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(54) **DYNAMIC INSULATION WALL ASSEMBLY AND RESPECTIVE CONTROL METHOD**

(57) A dynamic insulation wall assembly and a method for automatically controlling one or more airflows in a dynamic insulation wall (1) interposed between an indoor environment (I) of a building and the outdoor environment (E) are described. The wall (1) has at least one inner air cavity (40) and the assembly comprises a ventilation unit (100) equipped with a programmable control device (CPU) to automatically control an airflow at least in the inner air cavity (40) of the wall (1). The ventilation unit

(100) comprises at least one primary channel (75) which directly connects the ventilation unit (100) with the outdoor environment (E) and at least one secondary channel which connects the ventilation unit (100) with the inner air cavity (40) or the outdoor environment (E). The ventilation unit (100) further comprises a control damper (SC) of the airflows, arranged between the extraction (25) and supply (45) channels and the primary (75) and secondary (85) channels.

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Description

Field of the invention

[0001] The present invention relates to a dynamic insulation wall assembly and a method for automatically controlling one or more airflows in a dynamic insulation wall interposed between a confined indoor environment of a building and the outdoor environment.

Prior art

[0002] Conventionally, buildings consist of a partially opaque and partially transparent envelope, which has the purpose to define the geometry of the same buildings and to mitigate the outdoor climatic conditions, thus ensuring the comfort conditions required by the occupants of the confined environments, thanks also to the contribution of heating and cooling systems. Additionally, these environments require adequate air changes in order to ensure adequate hygienic and sanitary conditions.

[0003] The energy required to maintain the indoor thermal conditions imposed by the user depends, among other things, on the heat exchange through a building envelope (conduction losses) and the heat load related to the ventilation of the environments (ventilation losses) necessary to ensure proper hygiene conditions in the presence of people. At the same boundary conditions (internal and external temperature), the heat exchange conditions through the building envelope depend on the heat resistance of the envelope structures, whereas the heat load conditions related to ventilation of the environments depend on the air flow rates and the inlet temperature thereof.

[0004] In order to limit the energy requirements for winter and summer air conditioning of buildings, the common (or conventional) practice is to reduce conduction losses by increasing the heat resistance of the building envelope, e.g. by installing layers of insulating material (by way of example, the external thermal insulation is considered). Here and hereinafter, "conventional" behaviour is defined as that manifested by buildings in which conduction losses are simply reduced by increasing the heat resistance of the walls, regardless of the use of ventilation, air conditioning or similar systems. The heat resistance of the conventional envelope, and of the materials that constitute it, is an inherent and invariable characteristic thereof and affects the thermal power exchanged through the same envelope as a result of a given temperature difference between the inside and outside.

[0005] For locations characterised by cold winters, high heat resistance will always result in a better performance thereof.

[0006] Conversely, during the summer period, when it is necessary to effectively dispose of the heat present in the confined environments (as a result of people, equipment, radiation entering from windows), the high heat resistance of a building envelope can result in greater

loads on the air-conditioning system and, consequently, an increase in energy demand. In common practice, strategies such as shading are implemented to decrease the heat load resulting from the solar gain (screens, sunshades, vertical or horizontal overhangs, ventilated walls, etc.).

[0007] As far as ventilation losses are concerned, there are two commonly adopted practices: in many residential buildings, the air exchange is left to the manual opening of windows and doors by the users (natural ventilation), renouncing the control of air flow rates which depend on external wind conditions and many other factors, and of the inlet temperature, which will always be equal to the external air. In other habitable buildings, air changes are achieved as a result of a centralised mechanical ventilation system capable of adjusting flow rates depending on design conditions and of mitigating the inlet temperature as a result of a heat recovery unit.

[0008] Italian and international regulations have aligned in setting strict limits as regards both the thermal transmittances of the envelope and the efficiency of heat recovery units in controlled mechanical ventilation systems, in order to decrease the heat demand in the winter period, and as regards the decrease of solar gains in the summer period. Thermal transmittances, which may be set by current legislation and technical regulations, are characterised by fixed and invariable limits, which describe the performance of the envelope solution.

[0009] On the other hand, as far as ventilation is concerned, it should be noted that the air entering the confined environments is not only that related to natural or mechanical ventilation, but may be due to parasitic infiltration over which the users have no control (e.g., air entering through joints between walls and windows or as a result of imperfect air-tightness of windows and doors). The common practice is that of trying to mitigate this phenomenon as much as possible, by improving the air tightness of the envelope as a whole, and quantifying its performance through measurements of the "blower door test" type typically adopted for passive houses.

[0010] However, it should be borne in mind that this approach, in the case of buildings with only natural ventilation (without installation of a controlled mechanical ventilation system), can result in healthiness problems of indoor environments: as the users are not capable of adequately controlling the entering air flow rates (e.g., by opening windows), these may not be sufficient to dispose of indoor pollutants or water vapour (especially in environments such as kitchens, bathrooms and bedrooms), thus causing the formation of interstitial condensation or condensation on inner surfaces.

[0011] It can further be observed that the ventilation as a result of the opening of windows and doors does not allow any filtering of the air fed into the rooms of the building, which, particularly in urban context, will bring therewith fine and ultra-fine particulates that are harmful to health.

[0012] DE 3546455A1 describes a building equipped

with a centralised mechanical ventilation system that takes external air from the north-facing walls and expels indoor air from the south-facing walls. The operation of the system described in this document is essentially focused on the behaviour of the same system in the winter season. No mention is made of the possibility that the layers of the various walls are crossed by air flow rates, nor regarding the direction and flow rates of the airflows entering or exiting the building as climatic conditions change, such as e.g. during the summer season. Therefore, some criticalities inherently present in commonly adopted constructive practice can be summarised as follows:

- in buildings characterised by natural ventilation (highly common in the residential sector), it is not possible to have any real control over ventilation losses, as there is no effective way, through the opening of windows and doors only, to modulate the entering air flow rates, to control their temperature and to reduce the concentration of dust therein, resulting in risks of overloading the air-conditioning systems, discomfort due to the temperatures and poor healthiness of the confined environments;
- in buildings characterised by mechanical ventilation, the systems are generally of the centralised type and their operation is at the service of significant portions of the buildings and depends on daily planning, regardless of whether or not the rooms are actually occupied by persons and whether or not air change in the room is actually necessary;
- even in the case of mechanical ventilation, the direction and speed of the air flow rates for air-permeable walls are not controlled.

Summary of the invention

[0013] That being said, the task of the present invention is to provide a dynamic insulation wall assembly which allows to reduce the drawbacks highlighted so far for buildings built according to the known art.

[0014] Within the scope of this task, an object of the present invention is to provide a dynamic insulation wall assembly interposed between an indoor environment of a building and the outdoor environment, that allows efficient control of one or more airflows in the dynamic insulation wall.

[0015] Another object of the present invention is to provide a dynamic insulation wall assembly and a method of controlling airflows that is versatile and, therefore, capable of resorting to dynamic or conventional behaviour depending on the instantaneous conditions.

[0016] Another object of the present invention is to provide a dynamic insulation wall assembly which allows to limit energy consumption for optimal air conditioning of an indoor environment.

[0017] Yet another object of the present invention is to provide a dynamic insulation wall assembly that allows

to effectively limit particulates harmful to health to enter an indoor environment.

[0018] A further object of the present invention is to provide a method for automatically controlling one or more airflows, both in terms of speed, direction and flow rates of the airflows, in a dynamic insulation wall interposed between an indoor environment of a building and the outdoor environment.

[0019] These and other objects are achieved by the present invention which concerns dynamic insulation wall assembly according to claim 1. Further peculiar characteristics of the present invention are set forth in the respective dependent claims.

[0020] A dynamic insulation wall assembly is adapted to make air-permeable walls interposed between an indoor environment of a building and the outdoor environment, e.g., constituting a building envelope.

[0021] The assembly comprises at least one wall having an inner air cavity delimited externally by at least one intermediate layer of air-permeable material and, internally, by a layer of air-impermeable material.

[0022] In an embodiment of the present invention, the dynamic insulation wall assembly comprises a ventilation unit equipped with a programmable control device to automatically control an airflow at least in the inner air cavity. The ventilation unit comprises at least one primary channel directly connecting the ventilation unit with the outdoor environment and at least one secondary channel connecting the ventilation unit with the inner air cavity or the outdoor environment.

[0023] In particular, the ventilation unit comprises a damper for controlling the airflows, which is arranged between the extraction and supply channels and the primary and secondary channels. A bypass channel is connected to the secondary channel and at least one damper is arranged between the secondary channel and the bypass channel to direct the airflows of the secondary channel, in a mutually excluding way, into the inner air cavity or directly into the outdoor environment.

[0024] The control damper is equipped with a motorised actuator controlled by the programmable control device to selectively put in fluid communication the indoor environment with the inner air cavity or with the environment outside the wall.

[0025] Here and hereinafter, the term "supply channel" should be understood as a channel for the inflow of air into an indoor environment and the term "extraction channel" should be understood as a channel for taking an airflow from an indoor environment. Additionally, the term "primary channel" should be understood as a channel directly connecting the ventilation unit with the outdoor environment and the term "secondary channel" should be understood as a channel that can indirectly, or directly, connect the ventilation unit with the outdoor environment through the inner air cavity and the air-permeable walls.

[0026] In an embodiment of the present invention, the dynamic insulation wall assembly may further comprise an outer air cavity delimited externally by an outer layer

of air-permeable material and, internally, by the at least one intermediate layer of air-permeable material.

[0027] The wall can be formed, for example, by a plurality of modules juxtaposed in mutual contact, each of which has the outer air cavity and the inner air cavity in fluid communication with the respective outer air cavities and the respective inner air cavities of the adjacent modules. For example, the ventilation unit can be embedded, for example, in at least one of the modules or it can be a separate unit from the modules. At least one heat recovery unit may be connected between the supply channel and the extraction channel, or a heat exchanger in any case between the supply airflows and the extraction airflows along the respective channels.

[0028] The programmable control device can receive signals from various temperature and relative humidity sensors, such as e.g.:

- at least one temperature and relative humidity sensor placed outside the wall;
- at least one temperature and relative humidity sensor placed in the outer air cavity of the wall;
- at least one temperature and relative humidity sensor placed in the inner air cavity of the wall; and
- at least one temperature and relative humidity sensor placed in the indoor environment.

[0029] In an embodiment, at least one supply filter is arranged along the supply channel between the control damper of the airflows and the heat recovery unit, and at least one extraction filter is arranged along the extraction channel between the indoor environment and the heat recovery unit.

[0030] The programmable control device can further receive signals from a plurality of differential manometers, including:

- at least one differential manometer to measure the pressure differences between the inner air cavity and outer air cavity, or between the inner air cavity and the outer environment;
- at least one differential manometer to measure the pressure differences upstream and downstream of the supply filter, with reference to the supply airflow, along the supply channel;
- at least one differential manometer to measure the pressure differences upstream and downstream of the extraction filter, with reference to the extraction airflow, along the extraction channel;
- at least one differential manometer to measure the pressure differences upstream of the supply filter and downstream of the supply fan, with reference to the supply airflow, along the supply channel; and
- at least one differential manometer to measure the pressure differences upstream of the extraction filter and downstream of the extraction fan, with reference to the extraction airflow, along the extraction chan-

nel.

[0031] The programmable control device can further receive signals from other sensors, such as e.g. at least one first sensor of volatile organic compounds placed in the outdoor environment. The signals from the indoor environment can instead be produced by at least one second sensor of volatile organic compounds, by at least one carbon dioxide sensor, by at least one surface temperature sensor of at least one wall of the indoor environment and at least one room thermostat that can be manually set by a user.

[0032] The wall assembly may possibly also comprise a shading system that includes a solar radiation screen controlled by an actuator depending on a signal emitted by an irradiation sensor and sent to the programmable control device.

[0033] The present invention further relates to a method for automatically controlling one or more airflows in a dynamic insulation wall interposed between an indoor environment of a building and the outdoor environment. The method comprises the steps of:

- providing at least one wall having an inner air cavity delimited externally by at least one intermediate layer of air-permeable material and, internally, by a layer of air-impermeable material. The wall further comprises an outer layer of air-permeable material placed outside the intermediate layer of air-permeable material;
- providing a ventilation unit equipped with a programmable control device to automatically control a supply fan and/or an extraction fan which are adapted to generate an airflow at least in the inner air cavity, wherein the ventilation unit comprises at least one supply channel supplying an airflow to the indoor environment, at least one extraction channel extracting an airflow from the indoor environment, at least one primary channel directly connecting the ventilation unit with the outdoor environment, at least one secondary channel connecting the ventilation unit with the inner air cavity or the outdoor environment, and one airflow control damper arranged along the extraction and supply channels;
- activating the ventilation unit to supply the air taken from the outdoor environment to the indoor environment, and either directly expelling the air extracted from the indoor environment to the outdoor environment or expelling the air extracted from the indoor environment through the inner air cavity and/or through the layers of air-permeable materials to the outdoor environment.

[0034] In an embodiment of the method according to the invention, the control damper is activated to connect the extraction channel with the primary channel or the secondary channel in a mutually excluding way, and to connect the supply channel with the primary channel or

the secondary channel in a mutually excluding way.

[0035] This way, it is possible to feed the air taken from the outdoor environment through the inner air cavity to the indoor environment, so that the supply air flow rate transversely crosses the at least one air-permeable layer, and directly expel the air extracted from the indoor environment to the outdoor environment. Similarly, it is possible to feed the air taken directly from the outdoor environment to the indoor environment and to expel the air extracted from the indoor environment to the outdoor environment through the inner air cavity so that the air flow rate being expelled transversely crosses the at least one air-permeable layer. The advantages of thermal and mechanical interaction between the airflows and the solid matrix of the permeable layers are exploited.

[0036] According to an embodiment of the present invention, a bypass channel is connected to the secondary channel and at least one damper is arranged between the secondary channel and the bypass channel to direct the airflows of the secondary channel, in a mutually excluding way, into the inner air cavity or directly into the outdoor environment.

[0037] By operating the damper to direct the airflow to the bypass channel, it is possible to extract air from the indoor environment and expel it directly to the outdoor environment, whereas the air supplied to the indoor environment can be fed directly from the outdoor environment. In this case, the wall assembly behaves conventionally. In the method according to the present invention, the wall may further comprise an outer air cavity delimited externally by the outer layer of air-permeable material and internally by the intermediate layer of air-permeable material.

[0038] According to a possible embodiment of the method, a supply airflow is generated by the supply fan and an extraction airflow by the extraction fan. The indoor environment can be placed selectively in fluid communication with the inner air cavity of the wall or with the environment outside the wall.

[0039] The ventilation unit can be controlled as supply and/or extraction depending on various conditions, e.g. depending on temperature and relative humidity conditions of the outdoor environment and the indoor environment, and/or depending on the pressure differences between the inner air cavity and the outer air cavity, or depending on the pressure differences between the inner air cavity and the outdoor environment, and/or depending on the solar radiation detected in the outdoor environment, and/or depending on the concentration of carbon dioxide and/or volatile organic compounds in the indoor environment, and/or depending on the presence of people in the indoor environment.

Brief description of the drawings

[0040] Further characteristics and advantages of the present invention will be more evident from the following description, made for illustration purposes only and with-

out limitation, referring to the accompanying drawings, in which:

- Figure 1 is a diagram of a wall assembly according to an embodiment of the present invention;
- Figure 2 is a simplified diagram depicting a first operating mode of a wall assembly according to an embodiment of the present invention;
- Figure 2A is a simplified diagram of the wall assembly of Figure 1 in the operating mode of Figure 2;
- Figure 2B is a simplified diagram of airflows in the first operating mode of Figure 2;
- Figure 3 is a simplified diagram depicting a second operating mode of a wall assembly according to an embodiment of the present invention;
- Figure 3A is a simplified diagram of the wall assembly of Figure 1 in the operating mode of Figure 3;
- Figure 3B is a simplified diagram of the airflows in the second operating mode of Figure 3;
- Figure 4 is a simplified diagram depicting a further operating mode of a wall assembly according to an embodiment of the present invention;
- Figure 4A is a simplified diagram of the wall assembly of Figure 1 in the operating mode of Figure 4; and
- Figure 4B is a simplified diagram of the airflows in the second operating mode of Figure 4.

Detailed description

[0041] Figure 1 shows the diagram of a dynamic insulation wall assembly, in which a wall 1 is interposed between an indoor environment I of a building and the outdoor environment E.

[0042] In the embodiment shown here and hereinafter, the wall 1 has an outer air cavity 20 and an inner air cavity 40, which are separated from each other by at least one intermediate layer 30 of air-permeable material. The outer air cavity 20 is delimited externally by an outer layer 10 of air-permeable material and the inner air cavity 40 is delimited internally by a layer 60 of air-impermeable material.

[0043] The dynamic insulation wall assembly of Figure 1 particularly comprises a ventilation unit 100 equipped with a programmable control device, identified in Figure 1 by the sign CPU, to automatically control an airflow in the inner air cavity 40 and, possibly and indirectly, in the outer air cavity 20.

[0044] The wall 1 can be formed, for example, by a plurality of modules juxtaposed in mutual contact, each of which has the outer air cavity 20 and the inner air cavity 40 in fluid communication with the respective outer air cavities 20 and the respective inner air cavities 40 of the adjacent modules. The ventilation unit 100 can thus be embedded in at least one of the modules.

[0045] The ventilation unit 100 comprises in particular at least one supply channel 45 of an airflow to the indoor environment I. A supply fan V1 is arranged along the supply channel 45. The ventilation unit 100 further com-

prises at least one extraction channel 25 of an airflow, along which an extraction fan V2 is arranged, which takes the air from the indoor environment I.

[0046] Along the extraction 25 and supply 45 channels, a control damper is arranged, which is denoted in Figure 1 by the sign SC, which allows to direct the airflows of the extraction 25 and supply 45 channels. The control damper SC is equipped with a motorised actuator MS controlled by the programmable control device CPU, to selectively put in fluid communication the indoor environment I with the inner air cavity 40 or with the environment E outside the wall 1.

[0047] A heat recovery unit (or exchanger) RC is further arranged along the extraction 25 and supply 45 channels between the supply and extraction airflows along the respective channels 45 and 25.

[0048] The control damper SC is interposed between the extraction 25 and supply 45 channels and a pair of channels, here and hereinafter denoted as primary channel 75 and secondary channel 85. The embodiment of Figure 1 further depicts a bypass channel 54 along the secondary channel 85, which bypasses the wall 1 and then the inner air cavity 40, and makes the assembly work conventionally. The assembly preferably comprises a damper 95 controlled e.g. by the programmable control device CPU, to divert the entire air flow rate to the bypass channel 54 in a mutually exclusive way, where necessary (and, therefore, directly to the outdoor environment E), or to the inner air cavity 40. The wall assembly according to the embodiment of Figure 1 comprises a plurality of temperature and relative humidity sensors denoted in Figure 1 by the signs TUR_1 to TUR_4 , which send signals to the programmable control device 100. In particular, there are: at least one temperature and relative humidity sensor TUR_1 placed outside the wall 1; at least one temperature and relative humidity sensor TUR_2 placed in the outer air cavity 20 of the wall 1; at least one temperature and relative humidity sensor TUR_3 placed in the inner air cavity 40 of the wall 1; and at least one temperature and relative humidity sensor TUR_4 placed in the indoor environment I.

[0049] At least one supply filter, denoted by the sign FM in Figure 1, is arranged along the supply channel 45 between the control damper SC of the airflows and the heat recovery unit RC. An extraction filter, denoted in Figure 1 by the sign FE, is arranged along the extraction channel 25 between the indoor environment I and the heat recovery unit RC. In the embodiment shown in Figure 1, the wall assembly further comprises a plurality of differential manometers denoted in Figure 1 by the signs ΔP_1 to ΔP_5 , which send signals to the programmable control device CPU.

[0050] In particular, there are: at least one differential manometer ΔP_1 to measure the pressure differences between the outer air cavity 20 and the inner air cavity 40, or between the inner air cavity 40 and the outdoor environment E; at least one differential manometer ΔP_2 to measure the pressure differences upstream and down-

stream of the supply filter FM, with reference to the supply airflow, along the supply channel 45; at least one differential manometer ΔP_3 to measure the pressure differences upstream and downstream of the extraction filter FE, with reference to the extraction airflow along the extraction channel 25; at least one differential manometer ΔP_4 to measure the pressure differences upstream of the supply filter FM and downstream of the supply fan V1, with reference to the supply airflow along the supply channel 45; and at least one differential manometer ΔP_5 to measure the pressure differences upstream of the extraction filter FE and downstream of the extraction fan V2, with reference to the extraction airflow along the extraction channel 25.

[0051] Further sensors are provided in the embodiment of Figure 1. In the outdoor environment E, for example, an irradiation sensor SR may be provided, as well as a first sensor of volatile organic compounds denoted by the sign VOC_1 ; at least one second sensor of volatile organic compounds denoted by the sign VOC_2 is arranged in the indoor environment I. In the same indoor environment, I, a carbon dioxide sensor denoted by the sign CO_2 , a room thermostat denoted by the sign TS, in addition to at least one surface temperature sensor T5 of at least one wall of the indoor environment I, are also arranged. All these sensors VOC_1 , VOC_2 and CO_2 , as well as the room thermostat TS, send signals to the programmable control device CPU to which they are connected. Further sensors, although not explicitly shown in Figure 1, can be provided in the indoor environment I, such as e.g. an occupancy sensor that allows to detect whether or not people are present in the indoor environment I.

[0052] In the embodiment of Figure 1, a shading system is further shown that includes a solar radiation screen 5 controlled by an actuator MO depending on a signal emitted by the irradiation sensor SR and sent to the programmable control device CPU.

[0053] Further components of the wall assembly depicted in Figure 1 may consist, e.g., of a thermo-hygrometric air treatment circuit 46 placed along the supply channel 45 and embedded in the ventilation unit 100, and a fan coil 47 installed in the indoor environment I and connected to the supply channel 45. The airflow can also be conveyed to a zone air handling unit (also known by the acronym A.H.U.).

[0054] Figures 2, 2A and 2B depict a first operating mode of the wall assembly according to the present invention.

[0055] With reference to Figure 2, fresh air is taken from the outdoor environment E through the air-permeable outer layer 10, then crosses the outer air cavity 20 and the intermediate layer 30, which is also air permeable, until reaching the inner air cavity 40. The ventilation unit 100 then receives air from the inner air cavity 40 and feeds it into the indoor environment I through the secondary channel 85 and the supply channel 45. The stale air present in the indoor environment I is instead taken

via the extraction channel 25 and the primary channel 75 and then directly expelled to the outdoor environment E.

[0056] Figure 2A schematically depicts the position of the control damper SC of the airflows between the channels 25, 45, 75 and 85 in this first operating mode, and Figure 2B schematically depicts the airflows exchanging heat as they pass through the heat recovery unit RC.

[0057] This first operating mode is activated automatically, e.g. in winter, when the temperature in the inner air cavity 40 is higher than that of the outdoor environment E air, or in summer, when the temperature in the inner air cavity 40 is lower than that of the air of the outdoor environment E.

[0058] Figures 3, 3A and 3B depict a second operating mode of the wall assembly according to the present invention.

[0059] With reference to Figure 3, fresh air is taken directly from the outdoor environment E and sent to the indoor environment I via the primary channel 75 and the supply channel 45. Stale air present in the indoor environment I is fed into the inner air cavity 40 through the extraction channel 25 and the secondary channel 85, and is expelled to the outdoor environment E after crossing the air-permeable intermediate layer 30, the air cavity 20 and the outer layer 10 which is also air permeable.

[0060] Figure 3A schematically depicts the position of the control damper SC of the airflows between the channels 25, 45, 75 and 85 in this second operating mode, and Figure 3B schematically depicts the airflows exchanging heat as they pass through the heat recovery unit RC.

[0061] This second operating mode is automatically activated, e.g., in winter, when the temperature in the inner air cavity 40 is lower than that of the outdoor environment air, or in summer, when the temperature in the inner air cavity 40 is higher than that of the outdoor environment air.

[0062] Figures 4, 4A, and 4B depict a further operating mode similar to that of Figures 3, 3A and 3B, in the case where the wall assembly provides the bypass channel 54 and the damper 95 depicted in Figure 1. In this case, the extraction and supply airflows bypass the wall 1 and the wall assembly works conventionally. Similar to the second operating mode, Figure 4A schematically depicts the position of the control damper SC of the airflows between the channels 25, 45, 75 and 85 in this further operating mode, and Figure 4B schematically depicts the airflows exchanging heat as they pass through the heat recovery unit RC.

[0063] Switching between the various operating modes takes place automatically and does not only depend on the season but also takes into account, e.g., the temperatures measured by the various sensors shown in Figure 1, such as the TUR_1 - TUR_4 , T_5 sensors, and the settings of the room thermostat TS.

[0064] The control logic described so far is provided by way of example. For example, the programming of the programmable control device CPU shall also take

into account the intended use of the building, its structural characteristics and the composition of the energy balance to be evaluated at the design step.

[0065] The air speed produced by V1 and V2 fans is related, e.g., to the detections of relative humidity in the indoor environment I, carbon dioxide concentration and volatile organic compounds, as well as any occupancy sensors for the presence of people in the indoor environment I. This way, the wall assembly according to the present invention is capable of blocking the air circulation, e.g., in the absence of people, and of modulating the flow rate depending on the conditions of the indoor environment I. This allows to find a value of the air speed related to the activation of the fans V1 and/or V2.

[0066] The possible outdoor shading control system, which includes the solar radiation screen 5 controlled by the actuator MO depending on the signal emitted by the irradiation sensor SR, is capable of raising and lowering the blades of the screen 5, as well as manage its inclination depending on the irradiation conditions detected by the sensor SR.

[0067] In summary, the solution proposed by the present invention involves the simultaneous use of the walls of a building envelope as a mechanical ventilation, heat recovery and anti-particulate filter system. This is an embedded envelope-plant system, in which part of the plant functions are delegated to the same wall, as well as to the ventilation unit, thanks to some technological measures and the use of porous and air-permeable materials.

[0068] The advantages of a solution according to the present invention are many, including:

- winter heat recovery: the external ventilation air is pre-heated by convection in a heat recovery unit before being fed into the indoor environment, thus mitigating conduction heat losses of the wall;
- decrease in summer heat storage: indoor air is expelled through the wall when it is energetically convenient, in order to thermally discharge the inner masses and offer greater thermal inertia during day-time hours;
- reduction in energy demand for heating, cooling and ventilation, compared to conventional building technologies;
- improvement of indoor air quality: the wall acts as a high-efficiency anti-particulate filter for PM10 and PM2.5, feeding air cleaner than the extracted air into the environment;
- integration of the building-plant system: the envelope becomes an integral part of the ventilation system, thus allowing to reduce number and section of the channels and, consequently, to reduce the costs of installation and maintenance of these plant components.
- modulation of the behaviour of the building envelope: the management of the airflows allows to pursue mitigation and adaptation strategies to different climatic

conditions.

[0069] Various modifications may be made to the embodiments described so far without departing from the scope of the present invention. For example, embodiments in which the outer air cavity 20 is not present may be provided.

Claims

1. A dynamic insulation wall assembly to build air-permeable walls interposed between an indoor environment (I) of a building and the outdoor environment (E), comprising at least one wall (1) having an inner air cavity (40) delimited externally by at least one intermediate layer (30) of air-permeable material and internally by a layer (60) of air-impermeable material, and a ventilation unit (100) equipped with a programmable control device (CPU) for automatically controlling an airflow at least in said inner air cavity (40), wherein said ventilation unit (100) comprises at least one supply channel (45) of an airflow toward the indoor environment (I), at least one extraction channel (25) of an airflow of the indoor environment (I), **characterised in that** said ventilation unit (100) comprises at least one primary channel (75) directly connecting said ventilation unit (100) with the outdoor environment (E) and at least one secondary channel connecting said ventilation unit (100) with said inner air cavity (40) or said outdoor environment (E), wherein said ventilation unit (100) further comprises a control damper (SC) of the airflows, which is arranged between said extraction (25) and supply (45) channels and said primary (75) and secondary (85) channels.
2. The wall assembly according to claim 1, wherein a bypass channel (54) is connected to said secondary channel (85) and wherein at least one damper (95) is arranged between said secondary channel (85) and said bypass channel (54) to direct the airflows of said secondary channel (85), in a mutually excluding way, into said inner air cavity (40) or directly into the outdoor environment (E).
3. The wall assembly according to claim 1, further comprising an outer air cavity (20) delimited externally by an outer layer (10) of air-permeable material and internally by said at least one intermediate layer (30) of air-permeable material.
4. The wall assembly according to claim 3, wherein said wall (1) is formed by a plurality of modules juxtaposed in mutual contact, each of which has the outer air cavity (20) and the inner air cavity (40) in fluid communication with the respective outer air cavities (20) and the respective inner air cavities (40) of the ad-

jacent modules.

5. The wall assembly according to claim 1, wherein said ventilation unit (100) comprises at least one supply fan (V1) arranged along said supply channel (45) and at least one extraction fan (V2) arranged along said extraction channel (25).
6. The wall assembly according to claim 1, wherein said control damper (SC) is equipped with a motorised actuator (MS) controlled by said programmable control device (CPU), to selectively put in fluid communication the indoor environment (I) with said inner air cavity (40) or with the outdoor environment (E).
7. The wall assembly according to claim 5, further comprising at least one heat recovery unit (RC) between the supply airflows and the extraction airflows along the respective channels (45) and (25).
8. The wall assembly according to claim 3, further comprising a plurality of temperature and relative humidity sensors (TUR₁-TUR₄) which send signals to said programmable control device (CPU) and which comprise:
 - at least one temperature and relative humidity sensor (TUR₁) placed outside said wall (1);
 - at least one temperature and relative humidity sensor (TUR₂) placed in the outer air cavity (20) of said wall (1);
 - at least one temperature and relative humidity sensor (TUR₃) placed in the inner air cavity (40) of said wall (1); and
 - at least one temperature and relative humidity sensor (TUR₄) placed in said indoor environment (I).
9. The wall assembly according to any one of the preceding claims, wherein at least one supply filter (FM) is arranged along said supply channel (45) between said control damper (SC) of the airflows and said heat recovery unit (RC) and at least one extraction filter (FE) is arranged along said extraction channel (25) between said indoor environment (I) and said heat recovery unit (RC), and wherein the wall assembly further comprises a plurality of differential manometers (ΔP_1 - ΔP_5) which send signals to said programmable control device (CPU) and which comprise:
 - at least one differential manometer (ΔP_1) to measure the pressure differences between said inner air cavity (40) and said outer air cavity (20), or between said inner air cavity (40) and said outdoor environment (E);
 - at least one differential manometer (ΔP_2) to measure the pressure differences upstream and

- downstream of said supply filter (FM), with reference to the supply airflow, along said supply channel (45);
- at least one differential manometer (ΔP_3) to measure the pressure differences upstream and downstream of said extraction filter (FE), with reference to the extraction airflow, along said extraction channel (25);
 - at least one differential manometer (ΔP_4) to measure the pressure differences upstream of said supply filter (FM) and downstream of said supply fan (V1), with reference to the supply airflow, along said supply channel (45); and
 - at least one differential manometer (ΔP_5) to measure the pressure differences upstream of said extraction filter (FE) and downstream of said extraction fan (V2), with reference to the extraction airflow, along said extraction channel (25).
10. The wall assembly according to any one of the preceding claims, further comprising at least one first sensor (VOC_1) of volatile organic compounds which is placed in the outdoor environment (E), at least one second sensor (VOC_2) of volatile organic compounds, at least one room thermostat (TS), at least one surface temperature sensor (T5) of at least one wall of said indoor environment (I) and at least one sensor (CO_2) of carbon dioxide which are placed in said indoor environment (I), said sensors sending signals to said programmable control device (CPU) to which they are connected.
11. The wall assembly according to any one of the preceding claims, further comprising a shading system that includes a solar radiation screen (5) controlled by an actuator (MO) depending on a signal emitted by an irradiation sensor (SR) and sent to said programmable control device (CPU).
12. A method for automatically controlling one or more airflows in a dynamic insulation wall interposed between an indoor environment (I) of a building and the outdoor environment (E), comprising the steps of:
- providing at least one wall (1) having an inner air cavity (40) delimited externally by at least one intermediate layer (30) of air-permeable material and internally by a layer (60) of air-impermeable material, said wall (1) further comprising an outer layer (10) of air-permeable material placed outside said intermediate layer (30) of air-permeable material;
 - providing a ventilation unit (100) equipped with a programmable control device (CPU) to automatically control a supply fan (V1) and/or an extraction fan (V2) which are adapted to generate an airflow at least in said inner air cavity (40), wherein said ventilation unit (100) comprises at least one supply channel (45) of an airflow toward the indoor environment (I), at least one extraction channel (25) of an airflow from the indoor environment (I), at least one primary channel (75) directly connecting said ventilation unit (100) with the outdoor environment (E), at least one secondary channel (85) connecting said ventilation unit (100) with said inner air cavity (40) or said outdoor environment (E), and a control damper (SC) of the airflows arranged along said extraction (25) and supply (45) channels, and wherein said ventilation unit (100) further comprises a control damper (SC) of the airflows arranged between said extraction (25) and supply (45) channels and said primary (75) and secondary (85) channels;
 - activating said ventilation unit (100) to supply the air taken from the outdoor environment to said indoor environment (I) and to expel to the outdoor environment (E) the air extracted from said indoor environment (I), **characterised by** comprising the step of:
 - activating said control damper (SC) to connect said extraction channel (25) with said primary channel (75) or said secondary channel (85) in a mutually excluding way and to connect said supply channel (45) with said primary channel (75) or said secondary channel (85) in a mutually excluding way.
13. The method according to claim 12, wherein a bypass channel (54) is connected to said secondary channel (85) and wherein at least one damper (95) is arranged between said secondary channel (85) and said bypass channel (54), further comprising the step of activating said damper (95) to direct the airflows of said secondary channel (85), in a mutually excluding way, into said air cavity (40) or directly into the outdoor environment (E).
14. The method according to claim 12, further comprising an outer air cavity (20) delimited externally by said outer layer (10) of air-permeable material and internally by said intermediate layer (30) of air-permeable material.
15. The method according to claim 12, wherein a supply airflow is generated by said supply fan (V1) and an extraction airflow is generated by said extraction fan (V2), and wherein the indoor environment (I) is selectively put in fluid communication with said inner air cavity (40) of the wall (1) or with the outdoor environment (E) outside said wall (1).
16. The method according to claim 15, wherein said ven-

tilation unit (100) is controlled as supply and/or extraction depending on one or more of the following conditions:

- temperature of the outdoor environment (E) 5
and/or the indoor environment (I);
- relative humidity of the outdoor environment (E) and/or of the indoor environment (I);
- pressure differences between said inner air cavity (40) and said outer air cavity (20) and/or said outdoor environment (E); 10
- solar radiation detected in said outdoor environment (E);
- concentration of carbon dioxide and/or volatile organic compounds in said indoor environment (I); 15
- presence of people in the indoor environment (I).

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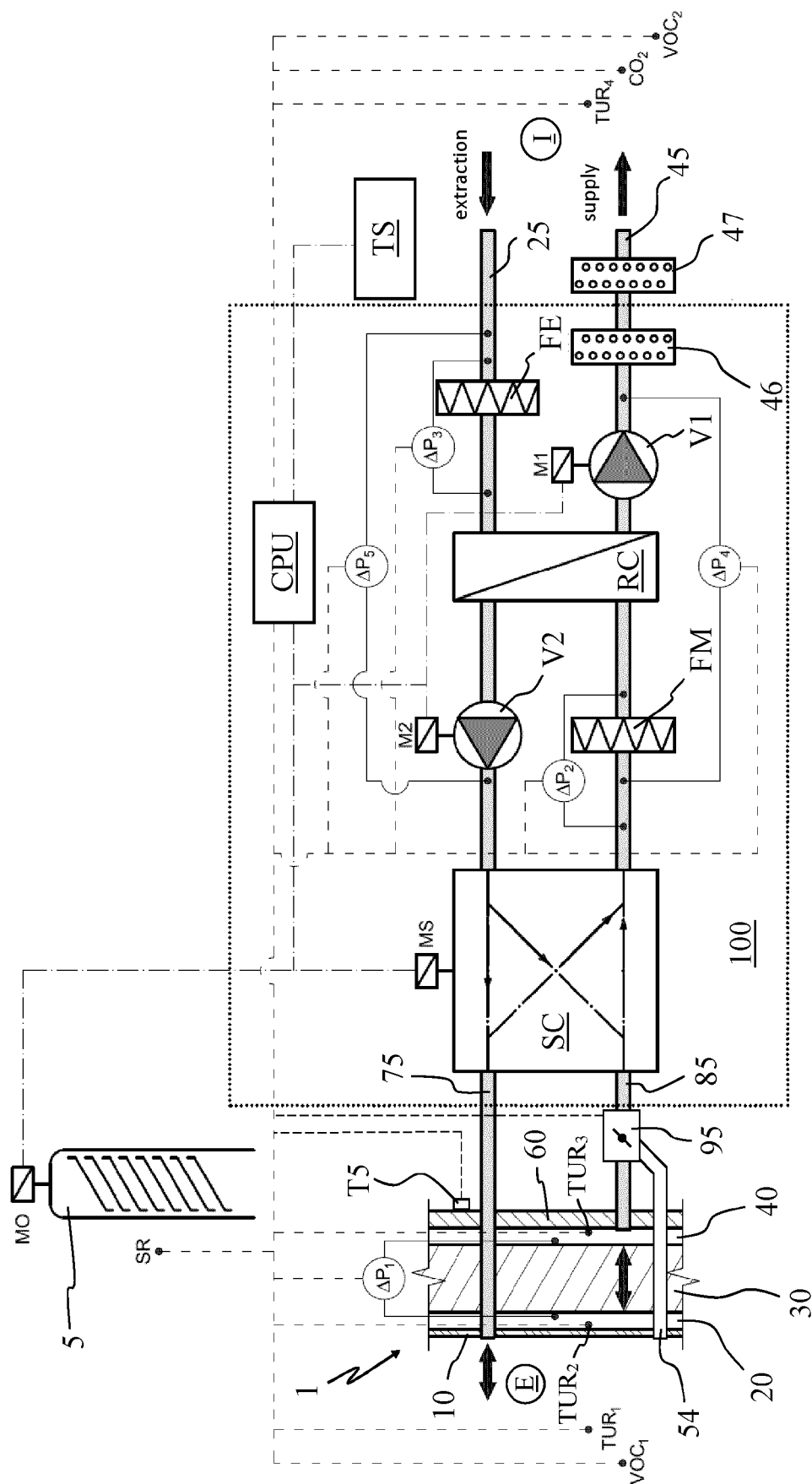


Fig. 1

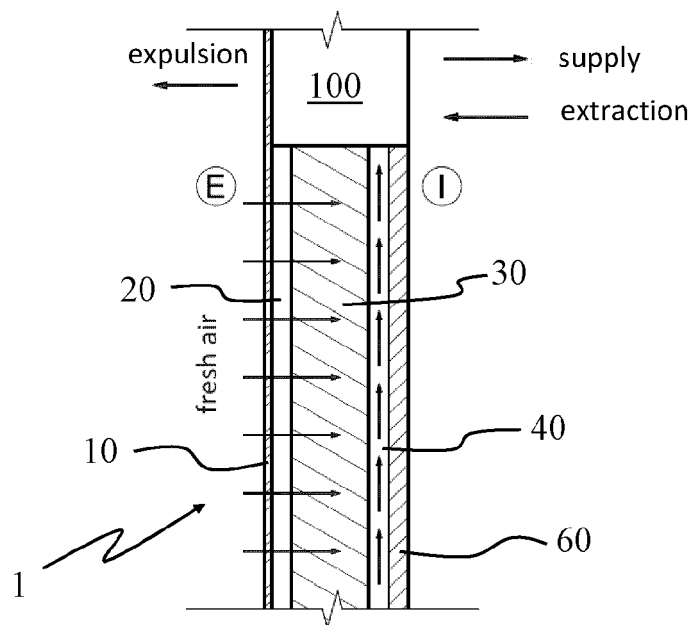


Fig. 2

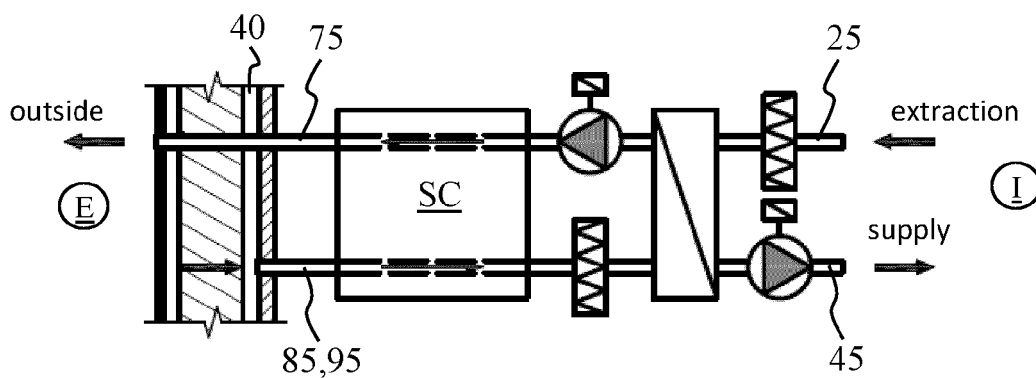


Fig. 2A

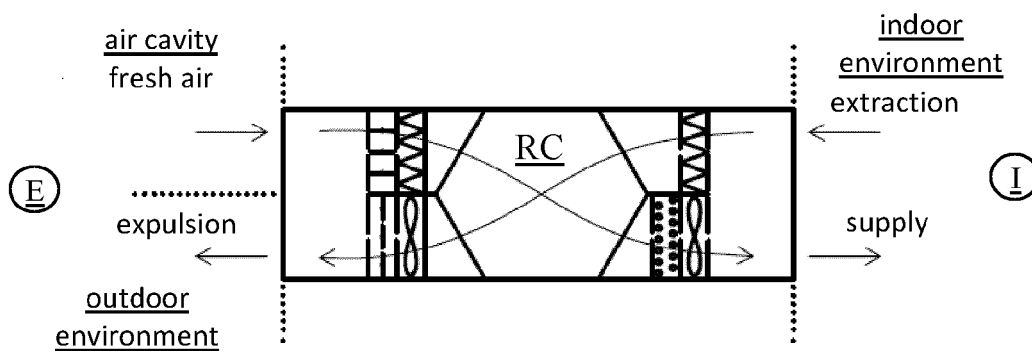


Fig. 2B

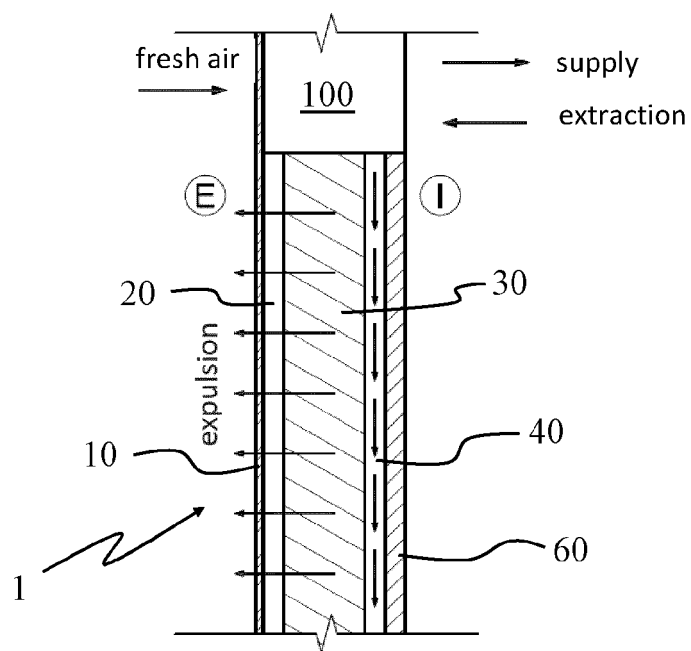


Fig. 3

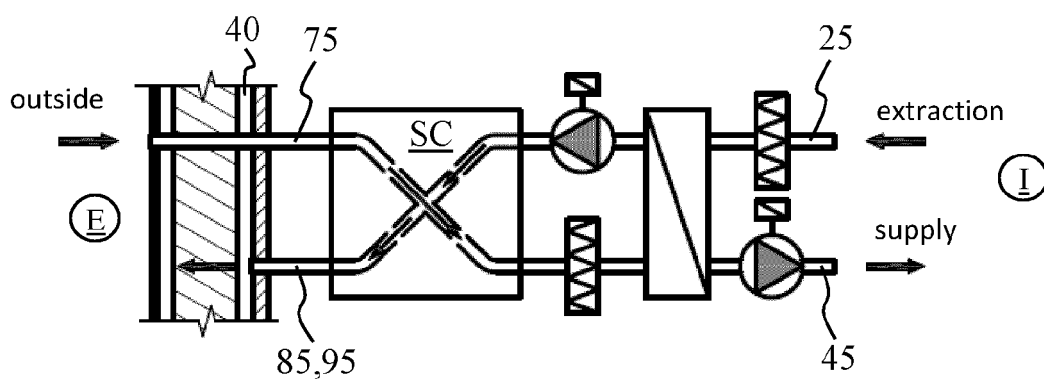


Fig. 3A

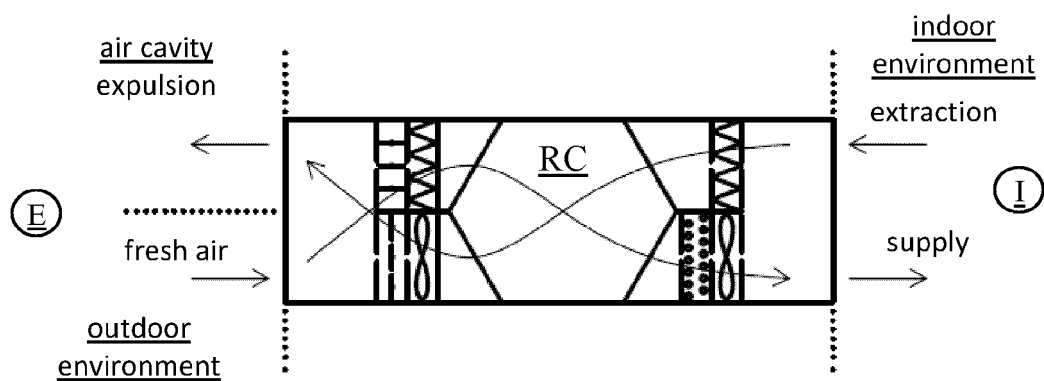


Fig. 3B

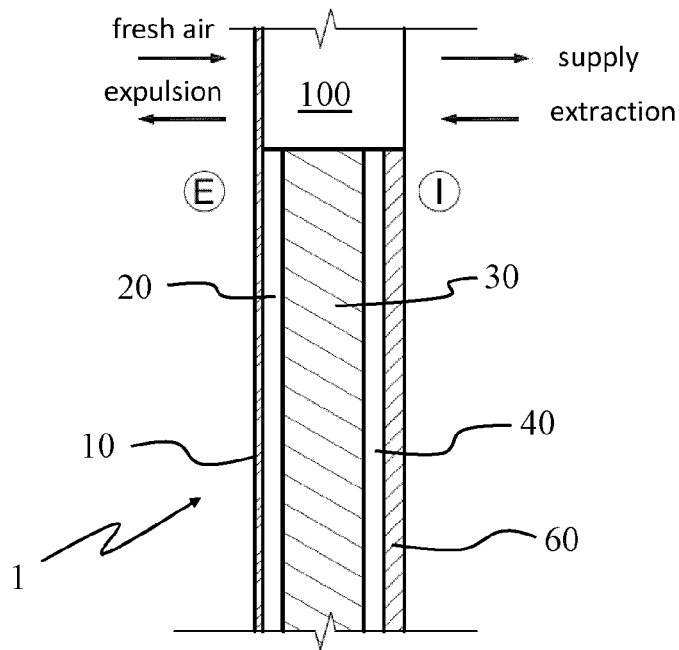


Fig. 4

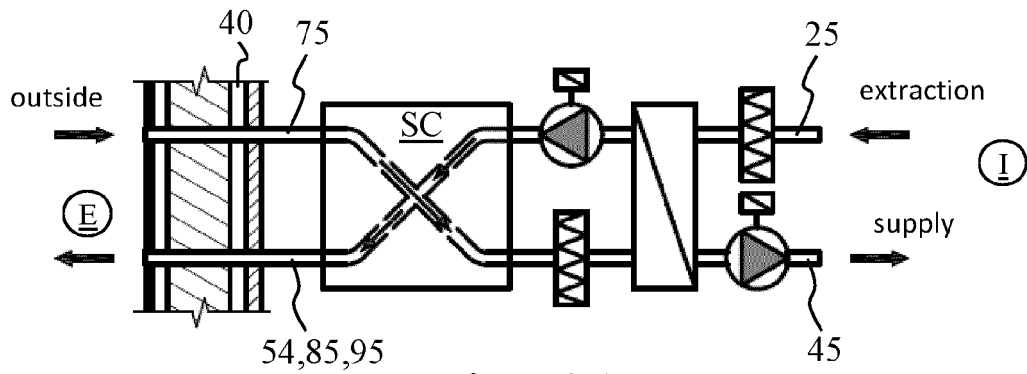


Fig. 4A

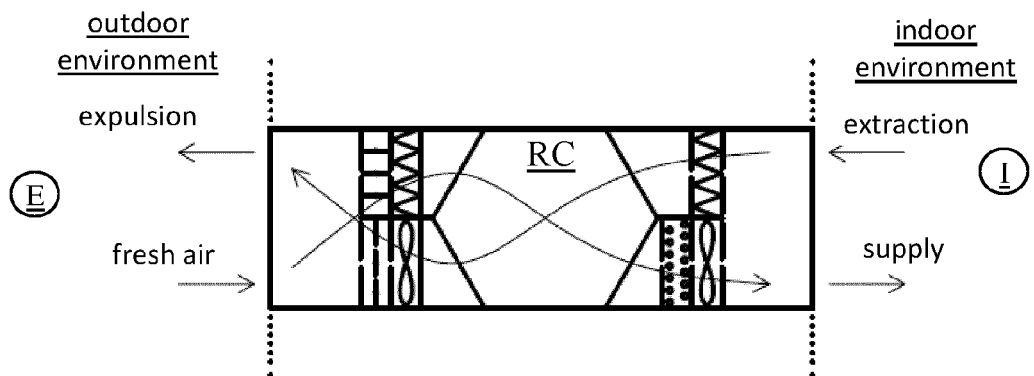


Fig. 4B



EUROPEAN SEARCH REPORT

Application Number

EP 23 20 0303

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Y	* page 7, paragraph 3 - page 11, paragraph 1; figures *	10,11	F24F7/013
A		2,6, 12-16	ADD. F24F110/12
X	WO 2016/079424 A1 (SERRAS EDOUARD [FR]) 26 May 2016 (2016-05-26)	1,3-5, 7-9	F24F110/22
Y	* page 6, line 13 - page 9, line 20;	10,11	F24F110/66
A	figures 1-3 *	2,6, 12-16	F24F120/10 F24F140/10
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	* the whole document *		
Y	US 8 423 192 B2 (LIU MINGSHENG [US]) 16 April 2013 (2013-04-16)	10	TECHNICAL FIELDS SEARCHED (IPC) F24F
	* column 3, line 11 - column 6, line 43 *		
Y	DE 21 2017 000173 U1 (KUNSHAN SILAIMU ENERGY SAVING TECH CO LTD [CN]) 5 February 2019 (2019-02-05)	10	
	* paragraph [0006] - paragraph [0036] *		
A	Anonymous: "Dampfbremse - Wikipedia", 19 August 2022 (2022-08-19), pages 1-11, XP093039022, Retrieved from the Internet: URL:https://de.wikipedia.org/w/index.php?title=Dampfbremse&oldid=225470308 [retrieved on 2023-04-13]	1	
The present search report has been drawn up for all claims			

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EPO FORM 1503 03/82 (P04C01)

Place of search

Munich

Date of completion of the search

22 February 2024

Examiner

Arndt, Markus

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

& : member of the same patent family, corresponding document

**ANNEX TO THE EUROPEAN SEARCH REPORT
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The members are as contained in the European Patent Office EDP file on
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22-02-2024

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