second fluid comprises water, and wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom, and wherein at least a portion of the water flowing through the evaporative cooler comprises the water removed from the first air stream by LAMEE**1**.
(154) Example 16 provides the system of any of Examples 13-15 and optionally further comprising a pre-cooler coil arranged inside the scavenger plenum upstream of LAMEE**2**, the pre-cooler coil configured to condition the scavenger air prior to the scavenger air entering LAMEE**2**.
(155) Example 17 provides the system of Example 16 and optionally wherein the pre-cooler coil is configured to receive at least a portion of the second fluid cooled by the evaporative cooler to condition the scavenger air.
(156) Example 18 provides the system of Example 16 and optionally further comprising a fluid storage tank to store the second fluid received from a fluid outlet of the evaporative cooler.
(157) Example 19 provides the system of Example 18 and optionally further comprising a

mechanical cooling system configured to cool the second fluid in the storage tank using a first cooling fluid.
(158) Example 20 provides the system of Example 18 and optionally further comprising a liquid-to-liquid heat exchanger (LLHX) configured to cool the second fluid in the storage tank using a first cooling fluid.
(159) Example 21 provides the system of Example 20 and optionally further comprising a third LAHX (LAHX**3**), LAHX**3** arranged inside of the first plenum downstream of the evaporative cooler and configured to cool at least one of the second fluid and the first cooling fluid using the scavenger air.
(160) Example 22 provides the system of Example 21 and optionally further comprising: a first fluid circuit configured to transport the water from a fluid outlet of the evaporative cooler, through the LLHX and return the water to a fluid inlet of the evaporative cooler; and a second fluid circuit fluidically isolated from the first fluid circuit, the second fluid circuit configured to transport the first cooling fluid from an outlet of LAHX**3** through the LLHX to an inlet of LAHX**1**, and return the first cooling fluid from the fluid outlet of LAHX**1** to a fluid inlet of LAHX**3**.
(161) Example 23 provides the system of any of Examples 13-22 and optionally further comprising a direct exchange (DX) coil arranged inside the process plenum downstream of LAHX**1**, the DX coil being configured to cool the process air using a second cooling fluid flowing there through.
(162) Example 24 provides the system of any of Examples 13-23 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water and heat therefrom, a temperature of the liquid desiccant at a fluid inlet of LAMEE**1** being lower than a temperature of the liquid desiccant at a fluid outlet of LAMEE**1**.
(163) Example 25 provides a method for controlling conditions in an enclosed space, the method comprising: directing a first air stream through a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside a first plenum, LAMEE**1** configured to use a liquid desiccant to lower an enthalpy of the first air stream; directing the first air stream through a second LAMEE (LAMEE**2**) arranged inside the first plenum downstream of LAMEE**1**, LAMEE**2** configured to use the first air stream to evaporatively cool water flowing through LAMEE**2**; directing a first cooling fluid through a first liquid-to-air heat exchanger (LAHX**1**) arranged inside a second plenum, the second plenum configured to direct a second air stream from a second inlet to a second outlet, the second inlet receiving heated air from the space and the second outlet supplying cooled air to the space, LAHX**1** configured to directly and sensibly cool the second air stream using the first cooling fluid; and directing the liquid desiccant through a second LAHX (LAHX**2**) in fluid communication with LAMEE**1**, LAHX**2** being configured to cool the liquid desiccant using outdoor air.
(164) Example 26 provides a system for controlling conditions in an enclosed space, the system comprising: a first plenum configured to direct a first air stream from a first inlet to a first outlet; a second plenum configured to direct a second air stream from a second inlet to a second outlet, the second inlet receiving heated air from the space and the second outlet supplying cooled air to the space; a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside the first plenum, LAMEE**1** configured to use a liquid desiccant to lower an enthalpy of the first air stream; an evaporative cooler arranged inside the first plenum downstream of LAMEE**1**, the evaporative cooler configured to use the first air stream to evaporatively cool water flowing therethrough; a first liquid-to-air heat exchanger (LAHX**1**) arranged inside the second plenum, LAHX**1** configured to directly and sensibly cool the second air stream using a first cooling fluid; and a second LAHX (LAHX**2**) in fluid communication with LAMEE**1**, LAHX**2** being configured to receive the liquid desiccant from LAMEE**1** and cool the liquid desiccant using outdoor air.
(165) Example 27 provides the system of Example 26 and optionally wherein the evaporative cooler comprises a second LAMEE.
(166) Example 28 provides the system of Example 26 and/or Example 27 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom.

(167) Example 29 provides the system of any of Examples 26-28 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom and wherein at least a portion of the water flowing through LAMEE**2** comprises the water removed from the first air stream by LAMEE**1**.
(168) Example 29 provides the system of any of Examples 26-29 and optionally wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water and heat therefrom, a temperature of the liquid desiccant at a fluid inlet of LAMEE**1** being lower than a temperature of the liquid desiccant at a fluid outlet of LAMEE**1**.
(169) Various examples according to this disclosure have been described. These and other examples are within the scope of the following claims.

Claims

1. A system for controlling conditions in an enclosed space, the system comprising: a first plenum configured to direct a first air stream from a first inlet to a first outlet; a second plenum configured to direct a second air stream from a second inlet to a second outlet, the second inlet receiving heated air from the space and the second outlet supplying cooled air to the space; a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside the first plenum, LAMEE**1** configured to use a liquid desiccant to lower an enthalpy of the first air stream; a second LAMEE (LAMEE**2**) arranged inside the first plenum downstream of LAMEE**1**, LAMEE**2** configured to use the first air stream to evaporatively cool water flowing through LAMEE**2**; a first liquid-to-air heat exchanger (LAHX**1**) arranged inside the second plenum, LAHX**1** configured to directly and sensibly cool the second air stream using a first cooling fluid; and a second LAHX (LAHX**2**) in fluid communication with LAMEE**1**, LAHX**2** being configured to receive the liquid desiccant from LAMEE**1** and cool the liquid desiccant using outdoor air.
2. The system of claim 1, wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom.
3. The system of claim 1, wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water therefrom and wherein at least a portion of the water flowing through LAMEE**2** comprises the water removed from the first air stream by LAMEE**1**.
4. The system of claim 1, further comprising a pre-cooler coil arranged inside the first plenum upstream of LAMEE**2**, the pre-cooler coil configured to condition the first air stream prior to the first air stream entering LAMEE**2**.
5. The system of claim 4, wherein the pre-cooler coil is configured to receive at least a portion of the water cooled by LAMEE**2** to condition the first air stream.
6. The system of claim 4, further comprising a fluid storage tank to store the water received from a fluid outlet of LAMEE**2**.
7. The system of claim 6, further comprising a mechanical cooling system configured to cool the water in the storage tank using the first cooling fluid.
8. The system of claim 6, further comprising a liquid-to-liquid heat exchanger (LLHX) configured to cool the water in the storage tank using the first cooling fluid.
9. The system of claim 8, further comprising a third LAHX (LAHX**3**), LAHX**3** arranged inside of the first plenum downstream of LAMEE**2** and configured to cool at least one of the water and the first cooling fluid using the first air stream.
10. The system of claim 9, further comprising: a first fluid circuit configured to transport the water from a fluid outlet of LAMEE**2**, through the LLHX and return the water to a fluid inlet of LAMEE**2**; and a second fluid circuit fluidically isolated from the first fluid circuit, the second fluid circuit configured to transport the first cooling fluid from an outlet of LAHX**3** through the LLHX to an inlet of LAHX**1**, and return the first cooling fluid from the fluid outlet of LAHX**1** to a fluid inlet of LAHX**3**.

11. The system of claim 1, further comprising a direct exchange (DX) coil arranged inside the second plenum downstream of LAHX**1**, the DX coil being configured to cool the second air stream using a second cooling fluid flowing there through.
12. The system of claim 1, wherein LAMEE**1** is configured to lower the enthalpy of the first air stream by removing water and heat therefrom, a temperature of the liquid desiccant at a fluid inlet of LAMEE**1** being lower than a temperature of the liquid desiccant at a fluid outlet of LAMEE**1**.
13. The system of claim 1, further comprising a third LAHX (LAHX**3**) arranged inside of the first plenum downstream of LAMEE**2** and configured to receive the first cooling fluid from LAHX**1** and to cool the first cooling fluid using the first air stream.
14. The system of claim 13, wherein: the first cooling fluid is the water; and the water flows from an outlet of the LAHX**3** to an inlet of the LAMEE**2**.
15. A system for controlling conditions in an enclosed space, the system comprising: a scavenger plenum configured to direct scavenger air from a scavenger inlet to a scavenger outlet; a process plenum configured to direct process air from a process inlet to a process outlet, the process inlet receiving heated air from the space and the process outlet supplying cooled air to the space; a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside the scavenger plenum, LAMEE**1** configured to use a first fluid flowing through LAMEE**1** to reduce a humidity of the scavenger air, a first concentration of water in the scavenger air at an air inlet of LAMEE**1** being higher than a second concentration of water in the scavenger air at an air outlet of LAMEE**1**; an evaporative cooler arranged inside the scavenger plenum downstream of LAMEE**1**, the evaporative cooler configured to use the scavenger air to evaporatively cool a second fluid flowing there through, a temperature of the second fluid at a fluid outlet of the evaporative cooler being lower than a temperature of the second fluid at a fluid inlet of the evaporative cooler; a first liquid-to-air heat exchanger (LAHX**1**) arranged inside the process plenum, LAHX**1** configured to directly and sensibly cool the process air being directed through the process plenum using a third fluid flowing through LAHX**1**; and a second LAHX (LAHX**2**), LAHX**2** in fluid communication with LAMEE**1** and configured to receive the first fluid from the LAMEE**1** and cool the first fluid using outdoor air.
16. The system of claim 15, wherein LAMEE**1** is configured to lower the enthalpy of the scavenger air by removing water therefrom.
17. The system of claim 15, wherein the second fluid comprises water, and wherein LAMEE**1** is configured to lower the enthalpy of the scavenger air by removing water therefrom, and wherein at least a portion of the water flowing through the evaporative cooler comprises the water removed from the scavenger air by LAMEE**1**.
18. The system of claim 15, further comprising a pre-cooler coil arranged inside the scavenger plenum upstream of LAMEE**2**, the pre-cooler coil configured to condition the scavenger air prior to the scavenger air entering LAMEE**2**.
19. The system of claim 18, wherein the pre-cooler coil is configured to receive at least a portion of the second fluid cooled by the evaporative cooler to condition the scavenger air.
20. The system of claim 18, further comprising a fluid storage tank to store the second fluid received from a fluid outlet of the evaporative cooler.
21. The system of claim 20, further comprising a mechanical cooling system configured to cool the second fluid in the storage tank using a first cooling fluid.
22. The system of claim 20, further comprising a liquid-to-liquid heat exchanger (LLHX) configured to cool the second fluid in the storage tank using a first cooling fluid.
23. The system of claim 22, further comprising a third LAHX (LAHX**3**), LAHX**3** arranged inside of the scavenger plenum downstream of the evaporative cooler and configured to cool at least one of the second fluid and the first cooling fluid using the scavenger air.
24. The system of claim 23, further comprising: a first fluid circuit configured to transport the water from a fluid outlet of the evaporative cooler, through the LLHX and return the water to a

fluid inlet of the evaporative cooler; and a second fluid circuit fluidically isolated from the first fluid circuit, the second fluid circuit configured to transport the first cooling fluid from an outlet of LAHX**3** through the LLHX to an inlet of LAHX**1**, and return the first cooling fluid from the fluid outlet of LAHX**1** to a fluid inlet of LAHX**3**.
25. The system of claim 15, further comprising a third LAHX (LAHX**3**) arranged inside of the scavenger plenum downstream of evaporative cooler and configured to receive the third fluid from LAHX**1** and to cool the third fluid using the scavenger air.
26. The system of claim 25, wherein: the third fluid is the second fluid; and the water flows from an outlet of the LAHX**3** to an inlet of the evaporative cooler.
27. A method for controlling conditions in an enclosed space, the method comprising: directing a first air stream through a first liquid-to-air membrane energy exchanger (LAMEE**1**) arranged inside a first plenum, LAMEE**1** configured to use a liquid desiccant to lower an enthalpy of the first air stream; directing the first air stream through a second LAMEE (LAMEE**2**) arranged inside the first plenum downstream of LAMEE**1**, LAMEE**2** configured to use the first air stream to evaporatively cool water flowing through LAMEE**2**; directing a first cooling fluid through a first liquid-to-air heat exchanger (LAHX**1**) arranged inside a second plenum, the second plenum configured to direct a second air stream from a second inlet to a second outlet, the second inlet receiving heated air from the space and the second outlet supplying cooled air to the space, LAHX**1** configured to directly and sensibly cool the second air stream using the first cooling fluid; and directing the liquid desiccant through a second LAHX (LAHX**2**) in fluid communication with LAMEE**1**, LAHX**2** being configured to receive the liquid desiccant from the LAMEE**1** and to cool the liquid desiccant using outdoor air.
28. The method of claim 27, further comprising directing the first cooling fluid received from the LAHX**1** through a third LAHX (LAHX**3**), the LAHX**3** arranged inside the first plenum downstream of the LAMEE**2** and configured to cool the first cooling fluid using the first air stream.
29. The method of claim 28, wherein: the first cooling fluid is the water; and the water flows from an outlet of the LAHX**3** to an inlet of the LAMEE**2**.