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[Continued on next page]

(54) Title: SYSTEM AND METHOD FOR AUTONOMOUS MANAGEMENT OF WATER CONTENT OF A FLUID

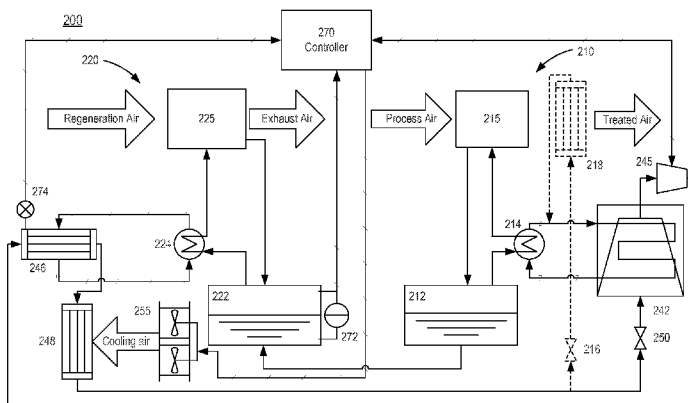


FIG. 2

(57) Abstract: A system includes a reservoir of liquid desiccant, a heat and mass exchanger, a heat source, an actuator and a controller. The heat and mass exchanger receives a flow of the liquid desiccant heated by the heat source and a gas such that water in the liquid desiccant can be transferred to the gas. The controller is configured to (1) receive a signal from a first sensor associated with an amount of water in the liquid desiccant and a signal from a second sensor associated with a heat energy of the heat source and a rate of heat transfer, (2) determine the amount of water in the liquid desiccant, and (3) send a signal to the actuator to cause a change to the heat energy of the heat source or the rate of heat transfer to change a water transfer rate from the liquid desiccant to the gas.

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## INTERNATIONAL SEARCH REPORT

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## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F24F 3/14, F24F 5/00, F24F 6/04 (2016.01)

CPC - F24F 3/14, B01D 2252/2025, B01D 2252/504, B01D 53/1425, B01D 53/263, F24F 2003/114.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC (8): F24F3/14 (2016.01)

CPC: F24F3/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
IPC (8): F24F5/00, F24F6/04 (2016.01). CPC: B01D2252/2025, B01D2252/504, B01D53/1425, B01D53/263, F24F2003/144, F24F2003/1458, F24F2005/0064, F24F2203/021, F24F3/1417, F24F3/1429, F24F5/001, F24F5/0035, F24F5/0046, F24F6/04.Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
PatBase. Google (Web, Patent, Scholar). Search Terms: Absorb, Absorbent, Air, ASHRAE, Blower, Bulb, Centrifugal, Chemical, Compress\*, Concentration, Condition, Conductivity, Controller, Convection, Cool, Crystal, Cycle, Dehumidify, Desiccant, Diagram, Drip, Drizzle, Dry, Exchange, Fan, Forced, Gas, Gravity, Heat, HVAC, Hygroscopic, Level, Liquid,

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y ----- A	US 2013/0227982 A1 (FORKOSH) 05 September 2013 (05.09.2013) Figs. 1-2; paras [0018-21], [0025], [0028], [0032-3], [0035].	1-4, 7-15 ----- 5-6
Y ----- A	US 2010/0090356 A1 (SINES et al.) 15 April 2010 (15.04.2010) Fig. 1; para [0020].	1-4, 7-15 ----- 5-6
A	US 2014/0245769 A1 (VANDERMEULEN et al.) 04 September 2014 (04.09.2014) Fig. 3A; para [0011].	5-6
A	US 5,325,676 A (MECKLER) 05 July 1994 (05.07.1994) Figs 1-4, 11-12; col 5 ln 47 - col 6 ln 27.	1-15
A	US 2010/0319370 A1 (KOZUBAL et al.) 23 December 2010 (23.12.2010) Figs. 1-4, 12; paras [0035], [0037].	1-15

 Further documents are listed in the continuation of Box C.

## \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 15/62253

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:  
 -\*. See Extra Sheet -\*.

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-15

**Remark on Protest**

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

-\*- Box III - Observations where unity of invention is lacking -\*-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-15, directed to a system comprising a reservoir and a mass and heat exchanger.

Group II: Claims 16-28, directed to a method comprising a third sensor and the step of sending a third signal when the current operating condition satisfies an operating criterion.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1, because, under PCT Rule 13.2, they lack the same or corresponding technical feature(s) for the following reasons:

Group I requires the special technical features of a reservoir, a mass and heat exchanger, a liquid desiccant conduit, a predetermined amount of water in the liquid desiccant, and actuator control signal, and a parameter associated with a temperature of the source of heat energy.

Group II requires the special technical features of a second sensor, a third sensor, and the step of sending a third signal when the current operating condition satisfies an operating criterion.

The only shared technical feature(s) that would otherwise unify Groups I-II are a system or method comprising:

- a liquid desiccant,
- a regenerating gas,
- a source of heat energy,
- a sensor configured to sense a parameter associated with an amount of water contained in the liquid desiccant,
- a sensor associated with the source of heat energy and configured to sense a parameter associated with a rate of heat transfer between the source of heat energy and the liquid desiccant,
- an actuator associated with the source of heat energy, and
- a controller configured to receive signals from the sensors and send an actuator signal to the actuator to cause the actuator to change the rate of heat transfer between the source of heat energy and the liquid desiccant and a rate at which water is transferred from the liquid desiccant to the regeneration gas.

However, these technical features do not represent a contribution to the prior art, because they are obvious over US 2013/0227982 A1 (FORKOSH). Forkosh discloses a system or method (air conditioning system 10, Fig. 1; para [0018]) comprising:

- a liquid desiccant (liquid desiccant 42, Fig. 1; para [0019]),
- a regenerating gas (second airflow 66, Fig. 1; "In the regenerator 14, the desiccant 42 is pumped ... where it flows downward to contact a second airflow 66 para [0020]),
- a source of heat energy (heat source 88 and desiccant heat exchanger 84, Fig. 1; para [0024]),
- a sensor (temperature/relative humidity sensors "T,Rh", Fig. 1; para [0032]) configured to sense a parameter associated with a rate of heat transfer between the source of heat energy and the liquid desiccant (per para [0036], sensors indicate "various temperatures, pressures, and humidities and determines the appropriate source and quantity for cooling the desiccant 42", and so the sensor is therefore capable of accommodating this intended use),
- an actuator (valve 96, Fig. 1; "closing the valve 96" para [0030]) associated with the source of heat energy (by fluid communication via heat exchanger 84 as illustrated in Fig. 1; para [0025]),
- a controller (unnumbered; control system illustrated in schematic 100, Fig. 2; "a flow chart 100 is shown, which illustrates a control system ..." para [0027]) configured to receive signals from the sensors ("these sensors ... transmit signals to a control system" para [0032]) and cause the actuator to change the rate of heat transfer between the source of heat energy and the liquid desiccant (step 110, Fig. 2; para [0030]) and a rate at which water is transferred from the liquid desiccant to the regeneration gas (step 110, Fig. 2; para [0030]; By transferring heat to a desiccant, at least a finite amount of water must inherently be caused to evaporate or increase solubility in adjacent gasses, and the system should be treated as at least being configurable to transfer water from a desiccant to a regeneration gas/air; see para [0019], [0024])

Forkosh does not teach specifically teach the control system being configured to send an actuator signal to the actuator. However, Forkosh teaches the control system shutting off pumps and valves ("This may be accomplished by shutting off the pump 98 and closing the valve 96-see step 110", illustrated in Fig. 2; para [0030]) and valves being controlled by electric solenoids ("valve 123 is illustrated as an electric solenoid" in Fig. 1; para [0034]) for the purpose of controlling flow ("the flow of which is controlled by an electric solenoid valve 128" Fig. 1; para [0035])

- a controller (unnumbered; control system illustrated in schematic 100, Fig. 2; "a flow chart 100 is shown, which illustrates a control system ..." para [0027]) configured to receive signals from the sensors ("these sensors ... transmit signals to a control system" para [0032]) and cause the actuator to change the rate of heat transfer between the source of heat energy and the liquid desiccant (step 110, Fig. 2; para [0030]) and a rate at which water is transferred from the liquid desiccant to the regeneration gas (step 110, Fig. 2; para [0030]; By transferring heat to a desiccant, at least a finite amount of water must inherently be caused to evaporate or increase solubility in adjacent gasses, and the system should be treated as at least being configurable to transfer water from a desiccant to a regeneration gas/air; see para [0019], [0024])

-\*- See Next Supplemental Sheet -\*-

INTERNATIONAL SEARCH REPORT

International application No.

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-\*- Box III - Observations where unity of invention is lacking -\*-

Forkosh does not specifically teach the control system being configured to send an actuator signal to the actuator. However, Forkosh teaches the control system shutting off pumps and valves ("This may be accomplished by shutting off the pump 98 and closing the valve 96-see step 110", illustrated in Fig. 2; para [0030]) and valves being controlled by electric solenoids ("valve 123 is illustrated as an electric solenoid" in Fig. 1; para [0034]) for the purpose of controlling flow ("the flow of which is controlled by an electric solenoid valve 128" Fig. 1; para [0035])

Accordingly, it would have been obvious to one having ordinary skill in the art that the system taught by Forkosh could have been modified as claimed in view of Forkosh in order to use the control system to control the electric solenoid valve.

As the common technical feature(s) of Groups I-II were known in the art at the time of the invention, they cannot be considered to be common technical feature(s) that would otherwise unify Groups I-II.

Therefore, Groups I-II lack unity under PCT Rule 13.

Note: It is at least theoretically possible that a single sensor can be associated with a reservoir and be configured to sense a parameter associated with an amount of water contained therein while also being associated with a source of heat energy and being configured to sense one or both of a parameter associated with a temperature of the source of heat energy and a parameter associated with a rate of heat transfer (e.g., if the reservoir per se is also the source of heat in that it provides a supply of heated liquid, a real world thermometer inserted into the supply of heated liquid at a given initial temperature will have a response time proportional to the magnitude of the fluid flow as well as a final temperature proportional to the temperature of the fluid. Therefore, a single sensor should be treated as being capable of indicating two parameters).