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(54) SYSTEM AND METHOD FOR VENTILATING A DEFINED SPACE

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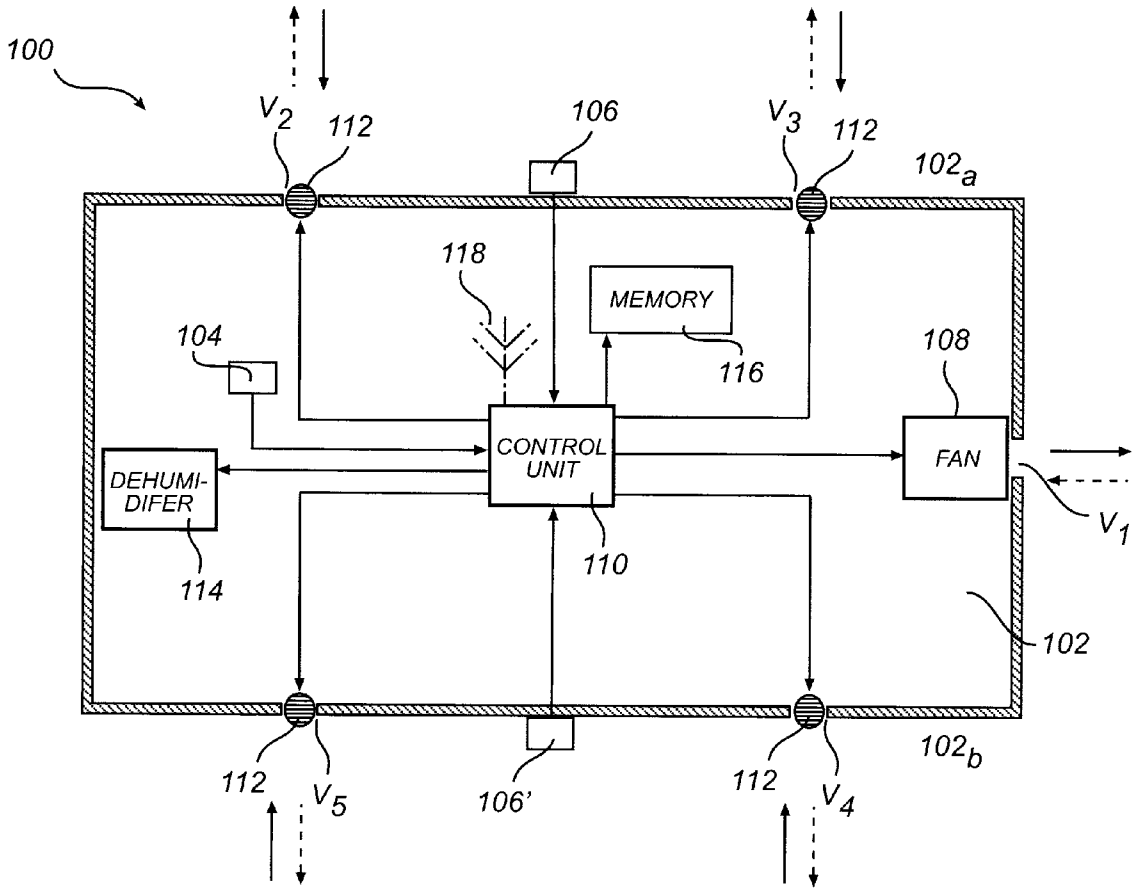
(57) **ABSTRACT**

The present invention relates to a system (**100**) for ventilating a defined space (**102**), such as for example an enclosed or at least partly enclosed basement, crawlspace or attic. The system (**100**) comprises a control unit (**110**) connected to at least one inside sensor (**104**), at least one outside sensor (**106**) and a controllable fan (**108**), the control unit (**110**) being configured to operate the controllable fan (**102**) if the absolute humidity (AH_{out}) outside of the defined space (**102**) is lower or equal to the absolute humidity (AH_{in}) within the defined space (**102**), and the temperature (T_{in}) within the defined space (**102**) is above a predetermined temperature when the temperature (T_{in}) outside of the defined space (**102**) is below the temperature (T_{in}) within the defined space (**102**). Advantages of the invention include energy efficient ventilation of the defined space and a high level of protecting from moisture related problems.



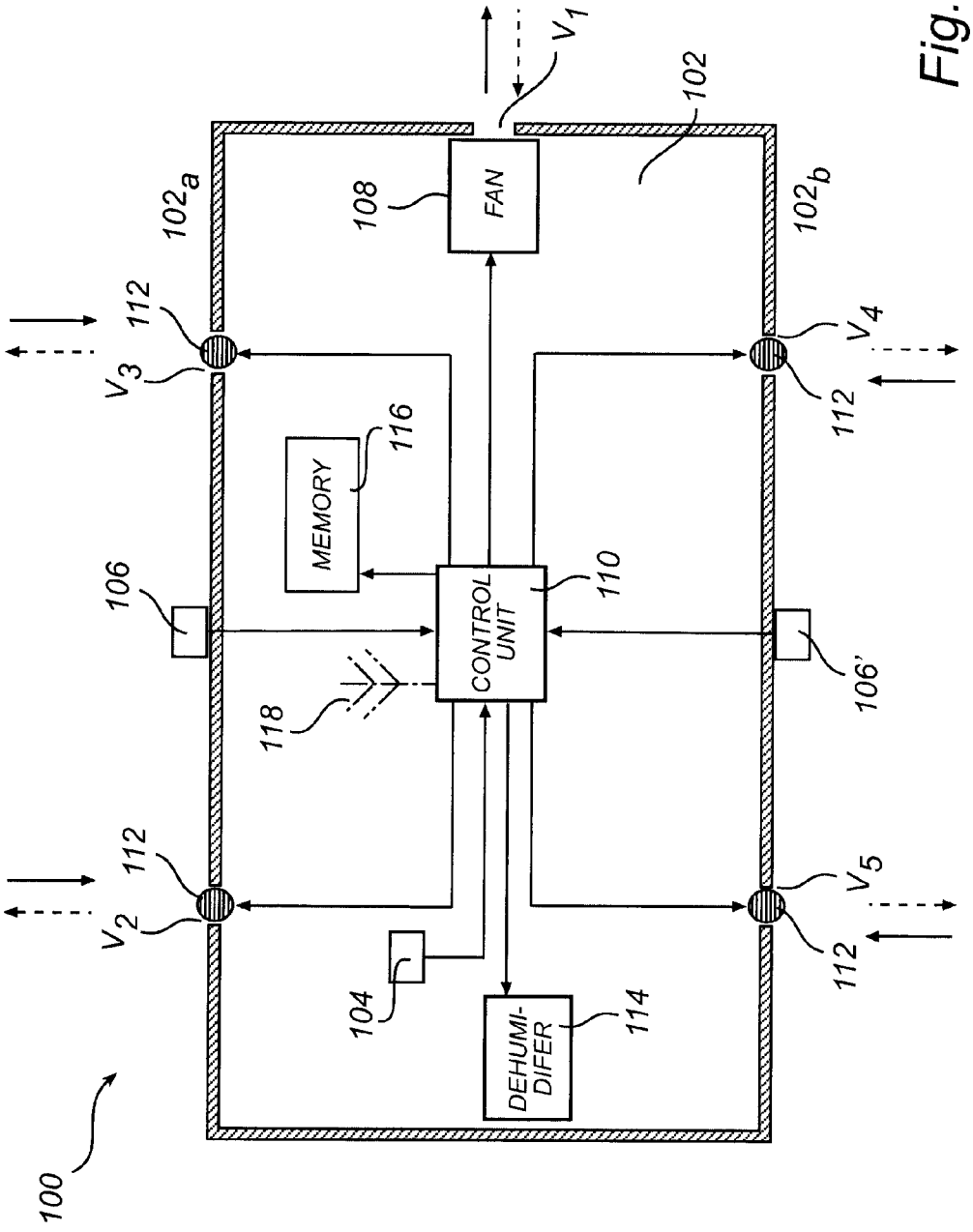

100
102
102a
102b
FAN
108
MEMORY
116
CONTROL UNIT
110
DEHUMI-DIFER
114
104
118
106
106'
112
V1
V2
V3
V4
V5

Fig. 1

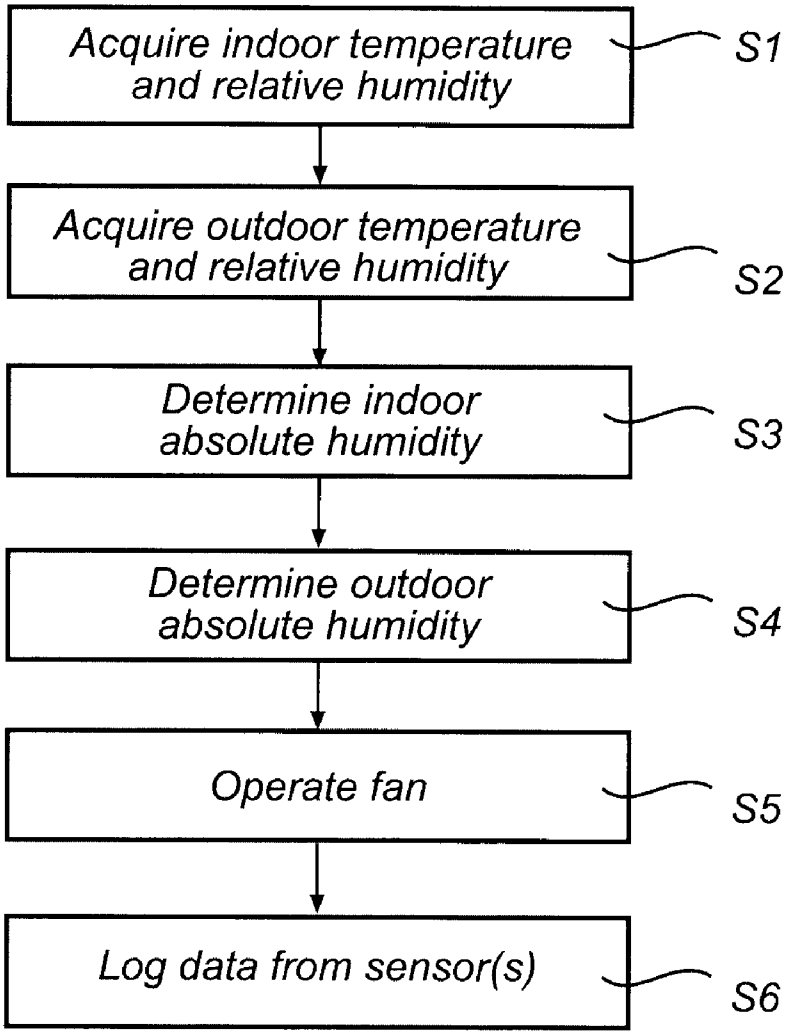

Acquire indoor temperature and relative humidity
S1
Acquire outdoor temperature and relative humidity
S2
Determine indoor absolute humidity
S3
Determine outdoor absolute humidity
S4
Operate fan
S5
Log data from sensor(s)
S6

Fig. 2

SYSTEM AND METHOD FOR VENTILATING A DEFINED SPACE

TECHNICAL FIELD

[0001] The present invention relates to a system and method for ventilating a defined space, such as for example an enclosed or at least partly enclosed basement, crawlspace, attic or trailer.

BACKGROUND OF THE INVENTION

[0002] There exists a plurality of different types of foundation used when constructing a building, such as for example a residential house. The most common types are crawlspaces and slab foundations, where crawlspaces generally are considered to possibly have some advantages over slab foundations. For example, crawlspaces, forming a defined space, offer a convenient access to pipes, substructures and a variety of other areas that may be difficult or expensive to access otherwise.

[0003] However, crawlspaces need to be ventilated with outside air, as water from the damp earth, humidity entering from crawlspace vents, and moisture seeping through porous concrete will create a perfect environment for mold, mildew to form on any surface in the crawlspace, especially wood floors and surfaces, drywall and some types of insulation. If not paying proper attention, molds, spores, bacteria, higher levels of chemical vapors and/or radon may migrate into the house.

[0004] Accordingly, there is a general desire to regulate the ambient humidity of the crawlspace interior to maintain reduced moisture levels to preserve the structural integrity of the house. For example, WO08039149 tries to solve this by controlling the supply of heat inside the crawlspace, based on known information about growing time and growing conditions for occurring mildew and rot fungi and absorption of moisture in occurring materials, possibly secures a climate where moisture-related damage cannot arise.

[0005] However, even though WO08039149 provides some relief to the inherent problems with crawlspaces, the supply of heat may be energy inefficient for the owner of the house. Accordingly, there exists a need for an effective and convenient system for use in monitoring and protecting defined spaces that are susceptible to moisture damage.

SUMMARY OF THE INVENTION

[0006] According to an aspect of the invention, the above is at least partly met by a system for ventilating a defined space, comprising at least one inside sensor configured to measure temperature and relative humidity within the defined space, at least one outside sensor configured to measure temperature and relative humidity outside of the defined space, a controllable fan adapted to ventilate the defined space, and a control unit connected to the at least one inside sensor, the at least one outside sensor and the controllable fan, the control unit being configured to determine absolute humidity within the defined space and absolute humidity outside of the defined space, wherein the control unit is further configured to operate the controllable fan if the absolute humidity outside of the defined space is lower or equal to the absolute humidity within the defined space, and the temperature within the defined space is above a predetermined temperature threshold when the temperature outside of the defined space is below the temperature within the defined space.

[0007] The present invention is based on the understanding that it may be advantageous to control the operation of the forced ventilation based on a comparison of the "indoor" absolute humidity and the "outdoor" absolute humidity rather than being based on the corresponding relative humidity in/outside of the defined space as is the case with some prior art ventilation systems. Using the absolute humidity inside/outside of the defined space further increases the reliability of the system and thereby the possibility of protecting the defined space from e.g. moisture related problems and/or damages.

[0008] In cases where the ground of the enclosed space is humid, the system may be complemented with a vapor barrier on the ground to keep moisture from evaporating into the air due to the increased airflow through the enclosed space.

[0009] On top of this, and as is noted above, the defined space is not ventilated if the inside temperature is below a predefined temperature threshold and the outside temperature is below the inside temperature. Preferably, the predetermined temperature threshold is within the range of 3-10° C., preferably 4-8° C. and most preferably 5-6° C. Thereby, the energy efficiency of the system is further increased as it has been found not necessary to ventilate the defined space outside this condition, i.e. when the inside temperature for example is below 3-10° C. as essentially no moisture related problems and/or damages will exist at this temperature. By not having to ventilate the defined space at below the above exemplified predefined temperature threshold, warm air within the defined space will not be expelled from the defined space, possibly affecting other for example living spaces adjacently arranged with the defined space. Also, by not ventilating at below the specific temperature, warm and possibly humid air from the adjacently arranged spaces will not be drawn into the crawlspace by mistake, possibly affecting the humidity levels within the enclosed space. In some cases it may however be necessary/useful to also ventilate the defined area even if the inside temperature is below the predefined temperature threshold. In such cases it is however desirable to ventilate in a restrictive manner, possibly during shorter time periods.

[0010] Advantageously, the control unit is further arranged to, in combination with the above two conditions, only operate the controllable fan if also the temperature outside the defined space is above a predetermined temperature threshold when the temperature outside of the defined space is below the temperature within the defined space. This further increases the reliability of the system.

[0011] Preferably, the enclosed or at least partly enclosed defined space is selected from a group comprising a basement, a crawlspace, an attic, a storage room, a caravan, a trailer and a cabin. Another defined space that is susceptible to moisture damage is the interior space of boats. In particular, the engine rooms and the interior cabins of boats that are stored at marinas can easily become mildewed, giving the boats a musty odor and damaging the materials of the boats.

[0012] In a preferred embodiment the system comprises at least two outside sensors arranged on opposite sides of the defined space, for example one outside sensor arrange at the northern side of the defined space and one sensor arranged at the southern side of the defined space. Further sensors, inside and/or outside of the defined space may of course be possible and within the scope of the invention. Additionally, by providing the system with at least one controllable valve connected to the control unit, for example two controllable valves

arranged on the northern and southern side of the defined space, respectively, and configured to allow for supply of air to the defined space, it may be possible to ventilate the defined space using air from a side of the defined space where conditions are the most favorable.

[0013] Additionally, in some conditions it may also be possible to close the at least one controllable valve if the absolute humidity outside of the defined space is higher than the absolute humidity within the defined space.

[0014] In some cases it may be possible to further equip the system with a dehumidifier connected to and controllable by the control unit, where the control unit further may be configured to close the at least one valve and operate the dehumidifier if the relative humidity within the defined space is above a predefined humidity threshold, the humidity threshold possibly being within the range of 50-90%, preferably 60-80% and most preferably 65-75%. Operating the dehumidifier may be necessary if conditions are very unfavorable and obvious moisture related problems may exist. Such conditions may for example relate to specific weather conditions and/or due to construction related issues.

[0015] Preferably, the system further comprises an operator accessable logger connected to the control unit and configured to log data from the inside and/or outside sensor(s). The logger may be for example comprise a digital storage means such as an USB or a flash memory card, e.g. CompactFlash, Memory Stick, Secure digital etc and be accessed by the home owner or any other possibly remote and valid users for reviewing the conditions over a longer time period, such as over a month, quarter, year and so on for determining the structural integrity of the house.

[0016] Alternatively or additionally the logger may be connected to a remote server where the information from the sensor(s) is stored. Thereby, other valid users, such as potential house buyers, house brokers, etc. may access the information to draw conclusions as to the health of the house. The transmission may be wired or wireless, including for example wired connections like USB, FireWire, VGA, or similar, and wireless connections like WLAN, CDMA, GSM, GPRS, 3G mobile communications, 4G mobile communications, Bluetooth, infrared, or similar.

[0017] According to another aspect of the present invention there is provided a method for ventilating a defined space, the method comprising the steps of acquiring temperature and relative humidity within the defined space using at least one inside sensor, acquiring temperature and relative humidity outside of the defined space using at least one outside sensor, determining absolute humidity within the defined space, determining absolute humidity outside of the defined space, and operating a controllable fan if the absolute humidity outside of the defined space is lower or equal to the absolute humidity within the defined space, and the temperature within the defined space is above a predetermined temperature threshold when the temperature outside of the defined space is below the temperature within the defined space. This aspect of the invention provides similar advantages as discussed above in relation to the previous aspect of the invention.

[0018] Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following description. The skilled addressee realize that different features of the present invention may be combined to create embodiments other than those described in the following, without departing from the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The various aspects of the invention, including its particular features and advantages, will be readily understood from the following detailed description and the accompanying drawings, in which:

[0020] FIG. **1** conceptually illustrates a currently preferred embodiment of the system for ventilating a defined space; and

[0021] FIG. **2** shows a schematic flow chart of a currently preferred method for ventilating a defined space.

DETAILED DESCRIPTION

[0022] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which currently preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be constructed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness, and fully convey the scope of the invention to the skilled addressee. Like reference characters refer to like elements throughout.

[0023] Referring now to the drawings and to FIG. **1** in particular, there is depicted a system **100** for ventilating a defined space, such as for example a crawlspace **102**. The system **100** further comprises an inside sensor **104**, for example centrally arranged within the crawlspace **102** and a first and a second outside sensor **106**, **106'** arranged on opposite sides $\mathbf{102}_a$, $\mathbf{102}_b$, outside of the crawlspace **102**, respectively. The inside **104** and the outside sensors **106**, **106'** may be of the same type, or may be specifically adapted based on their placement, e.g. having different waterproofing/protection. Each of the sensors **104**, **106**, **106'** is further configured to measure temperature ($T_{in/out}$) and relative humidity ($RH_{in/out}$) at their placement, respectively. The sensors **104**, **106**, **106'** may comprise a combination of elements for sensing temperature and humidity, or may be combined into a single element.

[0024] The system **100** also comprise a controllable fan **108** adapted to ventilate the defined space. The fan **108** is preferably arranged in vicinity of a ventilation opening V_1 of the crawlspace **102** and configured to provide a ventilation rate for example depending on the volume/area of the crawlspace **102**, for example base on speed control of the fan **108**. The fan **108** may be operated in two directions, i.e. to draw air from the outside of the defined area **102** into the defined area **102**, or to expel air out from the defined area **102**. The selected direction may for example depend on the type of defined area **102**, where for example it may be preferred to expel air out from a crawlspace, but rather draw air into an attic.

[0025] The system further comprises a control unit control unit **110** being connected to the inside and outside sensors **104**, **106** and **106'**, and the fan **108**. The connection between the sensors **104**, **106** and **106'**, the fan **108** and the control unit **110** may be wired or wireless (using for example Bluetooth, infrared, ZigBee, or similar). The control unit **110** may include a microprocessor, a microcontroller, a programmable digital signal processor or another programmable device. The control unit **118** may also, or instead, include an application specific integrated circuit (ASIC), a programmable gate array programmable array logic, a programmable logic device, or a digital signal processor. Where the control unit **110** includes a programmable device such as the microprocessor or micro-

controller mentioned above, the processor may further include computer executable code that controls operation of the programmable device.

[0026] The control unit **110** is further connected to an operator accessable logger, such a memory **116** and configured to log data from the sensors and/or operation periods and speed of the fan **108**. Optionally or alternatively, the control unit **110** may be provided with a communication module **118** for providing the logged data to e.g. a remote server (not shown).

[0027] Additionally, in FIG. **1** there are provided a plurality of further ventilation openings V_2, V_3, V_4 and V_5, where two ventilation openings are provided on each of the opposite sides $\mathbf{102}_a$, $\mathbf{102}_b$ of the crawlspace **102** and in conjunction to the first and second outside sensors **106**, **106'**. The opposite sides $\mathbf{102}_a$, $\mathbf{102}_b$ of the crawlspace **102** may for example represent the north and southern sides of a building where the crawlspace **102** forms a foundation. Each, or at least some, of the ventilation openings V_2, V_3, V_4 and V_5 may be provided with valves **112** connected to and controllable by the control unit **110**. The valves **112** may be configured to be operated individually of each other, and to be opened/closed at a plurality of levels. Further (or fewer) ventilation openings, valves as well as outside sensors may of course be provided, e.g. one outside sensor per ventilation opening/ valve.

[0028] Some embodiments of the system **100** may additionally comprise a dehumidifier **114** arranged within the crawlspace **102** and controllable by the control unit **110**, such as for example a mechanical/refrigerative dehumidifier or a desiccant dehumidifier. The type of dehumidifier **114** may for example depend on the expected temperature within the defined space, where mechanical/refrigerative dehumidifiers generally only operates well above 12° C. When using a dehumidifier **114**, water generated by the dehumidifier **114** may be arrange to be expelled out from the crawlspace **102** for example using a pipe or hose (not shown). Traditional drawbacks of using a dehumidifier **114** include a high energy cost. By using the system **100** to complement the dehumidifier, e.g. the dehumidifier only operates over a predefined humidity threshold, the humidity threshold possibly being within the range of 50-90%, preferably 60-80% and most preferably 65-75%, it is possible to reduce the usage of the dehumidifier and thus reduce the energy usage needed to keep the relative humidity at a low level.

[0029] Turning now to FIG. **2** which provides a schematic flow chart of a currently preferred method for operating the system **100** to ventilate the crawlspace **102**. The process starts in steps S**1** and S**2**, where the control unit **110** acquire temperature, $T_{in/out}$, and relative humidity, $RH_{in/out}$, from within and outside of the crawlspace **102** using the inside sensor **104** and outside sensors **106**, **106'**. Following the acquisition of the temperature, $T_{in/out}$, and relative humidity, $RH_{in/out}$, in step S**3** and S**4** the control unit **110** determines the absolute humidity $AH_{in/out}$ for each of the sensors **104**, **106** and **106'**, i.e. in the embodiment shown in FIG. **1**, inside of the crawlspace **102**, on the northern side $\mathbf{102}_a$ outside of the crawlspace **102** and on the southern side $\mathbf{102}_b$ of the crawlspace **102**. The control unit **110** may determine the respective absolute humidity, $AH_{in/out}$, for each of the sensors **104**, **106**, **106'** using an approximate calculation or using for example a Mollier diagram adapted for the control unit **110**.

[0030] Depending on the results of the determinations of the absolute humidity, $AH_{in/out}$, for each of the sensors **104**, **106**, **106'**, the controllable fan **102** may be operated, S**5**, to ventilate the crawlspace **102**. The general condition for ventilating the crawlspace **102** is dependent on that the absolute humidity AH_{out} outside of the crawlspace **102** is lower than or equal to the absolute humidity AH_{in} within the crawlspace **102**, and to that the temperature T_{in} within the crawlspace **102** is above a predetermined temperature threshold when the temperature T_{out} outside of the crawlspace **102** is below the temperature T_{in} within the crawlspace **102**.

[0031] In the preferred embodiment of the system **100** shown in FIG. **1** and provided with a crawlspace **102**, the temperature threshold is around 5-6° C., and the condition on each side $\mathbf{102}_a$, $\mathbf{102}_b$ outside of the crawlspace **102** is taken into account. That is, during a cold but sunny day where sun is only shining on the southern side $\mathbf{102}_b$, the condition on the northern side $\mathbf{102}_a$ may be such that the general conditions outlined above are not met, for example when averaging the conditions of the northern and southern sides $\mathbf{102}_a$, $\mathbf{102}_b$. However, if only taking into account the conditions of the southern side $\mathbf{102}_b$, the conditions for operating the fan **108** for ventilating the crawlspace **102** may be met. Accordingly, in such a situation the valves **112** arranged in with the ventilation openings V_2, V_3 on the northern side $\mathbf{102}_a$ may be closed. Thereby, when operating the fan **108**, air will essentially only be drawn into the crawlspace **102** through the ventilation openings V_4, V_5 on the southern side $\mathbf{102}_b$ where the valves **112** are opened. Other ways of operating the valves **112** and the fan **108** may of course apply, i.e. where the valves **112** are individually operated such that the crawlspace **112** is ventilated in the most favorable manner but following the general conditions according to the invention.

[0032] The acquisition, S**1**/S**2**, as well as the determination S**3**/S**4** is preferably done periodically, for example every minute or hour. Thereby the best possible ventilation may be provided for the crawlspace **102**. Additionally, essentially in parallel to steps S**1**-S**5**, the control unit **110** may additionally be configured to operate a step S**6** where the values acquired from the sensors **104**, **106**, **106'** as well as control speed/ operating periods for the fan **108** may be logged.

[0033] Even though the invention has been described with reference to specific exemplifying embodiments thereof, many different alterations, modifications and the like will become apparent for those skilled in the art. Variations to the disclosed embodiments can be understood and effected by the skilled addressee in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. For example, in the above description of the ventilation system a plurality of elements, e.g. valves, dehumidifier, etc., have been included with the system. However, the system need not to at the same time comprise all of the above shown elements, but rather only some elements are necessary to at least provide the basic features of the invention as defined by the below claims.

[0034] Additionally, in some cases the conditions within the crawlspace may be determined to be so unfavorable such that it is necessary to active the dehumidifier, for example if the relative humidity, RH, reaches 70-75% humidity. When doing so it may generally be preferred to close all of the valves. Furthermore, in case the fan is provided with a valve (not shown) also such a valve may be closed.

[0035] Furthermore, in the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality.

We claim:

1. A system for ventilating a defined space, comprising:

at least one inside sensor configured to measure temperature and relative humidity within the defined space;

at least one outside sensor configured to measure temperature and relative humidity outside of the defined space;

a controllable fan adapted to ventilate the defined space; and

a control unit connected to the at least one inside sensor, the at least one outside sensor (**106**) and the controllable fan, the control unit being configured to determine absolute humidity within the defined space and absolute humidity outside of the defined space, wherein the control unit is further configured to operate the controllable fan if:

the absolute humidity outside of the defined space is lower or equal to the absolute humidity within the defined space, and

the temperature within the defined space is above a predetermined temperature threshold when the temperature outside of the defined space is below the temperature within the defined space.

2. The system of claim **1**, wherein the control unit is further configured to only operate the controllable fan if also the temperature outside the defined space is above a predetermined temperature threshold when the temperature outside of the defined space is below the temperature within the defined space.

3. The system of claim **1**, wherein the predetermined temperature threshold is within the range of 3-10° C., preferably 4-8° C. and most preferably 5-6° C.

4. The system of claim **1**, wherein the defined space is at least one of a basement, a crawlspace, a boat, an attic, a storage room, a caravan, a trailer, a cabin, a container.

5. The system of claim **1**, wherein the system comprises at least two outside sensors arranged on opposite sides of the defined space.

6. The system of claim **1**, wherein the system further comprises at least one controllable valve connected to the control unit, and the control unit is further configured to close the at least one controllable valve if the absolute humidity outside of the defined space is higher than the absolute humidity within the defined space.

7. The system of claim **6**, wherein the system further comprises a dehumidifier connected to and controllable by the control unit, the control unit further being configured to close the at least one valve and operate the dehumidifier if the relative humidity within the defined space is above a predefined humidity threshold.

8. The system of claim **7**, wherein the predetermined humidity threshold is within the range of 50-90%, preferably 60-80% and most preferably 65-75%.

9. The system of claim **1**, wherein the system further comprises an operator accessible logger connected to the control unit and configured to log data from the inside and/or outside sensor(s).

10. A method for ventilating a defined space, the method comprising the steps of:

acquiring temperature and relative humidity within the defined space using at least one inside sensor;

acquiring temperature and relative humidity outside of the defined space using at least one outside sensor;

determining absolute humidity within the defined space;

determining absolute humidity outside of the defined space; and

operating a controllable fan if:

the absolute humidity outside of the defined space is lower or equal to the absolute humidity within the defined space, and

the temperature within the defined space is above a predetermined temperature threshold when the temperature outside of the defined space is below the temperature within the defined space.

11. The method of claim **10**, wherein the controllable fan is operable only if also the temperature outside the defined space is above a predetermined temperature threshold when the temperature outside of the defined space is below the temperature within the defined space.

12. The method of claim **10**, further comprising the step of logging data from the inside and/or outside sensor(s).

13. The system of claim **1**, wherein the predetermined temperature threshold is within the range of 4-8° C.

14. The system of claim **1**, wherein the predetermined temperature threshold is within the range of 5-6° C.

15. The system of claim **7**, wherein the predetermined humidity threshold is within the range of 60-80%.

16. The system of claim **7**, wherein the predetermined humidity threshold is within the range of 65-75%.

* * * * *