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(54) **SYSTEM AND METHOD TO MAINTAIN NEGATIVE PRESSURE WITHIN ENCLOSED SPACES**

(57) The present disclosure provides a system (100) to maintain a negative pressure within an enclosed space (102). The system (100) comprises a negative pressure unit (110). The negative pressure unit (110) creates an internal pressure within the enclosed space (102). The system (100) further comprises an internal pressure determination unit (116) disposed within the enclosed space (102). The internal pressure determination unit (116) determines an internal pressure information of the enclose space (102). Moreover, the system (100) comprises a data logger (118) coupled to the negative pressure unit (110) and the internal pressure determination unit (116). The data logger (118) receives the internal pressure information from the internal pressure determination unit (116). Further, the data logger (118) analyses the internal pressure information to calculate a change to be made to an operating characteristic of the negative pressure unit (110). Moreover, the data logger (118) manages the negative pressure unit (110) to regulate the operating characteristic of the negative pressure unit (110) to maintain the enclosed space (102) at a predefined negative pressure.

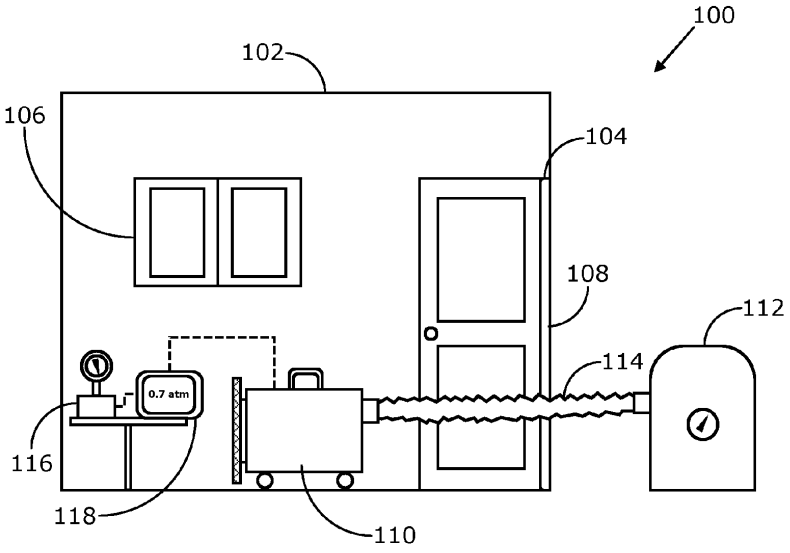

FIG. 1

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Description

FIELD OF INVENTION

[0001] The present disclosure generally relates to pressure creation devices and specifically, to a system to maintain a negative pressure within an enclosed space. The present disclosure also relates to manage negative pressure unit from a remote location to maintain a negative pressure within enclosed space.

BACKGROUND

[0002] Generally, people only spend a limited amount of time in any particular indoor facility. Such an indoor facility can comprise their homes, schools, offices, favourite cafes, and the like. Thus, such indoor facilities only suffer a moderate amount of wear and tear from regular usage, only requiring repairs or renovations once every few years or so. However, since the COVID-19 pandemic started affecting the global population in late 2019, governments-imposed lockdowns to ensure safety of people, necessitating everyone to self-quarantine by staying indoors for extended durations. Further, once the COVID-19 transmission rates decreased and the imposed lockdowns were lifted, various indoor facilities where the people had self-quarantined had suffered substantial wear and tear, requiring urgent repairs and renovations.

[0003] It will be appreciated that numerous repairs and renovations of adjacent indoor facilities, if performed simultaneously, can have a major adverse effect not only on users of such indoor facilities but also an external environment outside the indoor facilities. For example, particulate manner including PM2.5 and PM10 that gets expelled during repair and renovation of one uninhabited facility may enter a neighbouring facility that may be inhabited by occupants such as children, geriatrics, pets, and the like, leading to such occupants potentially suffering adverse health effects such as allergic reactions, asthmatic attacks, breathing difficulties and so forth.

[0004] Therefore, in light of the foregoing discussion, there exists an urgent need for solutions that enable reconstruction processes to be undertaken without adversely effecting neighbouring facilities or the environment.

SUMMARY

[0005] The present disclosure seeks to enable management of a negative pressure generating device from remote location. The present disclosure further seeks to provide a method for managing a negative pressure within an enclosed space. An aim of the present disclosure is to provide a solution that overcomes at least partially the problems encountered in prior art.

[0006] The present disclosure relates to a system to maintain a negative pressure within an enclosed space. The present disclosure also relates to a method to maintain a negative pressure within an enclosed space.

[0007] In one aspect of the present disclosure, there is provided a system to maintain a negative pressure within an enclosed space. The system comprises a negative pressure unit disposed within the enclosed space. The negative pressure unit creates an internal pressure within the enclosed space. The system further comprises an internal pressure determination unit disposed within the enclosed space. The internal pressure determination unit determines an internal pressure information of the enclose space. Moreover, the system comprises a data logger coupled to the negative pressure unit and the internal pressure determination unit. The data logger receives the internal pressure information from the internal pressure determination unit; analyses the internal pressure information to calculate a change to be made to an operating characteristic of the negative pressure unit; and manages the negative pressure unit to regulate the operating characteristic of the negative pressure unit to maintain the enclosed space at a predefined negative pressure.

[0008] In one embodiment, the system further comprises an external pressure determination unit disposed outside the enclosed space. The external pressure determination unit determines an external pressure information associated with an environment outside the enclosed space. The data logger adjusts the operating characteristic of the negative pressure unit based on the determined external pressure information.

[0009] In another embodiment, the system further comprises at least one secondary negative pressure device coupled to the data logger. The data logger receives an operating parameter from each secondary negative pressure device or the operating characteristic of the negative pressure unit and regulates the operating parameter of at least one secondary negative pressure device or the operating characteristic of the negative pressure unit to maintain the enclosed space at the predefined negative pressure.

[0010] In yet another embodiment, the at least one secondary negative pressure device is disposed at a subregion of the enclosed space.

[0011] In still another embodiment, the data logger is implemented in a cloud server arrangement. The cloud server arrangement stores a historical information associated with the negative pressure maintained within the enclosed space.

[0012] In a further embodiment, the internal pressure determination unit comprises a sensor unit to detect a motion event within the enclosed space. The data logger determines a change in the internal pressure information based on the detected motion event within the enclosed space and recalibrates the operating characteristic of the negative pressure unit based on the determined change in the internal pressure information.

[0013] In another embodiment, the sensor unit is implemented using a motion sensor or a sound pulse de-

tector.

[0014] In yet another embodiment, the data logger receives a weather forecast information from a server platform.

[0015] In still another embodiment, the system further comprises an input unit that receives a user input. The user input comprises a time input corresponding to a specific duration. The data logger maintains the negative pressure within the enclosed space for the specific duration.

[0016] In a further embodiment, the input unit receives a control command from a user to control the negative pressure unit.

[0017] In another embodiment, the operating characteristic of the negative pressure unit is selected from an electrical power supplied to the negative pressure unit, a rotational speed of a motor associated with the negative pressure unit, and an orientation of the negative pressure unit within the enclosed space.

[0018] In yet another embodiment, the system further comprises a data transceiver for transmission of information between an operator accessible computing unit, the data logger, and the negative pressure unit.

[0019] In still another embodiment, the data logger transmits an alert signal comprising an operational status of the negative pressure unit.

[0020] In another aspect of the present disclosure, there is provided a method to maintain a negative pressure within an enclosed space. The method comprises disposing a negative pressure unit within the enclosed space. The negative pressure unit creates an internal pressure within the enclosed space. The method further comprises determining an internal pressure information of the enclosed space. Moreover, the method comprises analysing the internal pressure information to calculate a change to be made to an operating characteristic of the negative pressure unit. The method also comprises operating the negative pressure unit to regulate the operating characteristic of the negative pressure unit to maintain the enclosed space at a predefined negative pressure.

[0021] In one embodiment, the method further comprises regulating the operating characteristic of the negative pressure unit based on a particle count information derived from a particle counter.

[0022] Additional aspects, advantages, features, and objects of the present disclosure would be made apparent from the drawings and the detailed description of the illustrative embodiments construed in conjunction with the appended claims that follow.

[0023] It will be appreciated that features of the present disclosure are susceptible to being combined in various combinations without departing from the scope of the present disclosure as defined by the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0024] The summary above, as well as the following detailed description of illustrative embodiments, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the present disclosure, exemplary constructions of the disclosure are shown in the drawings. However, the present disclosure is not limited to specific methods and instrumentalities disclosed herein. Moreover, those skilled in the art will understand that the drawings are not to scale. Wherever possible, like elements have been indicated by identical numbers.

[0025] Embodiments of the present disclosure will now be described, by way of example only, with reference to the following diagrams wherein:

FIG. 1 shows a schematic illustration of a system to maintain a negative pressure within an enclosed space as per one embodiment of the present disclosure;

FIG. 2 shows a schematic illustration of the system of FIG. 1 according to another embodiment of the present disclosure;

FIG. 3 shows a schematic illustration of a system to maintain a negative pressure within enclosed spaces as per one embodiment of the present disclosure;

FIG. 4 shows a pressure difference vs. time graph for operation of a system to maintain a negative pressure within an enclosed space (such as the system of FIG. 1) according to one embodiment of the present disclosure; and

FIG. 5 shows a flowchart illustrating a method to maintain a negative pressure within an enclosed space as per one embodiment of the present disclosure.

[0026] In the accompanying drawings, an underlined number is employed to represent an item over which the underlined number is positioned or an item to which the underlined number is adjacent. A non-underlined number relates to an item identified by a line linking the non-underlined number to the item. When a number is non-underlined and accompanied by an associated arrow, the non-underlined number is used to identify a general item at which the arrow is pointing.

DETAILED DESCRIPTION OF EMBODIMENTS

[0027] The following detailed description illustrates embodiments of the present disclosure and ways in which they can be implemented. Although some modes of carrying out the present disclosure have been disclosed, those skilled in the art would recognize that other embodiments for carrying out or practising the present disclosure are also possible.

[0028] The present disclosure relates to a system to

maintain a negative pressure within an enclosed space. The term "enclosed space" as used throughout the present disclosure relates to a building having walls enclosing a particular volume to allow people or animals to reside within the building. Such a building may be a residential building such as a house (or a residential apartment in an apartment complex), a pet shelter and the like or a commercial establishment including a hotel (or a particular room within a hotel), a movie hall (or a single movie hall within a multiplex movie theatre), a pet shop and so forth. Further, the term "negative pressure" as used throughout the present disclosure relates to an amount of pressure inside the enclosed space such that the amount of pressure is lower than pressure outside the enclosed space. Such a pressure outside the enclosed space can relate to atmospheric pressure. For example, the enclosed space is a convenience store attached to a petrol bunk such that the convenience store has an entry and an exit towards a street outside the petrol bunk. Further, the pressure outside the enclosed space would be atmospheric pressure having a value of 101325 Pa (or 1 atm). In such an example, the negative pressure within the enclosed space can be 100311.75 Pa (or 0.99 atm), 99298.5 Pa (or 0.98 atm), 96258 Pa (or 0.95 atm), 91192.5 Pa (or 0.9 atm), 81060 Pa (or 0.8 atm), 75993.75 (or 0.75 atm) and the like. Alternatively, the pressure outside the enclosed space, such as a first enclosed space, can relate to pressure inside an adjacent enclosed space, such as a second enclosed space with which the first enclosed space is fluidically coupled (such that air can flow between the first enclosed space and the second enclosed space). For example, the first enclosed space can be an office room having an entry and an exit into an enclosed lobby that comprises the second enclosed space. The pressure inside the enclosed lobby can be 91192.5 Pa (or 0.9 atm). In such an example, the negative pressure inside the office room can be 90179.25 Pa (or 0.89 atm) or 86126.25 Pa (or 0.85 Pa), 81060 Pa (or 0.8 atm), 70927.5 Pa (or 0.7 atm) and the like.

[0029] The system comprises a negative pressure unit disposed within the enclosed space. The negative pressure unit creates an internal pressure within the enclosed space. The term "negative pressure unit" as used throughout the present disclosure relates to an electromechanical device that is capable of being operated, such as by supplying electrical power to the device, to create negative pressure inside the enclosed space in which the negative pressure unit is disposed. Such a negative pressure unit operates by drawing air containing contaminants such as dust from inside the enclosed space and depositing the drawn air out of the enclosed space, for example, into a collection tank. Optionally, a filter is arranged in a flow path between the negative pressure unit and the collection tank or between the collection tank and an output port, such that the filter is capable of removing contaminants from the air that is transmitted out of the enclosed space or the negative pressure unit. Consequently, the filter can be disposed within the enclosed space to prevent escape of the contaminants from the enclosed space. Optionally, a current state of the filter can be monitored, such as, to enable timely changing or cleaning of the filter as and when needed. The negative pressure unit creates the internal pressure within the enclosed space such that the internal pressure is lower than an external pressure outside the enclosed space. It will be appreciated that creation of such an internal pressure to be lower than the external pressure outside the enclosed space inhibits natural flow of air from the enclosed space to an external environment out of the enclosed space due to pressure difference between the enclosed space and the external environment. Consequently, contaminants such as dust and debris that are expelled during repair or renovation of the enclosed space are retained within the enclosed space for controlled discarding of the contaminants later. Thus, the negative pressure unit reduces air pollution (due to fine dust/particle of contaminants), prevents damage to other surfaces of the enclosed space, maintain hygienic environment for humans (such as, working personals or occupants of the enclosed space) or animals (such as, pets including dogs, cats, parrots, and the like).

[0030] The system comprises an internal pressure determination unit disposed within the enclosed space. The internal pressure determination unit determines an internal pressure information of the enclose space. The term "internal pressure determination unit" as used throughout the present disclosure refers to an electronic device that is capable of detecting an amount of pressure within the enclosed space in which the internal pressure determination unit is disposed. It will be appreciated the enclosed space that is being subjected to repairing or renovation may experience changes in the internal pressure within the enclosed space. Such changes in the internal pressure can be caused by operation of the negative pressure unit disposed within the enclosed space, movement of air into or out of the enclosed space (such as, due to opening of doors or windows), changes in weather (such as, precipitation outside the enclosed space) and the like. The internal pressure determination unit enables to determine the amount of pressure within the enclosed space to enable detection of any changes in the amount of pressure, thereby, enabling to reliably maintain the negative pressure within the enclosed space. The internal pressure determination unit enables real-time or near real-time monitoring of the enclosed space, thereby, enabling automatic or semi-automatic control of the negative pressure unit based on the determined internal pressure information.

[0031] In one example, the internal pressure determination unit can be a pressure sensor (such as a barometer, an absolute pressure sensor, a gauge pressure sensor, a differential pressure sensor, a sealed pressure, and the like) that is disposed within the enclosed space such that the internal pressure determination unit detects the internal pressure inside the enclosed space. The internal pressure determination unit can output analogue

data corresponding to the detected internal pressure. Optionally, the internal pressure determination unit can be operably coupled to a microcontroller. The internal pressure determination unit transmits the analogue data corresponding to the detected internal pressure to the microcontroller such that the microcontroller subsequently converts the analogue data to digital information corresponding to internal pressure information of the enclose space. Optionally, the microcontroller can be configured to process the analogue data for generating the internal pressure information. In one example, the internal pressure determination unit transmits the analogue data to the microcontroller after a predefined duration. Such a predefined duration can be, for example, 0.01 second (or 1 ms), 0.05 seconds (or 50 ms), 0.1 second (or 100 ms) and the like. In such an example, the microcontroller determines a change in the internal pressure within the enclosed space by calculating a difference between a latest detected internal pressure and a previously detected internal pressure within the enclosed space. Subsequently, the microcontroller stores the difference and the latest detected amount of pressure as the internal pressure information of the enclosed space.

[0032] The system comprises a data logger coupled to the negative pressure unit and the internal pressure determination unit. The term "data logger" as used throughout the present disclosure relates to an electronic device that is communicably coupled to the negative pressure unit and the internal pressure determination unit. For example, the data logger can be implemented as a hardware device that includes a memory and a processor or preferably, a combination of multiple hardware devices and software modules. The data logger handles functions and operations by utilizing the hardware devices, the software modules or preferably, a combination of the hardware devices and software modules.

[0033] In one embodiment, the data logger is implemented in a cloud server arrangement. The cloud server arrangement stores a historical information associated with the negative pressure maintained within the enclosed space. The data logger implemented in the cloud server arrangement enables access to a cloud computing service to a user (such as a resident of a house in which the negative pressure unit is disposed) or an operator (such as a construction worker) or an operator (such as a system administrator that manages the operation from a remote location). The cloud computing service may allow temporary or permanent storage of information within the cloud server arrangement by connecting to an external network such as the Internet. The term "historical information" as used throughout the present disclosure refers to stored negative pressure information of the enclosed space and the stored operating characteristic information corresponding to the negative pressure unit disposed within the enclosed space. Such stored negative pressure information and the operating characteristic information relates to operation of the negative pressure unit at a previous time (for example, a previous hour, a previous day, a previous month, and the like). For example, the cloud server arrangement stores the historical information associated with operation of the negative pressure unit within the enclosed space in a chronological order, thereby, enabling convenient retrieval of such information at present time.

[0034] The communicable coupling between the data logger, the negative pressure unit and the internal pressure determination unit can be established via a wired communication interface or a wireless communication interface. For example, the data logger can be communicably coupled to the negative pressure unit and the internal pressure determination unit using Ethernet communication or fibre-optic communication. In another example, the data logger can be communicably coupled to the negative pressure unit and the internal pressure determination unit using Bluetooth, Wi-Fi, fifth-generation wireless communication, sixth-generation wireless communication and the like. Optionally, the data logger can transmit an input to the negative pressure unit and the internal pressure determination unit and in response, receive a corresponding output. In one example, the input can comprise a command for changing an operating characteristic of the negative pressure unit. The term "operating characteristic" of the negative pressure unit relates to a parameter associated with an operation of the negative pressure unit. It will be appreciated that the negative pressure unit can be operated at different operating characteristics to allow negative pressure associated with different internal pressures to be created within the enclosed space. Optionally, the negative pressure can be created at different rates within the enclosed space. In one embodiment, the operating characteristic of the negative pressure unit is selected from: an electrical power supplied to the negative pressure unit, a rotational speed of a motor associated with the negative pressure unit, ON/OFF the negative pressure unit, time duration during which negative pressure unit remain active or inactive, an orientation of the negative pressure unit within the enclosed space. The electrical power supplied to the negative pressure unit can be varied to modify operation of various electrical components of the negative pressure unit. Further, the rotational speed of the motor associated with the negative pressure unit can be varied to change a rate at which a desired negative pressure is created within the enclosed space. For example, the electrical power supplied to the motor can be reduced to decrease the rotational speed of the motor, such as, to decrease the rate at which the desired negative pressure is created within the enclosed space. In such an example, the corresponding output received by the data logger can comprise a confirmation associated with the changed operating characteristic of the negative pressure unit. In another example, the negative pressure unit can be rotatably coupled to a base, such as, using a swivel coupling. Further, an auxiliary motor can be operably coupled to the swivel coupling such that the auxiliary motor is controlled by the data logger to cause rotation of the negative

pressure unit coupled to the base. In such an example, the orientation of the negative pressure unit within the enclosed space can be changed such that an intake port of the negative pressure unit faces a wall, thereby, decreasing an amount of air drawn into the negative pressure unit. Consequently, the rate at which the desired negative pressure is created within the enclosed space is reduced.

[0035] In one embodiment, the system comprises a drive unit coupled to the negative pressure unit or secondary negative pressure device. The drive unit can be coupled to multiple wheels disposed at a base of the negative pressure unit such that activation of the drive unit causes movement of the negative pressure unit or secondary negative pressure device within the enclosed space. In one example, the drive unit can be implemented using a direct current motor and the multiple wheels of the negative pressure unit can be implemented as omnidirectional wheels. In such an example, the drive unit is activated to change the orientation of the negative pressure unit within the enclosed space such that the intake port of the negative pressure unit faces a source of dust, pollutants, debris, and the like. It will be appreciated that such an orientation of the negative pressure unit towards the source of the dust, pollutants, debris, and such like results in entrapment of particles of the dust, pollutants, debris and so forth with higher efficiency, thereby, preventing contamination of an entire environment of the enclosed space. Further, drive unit enables reorientation of either negative pressure unit or secondary negative pressure device in specific events such as mechanical failure, requirement of high-power negative pressure creating device, alteration in characteristics (such as area/volume due to construction of partition or demolition thereof) of enclosed space, sudden increase in dust level and the like. Thus, the drive unit-based reorientation of negative pressure unit or secondary negative pressure device results in improvement in overall efficiency. The data logger receives the internal pressure information from the internal pressure determination unit. The data logger can transmit a request to the internal pressure determination unit for a latest determined internal pressure information. In response, the data logger can receive a digital signal associated with the determined internal pressure information. The data logger can receive real-time internal pressure information from the internal pressure determination unit. The term "real-time" is used to describe a system or process in which information is collected, processed, and acted upon immediately or within a minimal time delay such as 1-10 microseconds or 10-100 milliseconds and the like. In the context of present description, it refers to a feature or functionality that enables execution of task, respond to input, or produce output with negligible latency, closely approximating the actual time at which the event occur. This enables efficient and timely decision-making, control, or communication. Further, the data can receive real-time operational characteristic information of the negative pressure unit. Alternatively, the data logger can receive the internal pressure information from the internal pressure determination unit after pre-set time intervals. For example, the pre-set time intervals can be once every half second, once every second, once every 15 seconds, once every 60 seconds and the like. In another example, the data logger receives the internal pressure information from the internal pressure determination unit upon detection of a change in the amount of pressure within the enclosed space by the internal pressure determination unit. For example, the negative pressure unit is set up to maintain a negative pressure of 70927.5 Pa (or 0.7 atm) within the enclosed space. The internal pressure information detects an increase in the internal pressure within the enclosed space from 70927.5 Pa (or 0.7 atm) to 75993.75 (or 0.75 atm). Consequently, the internal pressure determination unit transmits the internal pressure information to the data logger, such that the internal pressure information is indicative of the change in the internal pressure inside the enclosed space. The data logger can store the received internal pressure information and operational characteristic information of the negative pressure. Alternatively, logger can perform various pre-processing functions such as encryption, filtering, noise removal and the like before storing the data. In one embodiment, the internal pressure determination unit comprises a sensor unit to detect a motion event within the enclosed space. The data logger determines a change in the internal pressure information based on the detected motion event within the enclosed space and recalibrates the operating characteristic of the negative pressure unit based on the determined change in the internal pressure information. It will be appreciated that the internal pressure within the enclosed space can suddenly change based on movement of persons and/or equipment into and out of the enclosed space. For example, numerous construction workers may move into and out of the enclosed space for depositing materials into the enclosed space (such as, by moving a trolley having the equipment into the enclosed space), for taking a break by exiting the enclosed space and the like. Further, the motion event associated with such a movement of persons and/or equipment into and out of the enclosed space is detected by the sensor unit. Subsequently, the data logger transmits a request to the internal pressure determination unit for the internal pressure information of the enclosed space. In response to receiving the internal pressure information, the data logger recalibrates, such as, by changing the operating characteristic of the negative pressure unit.

[0036] In one embodiment, the sensor unit is implemented using a motion sensor or a sound pulse detector. For example, the sensor unit is implemented using a motion sensor such that the motion sensor is an infrared sensor, tomographic sensor, an ultrasonic sensor, a vibration sensor, or a microwave sensor. In another example, the sensor unit is implemented using a sound pulse detector that detects sound pulses associated with opening or closing or doors and windows, footsteps, ratting of

metal or wood and the like. Further, the data logger detects the motion event based on the sound pulses detected by the sound pulse detector. Alternatively, the sound pulse detector emits acoustic waves into the enclosed space. The sound pulse detector determines the motion based a change in the acoustic waves that get reflected back towards the sound pulse detector, such that the change is associated with presence of a moving object within the enclosed space.

[0037] The data logger analyses the internal pressure information to calculate a change to be made to an operating characteristic of the negative pressure unit. The data logger analyses the internal pressure information, such as, by correlating the detected internal pressure within the enclosed space with the operating characteristic of the negative pressure unit. For example, the internal pressure within the enclosed space as indicated by the internal pressure information is 91192.5 Pa (or 0.9 atm) and a rotational speed of a motor associated with the negative pressure unit is 1500 rpm. However, a desired negative pressure within the enclosed space is 81060 Pa (or 0.8 atm), such that the negative pressure is achieved when the rotational speed of the motor is 1800 rpm. Consequently, the data logger calculates that the operating characteristic associated with rotational speed of the motor is required to be increased by 300 rpm to achieve the desired negative pressure.

[0038] The data logger can transmit the required operating characteristic to the negative control unit. Upon receipt of the required operating characteristic, onboard control unit (e.g., controller) may alter operating characteristic to manage the negative pressure unit to regulate the operating characteristic of the negative pressure unit to maintain the enclosed space at a predefined negative pressure. The data logger can regulate the operating characteristic of the negative pressure unit, such as, by varying an amount of electrical power supplied to the motor associated with the negative pressure unit. For example, the data logger increases the electrical power supplied to the motor. Such an increase in the electrical power supplied to the motor increases a reactivity associated with the negative pressure unit, such that the reactivity is associated with a time taken by the negative pressure unit to start creating the negative pressure within the enclosed space. Consequently, a volume of air drawn per unit time by the negative pressure unit from the enclosed space to be discharged out of the enclosed space is increased, thereby, lowering the internal pressure within the enclosed space (or increasing the internal pressure within the enclosed space). In another example, the data logger decreases a size of an intake port associated with the negative pressure unit, such as, by manipulating a valve that is disposed with the intake port. Consequently, airflow into the negative pressure unit per unit time is decreased, thereby, decreasing the rate at which the negative pressure is created within the enclosed space.

[0039] According to one embodiment, the data logger determines a nature of the enclosed space. The term "nature of the enclosed space" as used throughout the present disclosure relates to a shape (or volume) of the enclosed space, dimensions (or area) of the enclosed space, number of openings (such as doors and windows) within the enclosed space, openings created in the enclosed space as a result of repair or renovation being performed (such as, subsequent to removal of a wall) and the like. Optionally, the system comprises a sensor, such as an optical sensor or a three-dimensional scanner, to enable determination of the nature of the enclosed space. In one embodiment, the data logger receives information corresponding to the nature of the enclosed space from an external server (such as a third-party service). The data logger regulates the operating characteristic of the negative pressure unit to maintain the enclosed space at the predefined negative pressure based on the determined nature of the enclosed space. For example, the data logger operates the negative pressure unit at higher rotational speed of the motor within an enclosed space having a larger volume compared to rotational speed of the motor employed within an enclosed space having a relatively smaller volume.

[0040] In one embodiment, the data logger employs information associated with a nature of operation to regulate the operating characteristic of the negative pressure unit to maintain the enclosed space at the predefined negative pressure. The term "information associated with nature of operation" as used throughout the present disclosure relates to a type of operation being performed within the enclosed space, a duration of the operation being performed within the enclosed space, information corresponding to common types of contaminants expelled during the type of operation being performed within the enclosed space and the like. Optionally, the data logger receives an input corresponding to one parameter for the nature of operation being performed within the enclosed space, such as, the type of operation being performed within the enclosed space. Subsequently, the data logger extracts information associated with other parameters from an external source (such as, using a web-based search engine), such as, information corresponding to common types of contaminants expelled during the type of operation being performed within the enclosed space. Subsequently, the data logger employs the information associated with the nature of operation to regulate the operating characteristic of the negative pressure unit, such as, by increasing or decreasing the rotational speed of the motor associated with the negative pressure unit. In one example, the nature of operation corresponds to a woodworking operation within the enclosed space. In such an example, the data logger determines that the common types of contaminants expelled during the woodworking operation would be sawdust having a low density and consequently, the sawdust is prone to easily spread to other areas of the enclosed space due to action of a fan of the negative pressure unit. In such an example, the data logger maintains the orien-

tation of the negative pressure unit such that the fan of the negative pressure is always oriented away from a source of the sawdust.

[0041] Optionally, the negative pressure unit may associate with a misting device that is designed to spray very fine mist/aerosol of water to settle down ultrafine dust particles. Water mist may result in flocculation/agglomeration of fine dust particles, and flocculated particles may be removed with ease using negative pressure unit.

[0042] Optionally, the data logger considers a rate of change of the internal pressure within the enclosed space to change the operating characteristic of the negative pressure unit. For example, the internal pressure within the enclosed space experiences a sudden decrease such that the internal pressure becomes lower than the predefined negative pressure. In such an example, the data logger regulates the operating characteristic of the negative pressure unit, such as, by decreasing the rotational speed of the motor or manipulating the valve disposed with the intake port to compensate for the sudden decrease.

[0043] In one embodiment, the system comprises an external pressure determination unit disposed outside the enclosed space. The external pressure determination unit determines an external pressure information associated with an environment outside the enclosed space. The data logger adjusts the operating characteristic of the negative pressure unit based on the determined external pressure information. It will be appreciated that an amount of pressure outside the enclosed space influences the negative pressure created within the enclosed space. For example, the enclosed space can be a house in which negative pressure is required to be created for exhausting dust particles expelled during renovation of the house. Further, the pressure outside the enclosed space can be atmospheric pressure having a value of 101325 Pa (or 1 atm). In such an example, an amount of pressure required to be created within the enclosed space will be higher than when the pressure outside the enclosed space drops to (or 0.8 atm), such as, due to precipitation. The external pressure determination unit can be disposed inside an adjacent enclosed space that is fluidically coupled to the enclosed space or in an external environment. For example, the external pressure determination unit can be disposed inside an adjacent room within a house or outside the house. The external pressure determination unit determines the external pressure information associated with the adjacent room or an environment outside the house. Subsequently, the data logger adjusts the electrical power supplied to the negative pressure unit, the rotational speed of the motor associated with the negative pressure unit and/or the orientation of the negative pressure unit based on the determined external pressure information.

[0044] According to an embodiment, the data logger receives a weather forecast information from a server platform. The data logger receives the weather forecast information associated with a location of the enclosed space for a predefined duration. For example, the predefined duration can be 6 hours, 12 hours, 1 day, 3 days or the duration until a planned ending of the repair or renovation of the enclosed space. The data logger extracts external pressure information of the environment outside the enclosed space from the weather forecast information and subsequently, employs the extracted external pressure information to adjust the operating characteristic of the negative pressure unit.

[0045] Optionally, the data logger employs a real-time price of electrical power to adjust the operating characteristic of the negative pressure unit. For example, when the real-time price of electrical power obtained from grid is high, the data logger reduces the amount of electrical power supplied to the motor of the negative pressure device. Similarly, when the real-time price of electrical power obtained from grid is low, the data logger increases the amount of electrical power supplied to the motor of the negative pressure device. Consequently, the data logger enables to efficiently reduce operating costs associated with operation of the system, further, enabling efficient usage of the electrical power for operation of the system. In an embodiment, the system comprises at least one secondary negative pressure device coupled to the data logger that receives an operating parameter from the each secondary negative pressure device or the operating characteristic of the negative pressure unit and regulates the operating parameter of at least one secondary negative pressure device or the operating characteristic of the negative pressure unit to maintain the enclosed space at the predefined negative pressure. It will be appreciated that a volume of the enclosed space may be bigger than that corresponding to an operating capacity of the negative pressure unit, preventing the negative pressure unit from creating the desired negative pressure within the enclosed space. Consequently, one or more secondary negative pressure devices can be disposed within the enclosed space to operate in conjunction with the negative pressure unit to create the desired negative pressure within the enclosed space. The data logger receives the operating parameter from each secondary negative pressure device or the operating characteristic of the negative pressure unit and subsequently analyses the received operating parameter or the operating characteristic. Such an analysis enables the data logger to determine if the received operating parameter or the received operating characteristic will respectively allow the secondary negative pressure device or the negative pressure unit to create the desired negative pressure within the enclosed space, for example, within a specified duration. The data logger regulates the operating parameter or the operating characteristic, such as a rotational speed of a motor associated with the secondary negative device or the rotational speed of the motor associated with the negative pressure unit, to maintain the enclosed space at the predefined negative pressure. Optionally, the negative pressure unit or one

or several of the secondary negative pressure devices may experience failure during repair or renovation operation of the enclosed space. For example, when the negative pressure unit experiences the failure and stops operation, the operating parameter of one or more secondary negative pressure devices can be adjusted to compensate for the failure of the negative pressure unit. In such an example, rotational speeds of motors associated with one or more secondary negative pressure devices can be increased to compensate for stopping of operation of the negative pressure unit.

[0046] As per one embodiment, the at least one secondary negative pressure device is disposed at a sub-region of the enclosed space. The term "sub-region of the enclosed space" can relate to a physically discernible region of the enclosed space that is separated from other regions of the enclosed space by walls, doors, windows and so forth. Alternatively, the term can refer to a virtually separate region of the enclosed space, such as, a top-left corner of a room, a middle portion of the room and the like. In one example, the at least one secondary negative pressure device is disposed at an antechamber leading into a lobby.

[0047] In one embodiment, the system further comprises an input unit that receives a user input. The user input comprises a time input corresponding to a specific duration. The data logger maintains the negative pressure within the enclosed space for the specific duration. The term "input unit" used throughout the present disclosure relates to an electronic device that can be employed to provide inputs to the data logger. Such inputs can be obtained by the input unit in real-time as a result of actions performed by a user (such as, due to the user tapping on a touchscreen or typing using a keypad). In one example, the input unit can include keyboards, mice, styluses, touchscreens, microphones, cameras, and the like that are either standalone devices or are implemented within other devices such as desktop computers, cellular telephones, smartphones, personal digital assistants, laptop computers, tablet computers and so forth. The input unit can comprise a display unit to present information to the user. The display unit can present such information on a graphical user interface (such as, on a web interface). In an example, a user such as a resident of a home may wish to operate the negative pressure unit within the home as long as the resident is not present at home. However, upon return of the resident, the resident may wish to halt operation of the negative pressure unit until such a time when the resident is away again. In such an example, the resident can provide user input to operate the negative pressure for the duration of 12 hours when the resident is not at home. The data logger maintains the negative pressure within the enclosed space by operating the negative pressure unit for the duration of 12 hours and subsequently, halts operation of the negative pressure unit after completion of the 12-hour duration.

[0048] As per an embodiment, the input unit receives a control command from a user who may present at a remote location to control the negative pressure unit. The term "control command" as used throughout the present disclosure relates to a request to change the operating characteristic of the negative pressure unit. In one example, the input unit receives the control command from the user to increase the rotational speed of the motor associated with the negative pressure unit. In another example, the input unit receives the control command from the user to switch on or switch off the negative pressure unit. In yet another example, the input unit receives the control command from the user to change the duration of operation of the negative pressure unit.

[0049] In one embodiment, the system further comprises a data transceiver for transmission of information between an operator accessible computing unit, the data logger, and the negative pressure unit. The term "data transceiver" as used throughout the present disclosure relates to an electronic device comprising a transmitter and a receiver for respectively transmitting and receiving information. The data transceiver can be implemented within the operator accessible computing unit, such as a mobile phone, a smartphone, a tablet computer, and the like that is associated with the operator. The operator can be a construction worker that is responsible for ensuring reliable operation of the negative pressure unit within the enclosed space. Alternatively, the data transceiver can be implemented within the cloud server arrangement, such as, to transmit and receive information via the Internet. Such a data transceiver can periodically transmit and/or receive the information from the data logger and the negative pressure unit.

[0050] As per an embodiment, the data logger transmits an alert signal comprising an operational status of the negative pressure unit. The term "alert signal" as used throughout the present disclosure refers to a notification (such as email, SMS, push notification, voice call and the like) transmitted to the input unit and/or the operator accessible computing unit, such that the notification corresponds to the operational status of the negative pressure unit. The term "operational status" of the negative pressure unit corresponds to an on/off status of the negative pressure unit. Optionally, the operation status also corresponds to device failure of the negative pressure unit. It will be appreciated that the negative pressure unit can be associated with an operating life, such that the negative pressure unit is likely to stop operating after completion of the operating life or at any time before completion of the operating life. Such a stoppage of operation of the negative pressure unit may be experienced during ongoing of the repair or renovation operation of the enclosed space. The data logger detects such a stoppage of operation of the negative pressure unit associated with device failure and transmits the alert signal to the operator accessible computing unit to enable the operator to repair or replace the negative pressure unit.

[0051] The present disclosure also provides a method to maintain a negative pressure within an enclosed space. The method comprises disposing a negative pres-

sure unit within the enclosed space. The negative pressure unit creates an internal pressure within the enclosed space. The method further comprises determining an internal pressure information of the enclosed space. Moreover, the method comprises analysing the internal pressure information to calculate a change to be made to an operating characteristic of the negative pressure unit. Further, the method comprises operating, from remote location, the negative pressure unit to regulate the operating characteristic of the negative pressure unit to maintain the enclosed space at a predefined negative pressure. The user/operator may provide input command (through a computing device such as smartphone) from remote location to manage/operate negative pressure unit.

[0052] In one embodiment, the method further comprises regulating the operating characteristic of the negative pressure unit based on a particle count information derived from a particle counter. The particle counter is deposed within the enclosed space. Further, the particle counter determines analogue data corresponding to a number of particles associated with particulate matter such as PM2.5 and PM10. Further, the data logger receives the analogue data and converts the analogue data to obtain digital information, such that the digital information forms the particle count information within the enclosed space. The data logger regulates the operating characteristic, for example, the rotational speed of the motor associated with the negative pressure unit based on the particular count information. In one example, the data logger increases the rotational speed of the motor based on the particle count information indicating presence of a high number of PM2.5 and PM10 within the enclosed space.

[0053] The disclosed system and method enable to conveniently maintain the enclosed space at a required negative pressure (such as, a negative pressure prescribed by national laws when construction, repair, renovation, or restoration operations are conducted for an enclosed space) to prevent contaminants such as dust, small debris, mould and the like from escaping into an atmosphere outside the enclosed space, thereby contaminating the atmosphere and other spaces near the enclosed space. The data logger is capable of automatically managing the negative pressure unit to maintain the desired negative pressure without necessitating presence of operators and/or other users (such as residents) to manage the negative pressure units, thereby, saving time and effort for the operators and/or users as well as ensuring safety and well-being of such operators and/or other users by preventing a need for their continued presence within a contaminated environment of the enclosed space. The system also considers external factors (such as external pressure information) for operation of the negative pressure unit, thereby, ensuring reliable operation of the negative pressure unit even during changes in external factors (including but not limited to, rain, storm, wind, and the like). The system and method also enable management of multiple negative pressure devices by a single data logger (and further, by the operator accessible computing unit), thereby, allowing convenient and low operating cost (such as, low requirement of electricity) management of both small-scale operations (such as, renovation of a single home) and largescale operations (such as, repair of multiple homes within a building). The system also enables operating characteristics of negative pressure units to be manipulated remotely (such as, by accessing a web interface on the input unit and/or the operator accessible computing unit) and in real-time (such as, upon determination of a change in the internal pressure information). Consequently, the system and the method enable to conveniently and remotely manage construction operations such that environments or habitats around a location of the construction operations are not negatively affected by uncontrolled expulsion of contaminants from the construction operations.

DETAILED DESCRIPTION OF DRAWINGS

[0054] Referring to FIG. 1, there is shown a schematic illustration of a system **100** to maintain a negative pressure within an enclosed space **102** as per one embodiment of the present disclosure. The enclosed space **102** is a room having an entrance/exit **104** and a window **106.** The entrance/exit **104** of the enclosed space **102** is closed by a seal **108** to prevent air, dust, and other contaminants from exiting from the enclosed space **102.** Further, the window **106** is maintained in a closed state to also prevent air, dust, and other contaminants from exiting from the enclosed space **102.** As shown, a negative pressure unit **110** is disposed within the enclosed space **102.** The negative pressure unit **110** is fluidically coupled to a collection tank **112** arranged outside the enclosed space **102** using a hose **114** such that air, dust and other contaminants drawn by the negative pressure unit **110** are deposited into the collection tank **112** via the hose **114.** Moreover, an internal pressure determination unit **116** is disposed within the enclosed space **102.** Further, a data logger **118** is coupled to the negative pressure unit **110** and the internal pressure determination unit **116.**

[0055] Referring to FIG. 2, there is shown a schematic illustration of the system **100** of FIG. 1 according to another embodiment of the present disclosure. As shown, the system **100** further comprises an external pressure determination unit **200** disposed outside the enclosed space **102** (such as, in an adjacent room). The external pressure determination unit **200** is coupled to the data logger **110.**

[0056] Referring to FIG. 3, there is shown a schematic illustration of a system **300** to maintain a negative pressure within enclosed spaces **302-308** as per one embodiment of the present disclosure. The enclosed spaces **302-308** are located within a same building (not shown). However, the enclosed spaces **302-308** are different rooms (such as a bedroom, a bathroom, a living room,

and a storeroom, respectively) belonging to various users **310-316.** The system **300** comprises negative pressure units **318-324** respectively disposed within the enclosed spaces **302-308.** Further, the system **300** comprises a data logger **326** coupled to each of the negative pressure units **310-316.** Moreover, the system **300** comprises input units **328-334** associated with the users **310-316,** respectively. The input units **328-334** are coupled to the data logger **326.**

[0057] Referring to FIG. 4, there is shown a pressure difference vs. time graph **400** for operation of a system to maintain a negative pressure within an enclosed space (such as the system **100** of FIG. 1) according to one embodiment of the present disclosure. As shown, a created pressure difference (real-time) is lower than a predefined negative pressure as well as a pressure difference indicated by negative pressure information. Consequently, an operating characteristic of a negative pressure unit (such as the negative pressure unit **110** of FIG. 1) is required to be regulated to maintain an enclosed space (such as the enclosed space **102** of FIG. 1) at the predefined negative pressure.

[0058] Referring to FIG. 5, there is shown a flowchart illustrating a method **500** to maintain a negative pressure within an enclosed space as per one embodiment of the present disclosure. At a step **502,** a negative pressure unit is disposed within the enclosed space. At a step **504,** an internal pressure information of the enclosed space is determined. At a step **506,** the internal pressure information is analysed to calculate a change to be made to an operating characteristic of the negative pressure unit. At a step **508,** the negative pressure unit is operated to regulate the operating characteristic of the negative pressure unit to maintain the enclosed space at a predefined negative pressure.

[0059] Modifications to embodiments of the present disclosure described in the foregoing are possible without departing from the scope of the present disclosure as defined by the accompanying claims. Expressions such as "including", "comprising", "incorporating", "have", "is" used to describe and claim the present disclosure are intended to be construed in a non-exclusive manner, namely allowing for items, components or elements not explicitly described also to be present. Reference to the singular is also to be construed to relate to the plural.

Claims

1. A system (100) to maintain a negative pressure within an enclosed space (102), the system (100) comprising:

   a negative pressure unit (110) disposed within the enclosed space (102), wherein the negative pressure unit (110) creates an internal pressure within the enclosed space (102);
   an internal pressure determination unit (116) disposed within the enclosed space (102), wherein the internal pressure determination unit (116) determines an internal pressure information of the enclose space (102);
   a data logger (118) coupled to the negative pressure unit (110) and the internal pressure determination unit (116), wherein the data logger (118) receives at least one of the following:

   - the real-time internal pressure information from the internal pressure determination unit (116);
   - the real-time operational characteristic information of the negative pressure unit (110); and wherein the data logger (118) records at least one of the following:
   - the received internal pressure information;
   - the received operational characteristic information of the negative pressure unit (110); and

   analyses the internal pressure information to calculate a change to be made to an operating characteristic of the negative pressure unit (110);
   and regulate the operating characteristic of the negative pressure unit (110) to maintain the enclosed space (102) at a predefined negative pressure.

2. The system (100) according to claim 1, further comprising an external pressure determination unit (200) disposed outside the enclosed space (102),

   wherein the external pressure determination unit (200) determines an external pressure information associated with an environment outside the enclosed space (102); and
   wherein the data logger (118) adjusts the operating characteristic of the negative pressure unit (110) based on the determined external pressure information.

3. The system (100) according to claim 1, further comprising at least one secondary negative pressure device coupled to the data logger (118) that:

   receives an operating parameter from each secondary negative pressure device or the operating characteristic of the negative pressure unit (110); and
   regulates the operating parameter of at least one secondary negative pressure device or the operating characteristic of the negative pressure unit (110) to maintain the enclosed space (102) at the predefined negative pressure.

4. The system (100) according to claim 3, wherein the

at least one secondary negative pressure device is disposed at a sub-region of the enclosed space (102).

5. The system (100) according to any of the preceding claims 1-3, wherein the data logger (118) is implemented in a cloud server arrangement, wherein the cloud server arrangement stores a historical information associated with the negative pressure maintained within the enclosed space (102).

6. The system (100) according to claim 1, wherein the internal pressure determination unit (116) comprises a sensor unit to detect a motion event within the enclosed space (102), wherein the data logger (118):

determines a change in the internal pressure information based on the detected motion event within the enclosed space (102); and
recalibrates the operating characteristic of the negative pressure unit (110) based on the determined change in the internal pressure information.

7. The system (100) according to claim 6, wherein the sensor unit is implemented using: a motion sensor or a sound pulse detector.

8. The system (100) according to any of the preceding claims 1-3 or 5-6, wherein the data logger (118) receives a weather forecast information from a server platform.

9. The system (100, 300) according to claim 1, further comprising an input unit (328-334) that receives a user input, wherein the user input comprises a time input corresponding to a specific duration, wherein the data logger (118) maintains the negative pressure within the enclosed space (102) for the specific duration.

10. The system (100, 300) according to claim 9, wherein the input unit (328-334) receives a control command from a user remotely to control the negative pressure unit (110, 318-324).

11. The system (100) according to any of the preceding claims 1-3 or 6, wherein the operating characteristic of the negative pressure unit (110) is selected from: an electrical power supplied to the negative pressure unit (110), a rotational speed of a motor associated with the negative pressure unit (110), an orientation of the negative pressure unit (110) within the enclosed space (102).

12. The system (100) according to any of the preceding claims, further comprising a data transceiver for transmission of information between an operator accessible computing unit, the data logger (118) and the negative pressure unit (110).

13. The system (100) according to any of the preceding claims, wherein the data logger (118) transmits an alert signal comprising an operational status of the negative pressure unit (110).

14. A method (500) to maintain a negative pressure within an enclosed space, wherein the method (500) comprising:

disposing (502) a negative pressure unit within the enclosed space, wherein the negative pressure unit creates an internal pressure within the enclosed space;
determining (504) an internal pressure information of the enclosed space;
analysing (506) the internal pressure information and the operational characteristic of the negative pressure unit to calculate a change to be made to an operating characteristic of the negative pressure unit; and
operating (508) remotely the negative pressure unit to regulate the operating characteristic of the negative pressure unit to maintain the enclosed space at a predefined negative pressure.

15. The method (500) according to claim 14, further comprising regulating the operating characteristic of the negative pressure unit based on a particle count information derived from a particle counter.

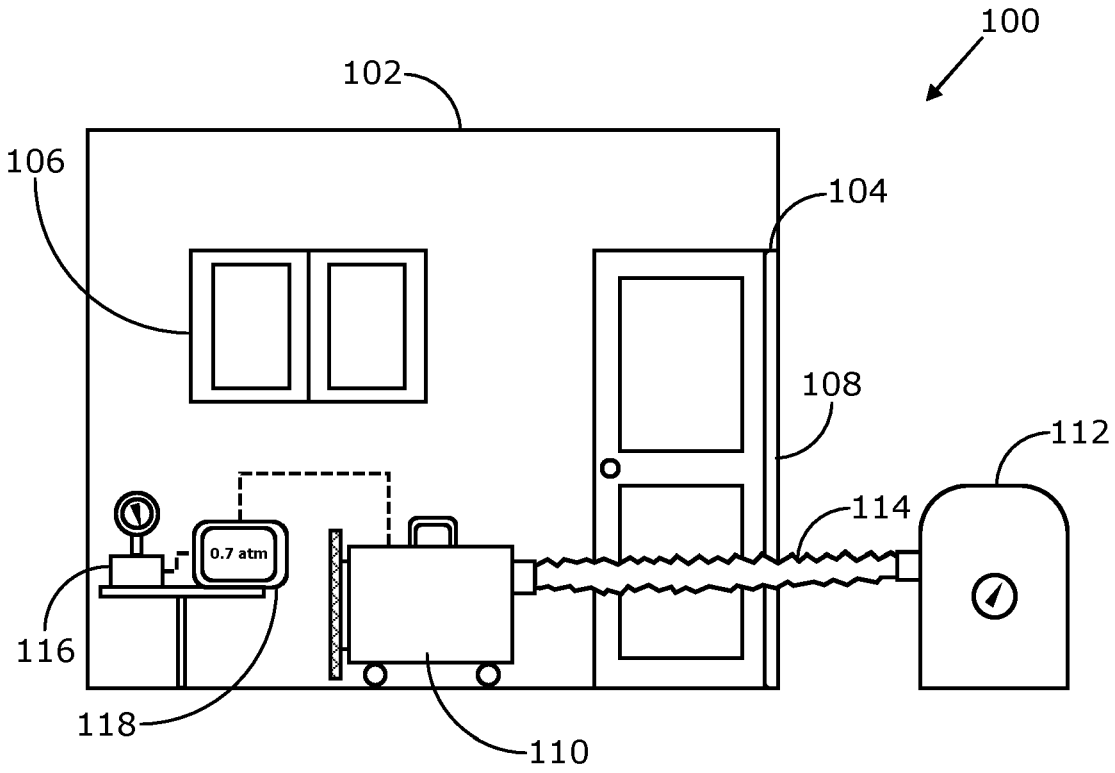
100
102
106
104
108
112
114
0.7 atm
116
118
110

FIG. 1

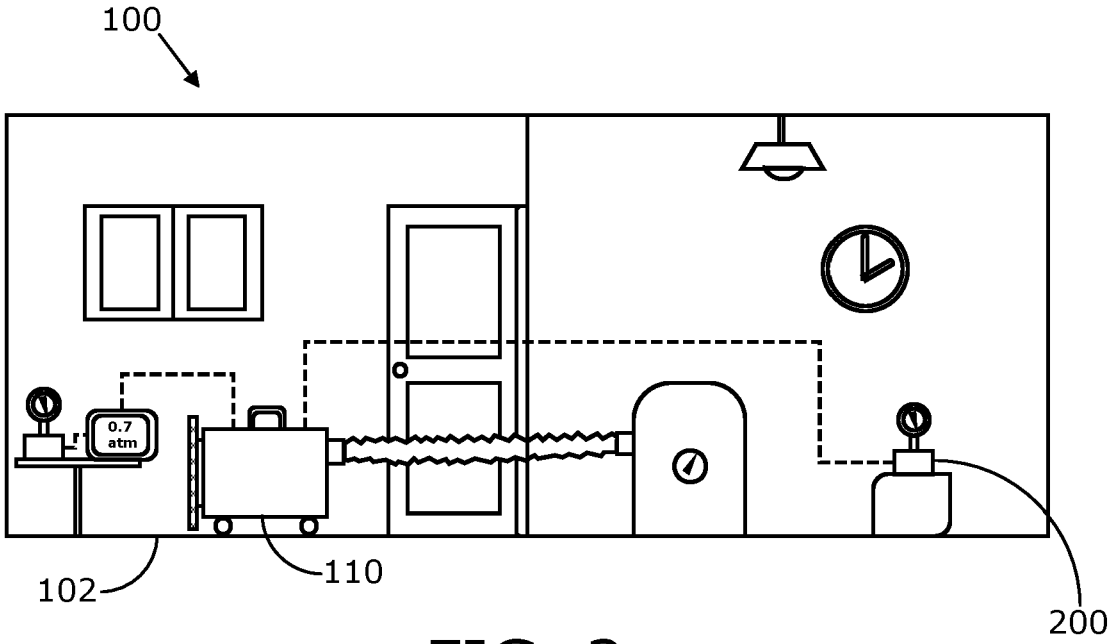
100
0.7 atm
110
102
200

FIG. 2

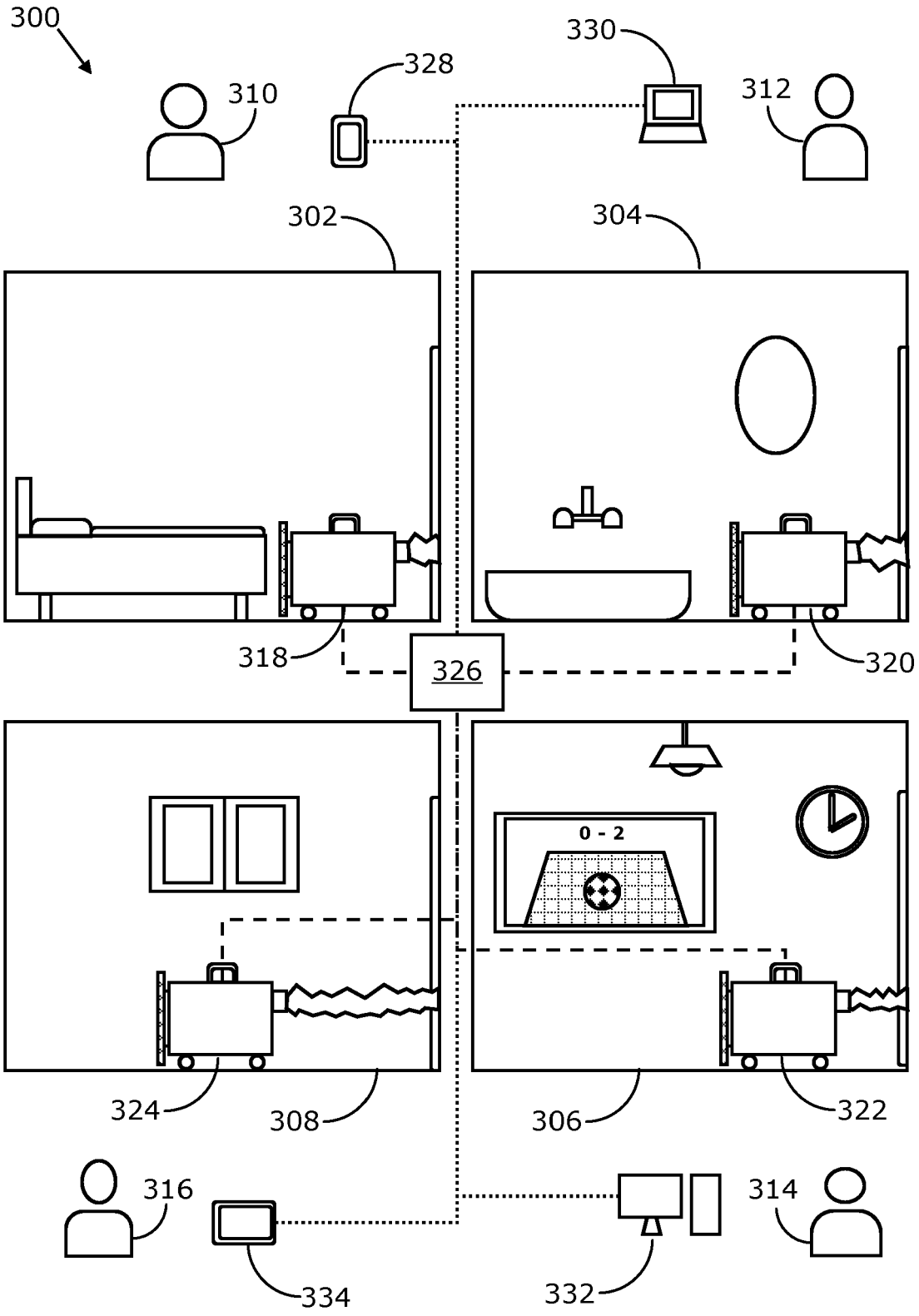
300
310
328
330
312
302
304
318
326
320
0 - 2
324
308
306
322
316
334
332
314

FIG. 3

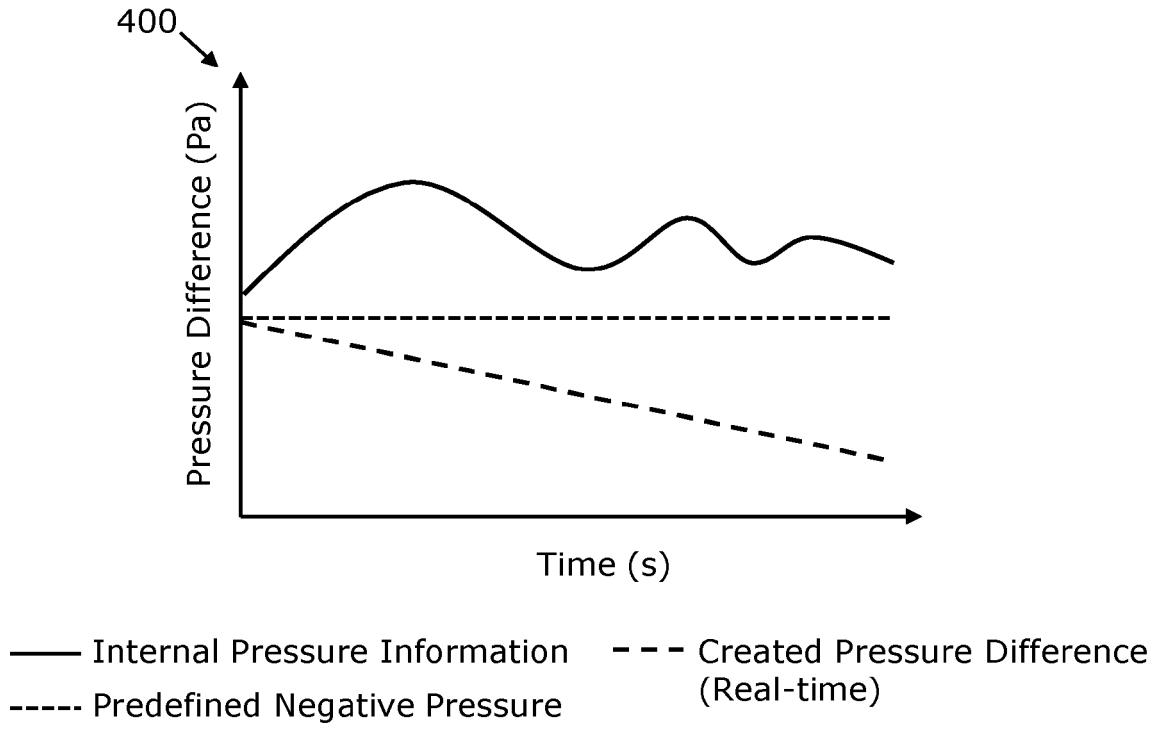
400
Pressure Difference (Pa)
Time (s)
Internal Pressure Information
Created Pressure Difference (Real-time)
Predefined Negative Pressure

FIG. 4

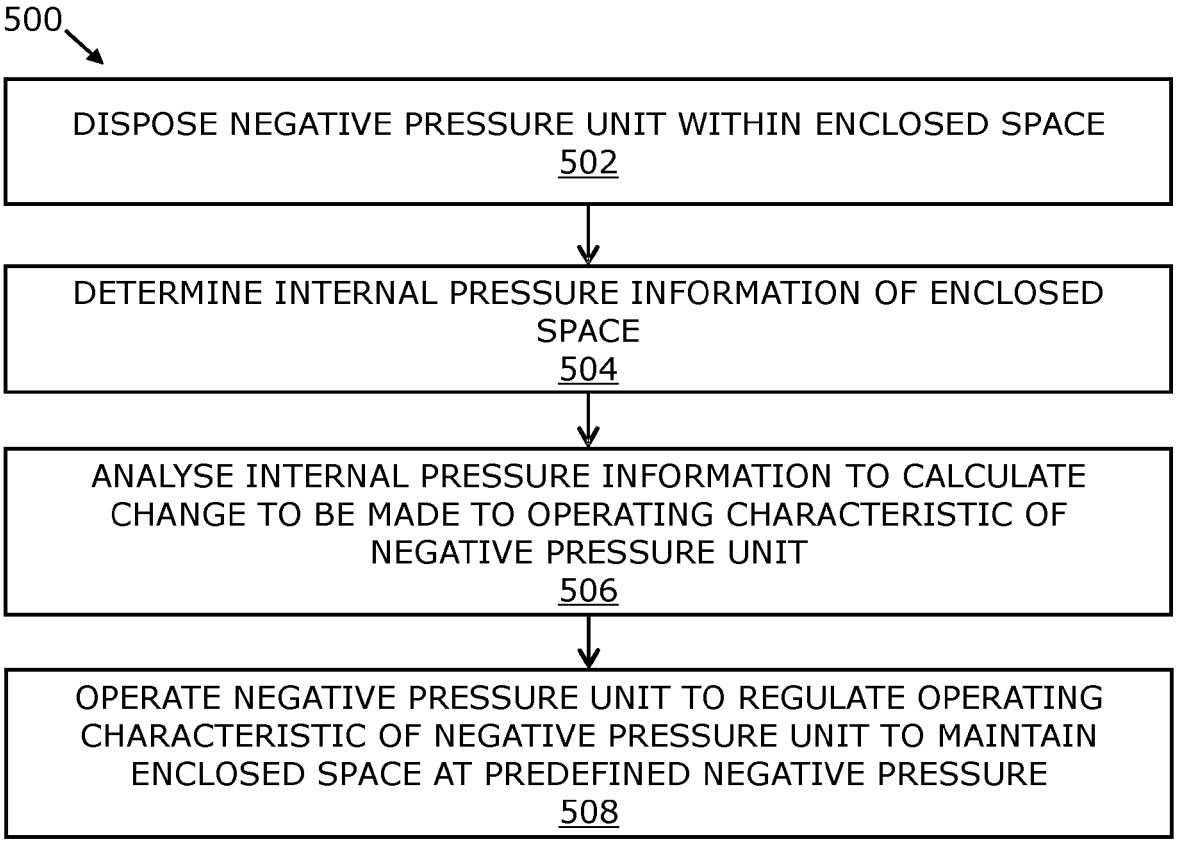
500
DISPOSE NEGATIVE PRESSURE UNIT WITHIN ENCLOSED SPACE
502
DETERMINE INTERNAL PRESSURE INFORMATION OF ENCLOSED SPACE
504
ANALYSE INTERNAL PRESSURE INFORMATION TO CALCULATE CHANGE TO BE MADE TO OPERATING CHARACTERISTIC OF NEGATIVE PRESSURE UNIT
506
OPERATE NEGATIVE PRESSURE UNIT TO REGULATE OPERATING CHARACTERISTIC OF NEGATIVE PRESSURE UNIT TO MAINTAIN ENCLOSED SPACE AT PREDEFINED NEGATIVE PRESSURE
508

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 3166

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	US 7 270 691 B2 (ARTS THEODORE A M [US] ET AL) 18 September 2007 (2007-09-18) * figures 1-13 *	1-15	
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			A61G F24F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 October 2023	Ismail, Youssef

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

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 17 3166

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
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