



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.07.2018 Bulletin 2018/29

(51) Int Cl.:
F24F 11/00 ^(2018.01) **F24F 13/22** ^(2006.01)

(21) Application number: **17160244.4**

(22) Date of filing: **10.03.2017**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Siemens Schweiz AG**
8047 Zürich (CH)

(72) Inventor: **Prochnow, Jan Erik**
8006 Zürich (CH)

(74) Representative: **Maier, Daniel Oliver**
Siemens AG
Postfach 22 16 34
80506 München (DE)

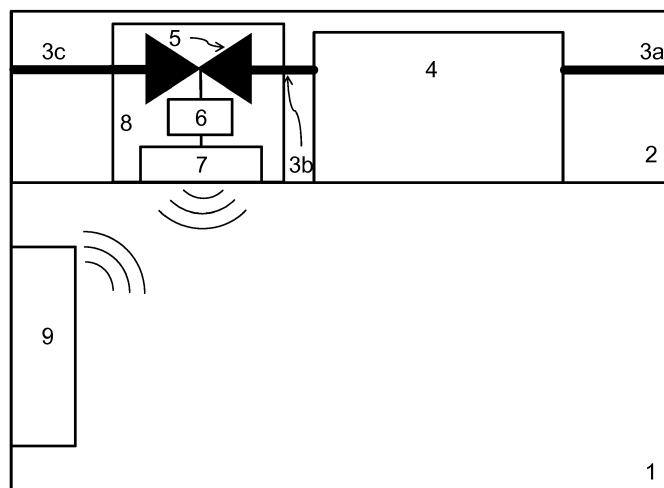
(30) Priority: **12.01.2017 EP 17151263**
13.01.2017 DE 102017200518
13.01.2017 DE 102017200530
13.01.2017 DE 102017200544
13.01.2017 EP 17151360
13.01.2017 EP 17151428
13.01.2017 EP 17151510
13.01.2017 EP 17151536

(54) **SYSTEM FOR COOLING A ROOM AND VALVE ASSEMBLY**

(57) System for cooling a room and valve assembly. A valve assembly comprising a valve with an inlet (3c), an outlet (3b), a fluid path connecting the inlet (3c) to the outlet (3b), a valve member disposed in the fluid path, and a valve actuator (6) configured to move the valve member such that it obturates the fluid path, and a valve controller (7) that is communicatively coupled to the valve actuator (6), the valve controller (7) being configured to

receive first data indicative of temperature, to receive second data indicative of humidity of air, to receive third data related to a temperature of a fluid in the fluid path, to determine a dewpoint estimate from the data, to determine a fluid temperature estimate from the third data, to compare the dewpoint estimate to the fluid temperature estimate and to send an instruction to the valve actuator (6) accordingly.

FIG 1



Description

Background

[0001] The disclosure relates to a system for cooling a room and to a valve assembly.

[0002] Structures with spaces and / or with rooms might comprise cooling devices to ensure the comfort of their occupants. Often, a cooling device is mounted entirely or mostly outside the boundaries of each room, which usually consist of its walls, doors, ceiling and floor, for reducing non-uniform cooling or noise. In the case of buildings, the main machinery of the cooling device typically is mounted on the rooftop or in the cellar, but its conduits for the coolant and its valves or its dampers for acting on the flow thereof are mounted behind the walls or above the ceilings.

[0003] For improving comfort further, the rooms typically contain a temperature sensor that is configured and mounted for sensing the air temperature therein.

Summary

[0004] The instant disclosure teaches a valve assembly capable of inhibiting condensation on outer surfaces of ceiling-mounted cooling devices. To that end, the valve assembly comprises a communication interface and is operable to receive data indicative of humidity and / or temperature via the interface. The valve assembly also provides a processor configured to determine dewpoint values from the data received. The assembly is sufficiently smart such that its processor can compare the calculated dewpoint to a temperature of a fluid flowing through a cooling battery. Flow through the cooling battery will be disabled by the valve if fluid temperature is too low, in particular if fluid temperature falls below the calculated dewpoint.

[0005] The above problems are resolved by a valve assembly in accordance with the main claims of this disclosure. Preferred embodiments of the present disclosure are covered by the dependent claims.

[0006] It is a related object of the instant disclosure to provide a valve assembly wherein data indicative of the temperature of a fluid flowing through a cooling battery are obtained by measurement upstream of the cooling battery.

[0007] It is another object of the instant disclosure to provide a valve assembly wherein the valve assembly and / or the processor of the valve assembly provide an interface such that the valve assembly may retrieve data from various devices remote from the valve assembly. These include, but are not limited to, mobile handheld devices, room units, room controllers, controllers of heating, ventilation and / or air-conditioning installations etc.

Brief description of the drawings

[0008] Various features will become apparent to those

skilled in the art from the following detailed description of the disclosed non-limiting embodiments. The drawing that accompanies the detailed description can be briefly described as follows:

FIG 1 is a schematic of a system with a smart valve according to the instant disclosure.

Detailed description

[0009] In order to inhibit condensation occurring on cold surfaces of the cooling device, the system further comprises at least one humidity sensor and at least one regulating device that is configured to set the valve or to set the damper or to influence the temperature of the coolant in the conduit not just on the basis of signals obtained from the temperature sensor, but also on the basis of signals obtained from the humidity sensor.

[0010] For instance, so-called chilled ceilings are deployed to cool down the room temperature, typically with water as the coolant. If the supply water temperature is too low, condensed water appears. This can in the long run compromise the building structure or create water marks on ceilings. The lower limit for the supply water temperature depends on the surrounding air temperature and humidity.

[0011] In such chilled ceilings and in similar cooling devices, dewpoint switches are mounted to every supply water pipe. They switch off the supply water when the relative humidity of the air close to the pipe approaches 100% relative humidity. Mounting them, cabling them to a controller and testing the wiring is cumbersome, especially since there is often little room in the ceiling with lots of piping, cabling and insulations.

[0012] Likewise, known data centre cooling devices include such dewpoint switches near coolant pipes or, alternatively, absolute humidity sensors in the flow path of the coolant air to or from the servers, as is described in the article "HUMIDITY IN THE DATA CENTER: DO WE STILL NEED TO SWEAT IT?" by Jeff Clark in the Data Center Journal of 27 March, 2012.

[0013] According to the disclosure, the humidity sensor is configured and mounted for sensing humidity in the room. Surprisingly, this measurement within the room can have a disproportionately large effect in inhibiting condensation in adjacent spaces. In this way, a single humidity sensor can be used both to improve comfort in the room and to inhibit condensation elsewhere, while avoiding the efforts to install any in inaccessible places.

[0014] On the basis of room temperature and room humidity, aware of easily established values for local heat transmission to and local heat absorption by the cooling device, the regulating device calculates whether the temperature and flow of the supply water likely would cause condensation on the supply conduit anywhere above the ceiling. If there is such a risk, the valve would reduce the flow of coolant, or the cooler unit would produce coolant of a higher temperature, or both, or the valve would stop

the flow of coolant altogether.

[0015] In a preferred embodiment of the disclosure, the humidity sensor is mounted such that it is accessible for air in the room at all times. The humidity sensor might be mounted within the room, maybe to a desk or as part of a portable electronic device, but, if there is a ventilation system, outside the air inlet conduit thereof, lest it measures only the air that the ventilation system produces. Preferably, the humidity sensor is mounted at the inside of the boundary of the room, say to a wall or to the ceiling.

[0016] In a preferred embodiment of the disclosure, the regulating device is configured for calculating an estimate of relative humidity at the cooling device, preferably in an area thereof, more preferably in an area thereof that has been selected for high relative humidity or for relative position to the boundary of the room, at least on the basis of signals obtained from the temperature sensor and from the humidity sensor, advantageously by using at least stored values for calculating an estimate of the heat transport through the boundary of the room outside which the cooling device is mounted, or by using at least stored values for calculating an estimate of the heat sink effect of the cooling device, or by using at least both stored values.

[0017] The instant disclosure teaches a system, wherein the cooling device 4 is mounted at least in part above the ceiling 2 of the room 1.

[0018] The disclosure further concerns a valve assembly and / or a valve according to claim 1.

[0019] The instant disclosure teaches a valve assembly and / or a valve comprising a valve with at least an inlet 3c, at least an outlet 3b, a fluid path connecting the at least an inlet 3c to the at least an outlet 3b, a valve member disposed in the fluid path, and

with a valve actuator 6 mechanically coupled to the valve member and configured to move the valve member such that the valve member obturates the fluid path, and the valve assembly further comprising a valve controller 7 that is communicatively coupled to the valve actuator 6, the valve controller 7 being configured to receive first data indicative of a temperature inside a structure 1, to receive second data indicative of a humidity of air inside the structure 1, to receive third data related to a temperature of a fluid in the fluid path, to determine a dewpoint estimate from the first and from the second data, to determine a fluid temperature estimate from the third data, to compare the dewpoint estimate to the fluid temperature estimate, to generate an instruction for the valve actuator 6 to move the valve member, wherein the instruction is generated on the basis of the comparison between the dewpoint estimate and the fluid temperature estimate, to send the generated instruction to the valve actuator 6.

[0020] In an embodiment, the valve controller 7 is con-

figured to generate an instruction for the valve actuator 6 to move the valve member such that the valve member obturates the fluid path, if the fluid temperature estimate is less than the dewpoint estimate by a pre-determined threshold.

[0021] In an embodiment, the valve controller 7 is configured to generate an instruction for the valve actuator 6 to move the valve member such that the valve member obturates the fluid path, if the fluid temperature estimate is less than the dewpoint estimate by a pre-determined threshold, wherein the instruction is generated on the basis of the comparison between the dewpoint estimate and the fluid temperature estimate.

[0022] It is envisaged that the pre-determined threshold is a temperature. According to an aspect, the pre-determined threshold is 1 K or 2 K or 5 K or at least 1 K or at least 2 K or at least 5 K. In a particular embodiment, the valve controller 7 comprises a memory, in particular a memory storing the pre-determined threshold.

[0023] It is also envisaged that the structure is a space (of a building) and / or is a room, in particular a room of a building. According to an aspect, the temperature estimate is a temperature value. According to an aspect, the dewpoint estimate is a dewpoint value. According to an aspect, the fluid temperature estimate is a value of fluid temperature.

[0024] In a particular embodiment, the valve controller 7 comprises an interface for communicating with the valve actuator 6 through a bus. The interface may, by way of non-limiting example, be an I2C interface. The bus may, by way of non-limiting example, be an I2C bus. It is also envisaged that the valve controller 7 is configured to send the generated instruction to the valve actuator 6 via the interface of the valve controller 7. It is still envisaged that the valve controller 7 is configured to send the generated instruction to the valve actuator 6 via the interface of the valve controller 7 and via the bus.

[0025] In a related embodiment, the valve actuator 6 comprises an interface for communicating with the valve controller 7 through a bus. The interface of the valve actuator 6 may, by way of non-limiting example, be an I2C interface. The bus may, by way of non-limiting example, be an I2C bus.

[0026] In a preferred embodiment of the disclosure, the valve comprises at least a temperature sensor disposed in the fluid path, the valve controller 7 is communicatively coupled to the at least a temperature sensor, and the valve controller 7 is configured to receive third data in the form of a signal from the at least a temperature sensor.

[0027] In a preferred embodiment, the valve comprises at least one temperature sensor (such as a PT100 sensor) disposed in the fluid path, the valve controller 7 comprises an analog-to-digital converter, the analog-to-digital converter is communicatively coupled to the at least a temperature sensor, and the analog-to-digital converter is configured to receive a

signal from the at least a temperature sensor and to convert the received signal to third data in the form of a digital representation of the received signal, wherein the valve controller 7 comprises a processing unit, the processing unit of the valve controller 7 being configured to receive third data from the analog-to-digital converter.

[0028] In another preferred embodiment, the valve controller 7 provides a bus connection and is configured to receive first data and second data from a room controller 9 and / or room unit 9 disposed in a structure via the bus connection.

[0029] In another preferred embodiment, the valve controller 7 provides an interface to a bus connection and is configured to receive first data and second data from a room controller 9 and / or room unit 9 disposed in a structure via the interface.

[0030] In another preferred embodiment, the valve controller 7 provides an interface to a bus connection and is configured to receive first data and second data originating from a room controller 9 and / or room unit 9 disposed in a structure using a pre-determined bus protocol via the interface.

[0031] In a particular embodiment, the pre-determined bus protocol is a pre-determined digital bus protocol. The pre-determined bus protocol may, by way of non-limiting example, be a pre-determined bus protocol of a CAN-bus (controller area network) under ISO 11898-1:2015.

[0032] According to a related aspect, the interface to a bus connection is an interface to a wireless bus connection.

[0033] In a related embodiment, the room controller 9 and / or room unit 9 preferably is arranged at a location remote from the valve controller 7 such as at least 1 m or at least 2 m or at least 5 m from the valve controller 7.

[0034] In a related embodiment, the room controller 9 and / or room unit 9 preferably is arranged at a location remote from the valve assembly such as at least 1 m or at least 2 m or at least 5 m from the valve assembly.

[0035] FIG 1 shows a system according to the instant disclosure.

[0036] ON FIG 1, room 1 contains a wall-mounted room controller 9 and / or room unit 9 with a temperature sensor that is configured and mounted for sensing the air temperature in the room and with a humidity sensor is configured and mounted for sensing humidity in the room. The humidity sensor is configured for sensing absolute humidity.

[0037] In an embodiment, room controller 9 and / or room unit 9 comprises a microcomputer such as a single core microcomputer and / or an analogue circuit.

[0038] Above ceiling 2, a conduit 3a - 3c of a cooling device 4 is mounted. A valve 5 has an inlet 3c, an outlet 3b and a fluid path that connects them, as well as a valve member disposed in the fluid path, and a valve actuator 6.

[0039] A regulating device 7 is configured to set valve 5 in the conduit at least on the basis of signals obtained from the temperature sensor and from the humidity sen-

sor. For this, the regulating device 7 calculates an estimate of relative humidity at the conduit 3a - 3c over its entire length across the ceiling on the basis of signals from the temperature sensor, from the humidity sensor and from an non-depicted temperature sensor for the temperature of the coolant, by using stored values for calculating an estimate of the heat transport through the ceiling 2, mainly the ceiling area and a ceiling material value that represents the rate of warm room air rising through the ceiling 2 per unit area, and by using stored values for calculating an estimate of the heat sink effect of the cooling device 4, mainly the surface area of the conduit 3a - 3c.

[0040] In an alternative embodiment, the regulating device has been integrated into and is a part of the room controller 9 and / or room unit 9.

[0041] In another alternative embodiment, the regulating device is a controller 7 of a valve assembly 8 that also includes valve 5. Then the controller 7 is configured to send an instruction to the valve actuator 6 according to its determination of a dewpoint estimate and of the fluid temperature estimate. For instance, the controller might cause the valve member close if the difference drops below a pre-determined threshold, or a threshold that varies with the speed of approach or other circumstances.

[0042] It is envisaged that the regulating device and / or the valve assembly connect to a power supply. The power supply may, by way of non-limiting example, be a flow battery. The power supply may, by way of another non-limiting example, be a flow battery comprising (a resilient form of) viologen (in the negative electrolyte) and / or ferrocene (in the positive electrolyte). The power supply may, by way of another non-limiting example, be a flow battery comprising water-soluble form of ferrocene (for storing electric charge), in particular functionalised ferrocene.

[0043] Any steps of a method according to the present application may be embodied in hardware, in a software module executed by a processor, in a cloud computing arrangement, or in a combination thereof. The software may include a firmware, a hardware driver run in the operating system, or an application program. Thus, the disclosure also relates to a computer program product for performing the operations presented herein. If implemented in software, the functions described may be stored as one or more instructions on a computer-readable medium. Some examples of storage media that may be used include random access memory (RAM), read only memory (ROM), flash memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, other optical disks, or any available media that can be accessed by a computer or any other IT equipment and appliance.

[0044] It should be understood that the foregoing relates only to certain embodiments of the disclosure and that numerous changes may be made therein without departing the scope of the disclosure as defined by the

following claims. It should also be understood that the disclosure is not restricted to the illustrated embodiments and that various modifications can be made within the scope of the following claims.

Reference numerals

[0045]

1	room
2	ceiling
3a, 3b, 3c	refrigerant conduits, in particular water conduits
3b	valve outlet
3c	valve inlet
4	cooling battery
5	valve
6	actuator
7	controller
8	valve assembly
9	room controller / room unit

Claims

1. A valve assembly comprising
a valve with at least an inlet (3c), at least an outlet (3b), a fluid path connecting the at least an inlet (3c) to the at least an outlet (3b), a valve member disposed in the fluid path, and
with a valve actuator (6) mechanically coupled to the valve member and configured to move the valve member such that the valve member obturates the fluid path, and
the valve assembly further comprising a valve controller (7) that is communicatively coupled to the valve actuator (6), the valve controller (7) being configured to receive first data indicative of a temperature inside a structure (1),
to receive second data indicative of a humidity of air inside the structure (1),
to receive third data related to a temperature of a fluid in the fluid path,
to determine a dewpoint estimate from the first and from the second data,
to determine a fluid temperature estimate from the third data,
to compare the dewpoint estimate to the fluid temperature estimate,
to generate an instruction for the valve actuator (6) to move the valve member, wherein the instruction is generated on the basis of the comparison between the dewpoint estimate and the fluid temperature estimate,
to send the generated instruction to the valve actuator (6).
2. The valve assembly according to claim 1,

wherein the valve comprises at least one temperature sensor disposed in the fluid path, and wherein the valve controller (7) is communicatively coupled to the at least one temperature sensor,
wherein the valve controller (7) is configured to receive third data in the form of a signal from the at least one temperature sensor.

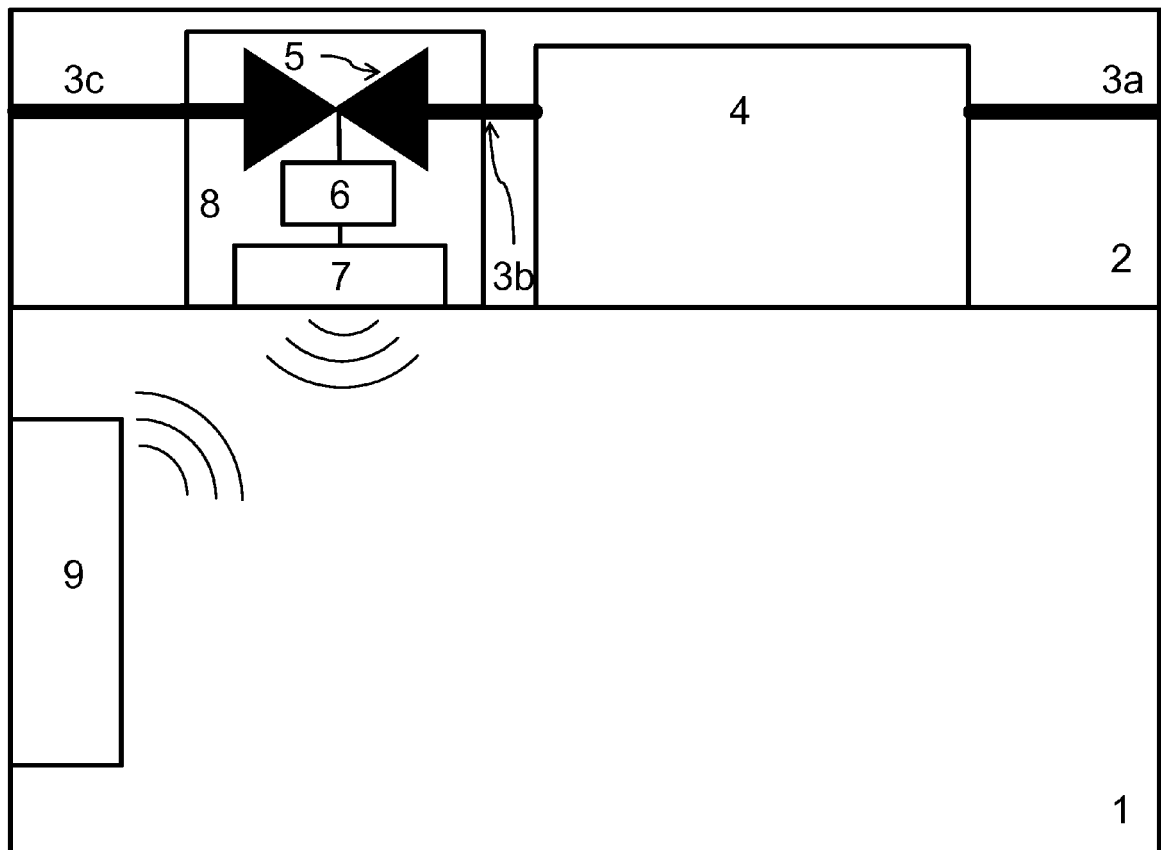
3. The valve assembly according to any of the claims 1 to 2,
wherein the valve controller (7) provides a bus connection,
wherein the valve controller (7) is configured to receive first data and second data from a room unit (9) disposed inside the structure (1) via the bus connection.
4. The valve assembly according to claim 3,
wherein the room unit (9) is arranged at a location remote from the valve controller (7).
5. A system for cooling a room (1) of a structure, comprising at least
a cooling device (4) that is mounted outside or essentially outside the boundary of the room (1), which cooling device (4) comprises at least one conduit (3a - 3c) for a coolant and at least one valve (5) or damper for acting on the flow of the coolant in the conduit (3a - 3c),
a temperature sensor that is configured and mounted for sensing the air temperature in the room (1),
a humidity sensor,
a regulating device (7) that is configured to set the valve (5) or damper or to influence the temperature of the coolant in the conduit at least on the basis of signals obtained from the temperature sensor and from the humidity sensor,
characterised in that
the humidity sensor is configured and mounted for sensing humidity in the room (1).
6. A system according to any of the preceding claims, wherein the humidity sensor is mounted such that it is accessible for air in the room (1) at all times.
7. A system according to any of the preceding claims, wherein the humidity sensor is mounted within the room and, if there is a ventilation system for the room (1), outside the air inlet conduit thereof.
8. A system according to any of the preceding claims, wherein the humidity sensor is mounted at the inside of the boundary of the room (1) such as a wall or a door or a ceiling or a floor of the room.
9. A system according to any of the preceding claims, wherein the humidity sensor is configured for sensing absolute humidity.

10. A system according to any of the preceding claims,
wherein the cooling device (4) is mounted above the
ceiling (2) of the room (1).
11. A system according to any of the preceding claims, 5
wherein the regulating device (7) is configured for
calculating an estimate of relative humidity at the
cooling device (4) at least on the basis of signals
obtained from the temperature sensor and from the
humidity sensor. 10
12. A system according to any of the preceding claims,
wherein the regulating device (7) is configured for
calculating an estimate of the relative humidity at the
cooling device (4) in an area thereof at least on the 15
basis of signals from the temperature sensor and
from the humidity sensor.
13. A system according to any of the preceding claims,
wherein the regulating device (7) is configured for 20
calculating an estimate of the relative humidity at the
cooling device in an area thereof that has been se-
lected for high relative humidity or for relative position
to the boundary of the room (1), at least on the basis 25
of signals from the temperature sensor and from the
humidity sensor.
14. A system according to any of the preceding claims,
wherein the regulating device (7) is configured for
calculating an estimate of relative humidity at the 30
cooling device (4) in an area thereof, by using at least
stored values for calculating an estimate of the heat
transport through the boundary of the room (1) out-
side which the cooling device (4) is mounted, at least
on the basis of signals from the temperature sensor 35
and from the humidity sensor.
15. A system according to any of the preceding claims,
wherein the regulating device (7) is configured for
calculating an estimate of the relative humidity at the 40
cooling device in an area thereof, by using at least
stored values for calculating an estimate of the heat
sink effect of the cooling device (4), at least on the
basis of signals from the temperature sensor and
from the humidity sensor. 45

50

55

FIG 1





EUROPEAN SEARCH REPORT

 Application Number
 EP 17 16 0244

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2010/112867 A1 (EATON WILLIAMS GROUP LTD [GB]; LUXFORD MARK [GB]; MORGAN DAVID [GB]) 7 October 2010 (2010-10-07) * page 10, line 21 - page 11, line 16; claims 1,12-14; figures 1,3,4 *	1-15	INV. F24F11/00 F24F13/22
A	US 2012/073783 A1 (NAIR RAJESH M [US]) 29 March 2012 (2012-03-29) * paragraph [0015]; figure 1 *	1-15	
A	US 2012/193066 A1 (LOWTHER PETER QUENTIN [GB]) 2 August 2012 (2012-08-02) * paragraphs [0046] - [0054]; figure 1 *	1-15	
A	US 4 526 011 A (LOGAN MAX C [US] ET AL) 2 July 1985 (1985-07-02) * abstract *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			G07C F24F G01J
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 12 September 2017	Examiner Degen, Marcello
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

 1
 EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 17 16 0244

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

12-09-2017

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010112867 A1	07-10-2010	CN 102449407 A	09-05-2012
		DK 2414741 T3	07-09-2015
		EP 2414741 A1	08-02-2012
		EP 3012544 A1	27-04-2016
		ES 2546662 T3	25-09-2015
		HK 1224003 A1	11-08-2017
		JP 2012522958 A	27-09-2012
		US 2011168379 A1	14-07-2011
		WO 2010112867 A1	07-10-2010

US 2012073783 A1	29-03-2012	NONE	

US 2012193066 A1	02-08-2012	EP 2481996 A1	01-08-2012
		GB 2487611 A	01-08-2012
		US 2012193066 A1	02-08-2012

US 4526011 A	02-07-1985	NONE	

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- **JEFF CLARK.** HUMIDITY IN THE DATA CENTER:
DO WE STILL NEED TO SWEAT IT?. *Data Center
Journal*, 27 March 2012 **[0012]**