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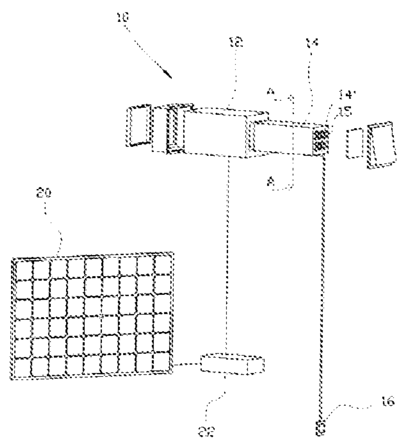
(54) Title **A VENTILATION SYSTEM AND A METHOD FOR PREHEATING A SUPPLY AIR IN THE SAME**

(57) Abstract

A ventilation system (1) and a method for preheating a supply air in the same, the system (1) being arranged in a building structure provided with a glazed balcony (3), wherein the ventilation system (1) comprises a pre-heating device configured for utilizing radiation from the sun to increase a temperature of a ventilation supply air prior to entering a room (5) of the building structure via an air supply channel (10) extending between the glazed balcony (3) and the room (5). The preheating device comprises the interior space of the glazed balcony (3).



A VENTILATION SYSTEM AND A METHOD FOR PREHEATING A SUPPLY AIR IN THE SAME

The invention concerns a ventilation system of a building, especially a ventilation system for blocks of flats, wherein the blocks of flats are provided with a glazed balcony.

More specifically, the invention is related to an improved ventilation system that for some particular conditions is configured for reducing energy consumption for heating a building structure.

There is a need for reducing energy consumption i.a. for heating building structures. The need is especially great for buildings constructed some decades ago wherein energy consumption at least in some areas was not an important issue, and wherein refreshment of air inside the building was prioritized over energy consumption for heating the air.

A ventilation system of a building may be a so-called mechanical ventilation system configured for drawing outside air through one or more openings (valves) in the building structure by providing an underpressure inside the building and expel “used” air out of the building via a ventilation channel typically protruding through the roof of the building. In a cold climate, a mechanical system continuously replaces heated inside air with cold outside air, and thus requires heating sources to provide a comfortable climate inside the building.

To reduce the disadvantage with respect to energy consumption required for providing a comfortable climate inside the building, building regulation in some countries requires a so-called balanced ventilation system provided with a heat-exchanging device for heating supply air by means of heat of the exhaust air.

Publication WO2011062541A1 discloses a device for heating supply air for the ventilation of a room, which is supplied with supply air from a glazed balcony located adjacent to the room. The device comprises an outer balcony parapet, which is permeable to the heat radiation of the sun, and a heat-absorbing inner balcony parapet located inside the outer balcony parapet. The inner balcony parapet is adapted to be heated by the solar heat radiation that penetrates the outer parapet. The outer and inner balcony parapets define between them a substantially vertical air gap. A fan arrangement is adapted to force air present in the glazed balcony through the air gap from the lower part thereof to the upper part thereof for heating of said air. Inner outlets are arranged in the upper part of the vertical air gap between the inner and outer balcony parapet. Heated air is allowed to flow out through the outlets and into the glazed balcony before being supplied to the room as supply air.

Publication CN104197558 discloses an integrated balcony solar heating device comprising a solar heat collector, a control system, a water tank, a connecting pipe for connecting the solar collector and the water tank. The solar heating device further comprises a solar greenhouse integrated with the outer wall of the balcony. The solar greenhouse extending laterally from one side of the balcony to the other side. A heat collector is vertically disposed at a rear portion of the solar greenhouse, and the solar heating device further includes an insulated back plate detachably disposed at a rear portion of the solar greenhouse.

Publication WO 2012/022877 A1 discloses a system for activating heat transfer from a solar extension of a building to at least one internal space to be heated of said building to ensure or complete the heating of the latter. The system comprises means for circulating air in a loop between said solar extension and the at least one internal space of the building to be heated.

Publication NO 20100475 A1 discloses a system for capturing and storing solar heat in buildings where stored warm air is heat exchanged with cold fresh air using a heat pump.

Publication JPS5731735 A discloses a building utilizing an attic for preheating air utilizing solar radiation.

There is a need for a ventilation system for a building that utilizes radiation from the sun to reduce energy consumption for heating the building, wherein the system can be retro-fitted substantially without reconstruction of the building.

The invention has for its object to remedy or to reduce at least one of the drawbacks of the prior art, or at least provide a useful alternative to prior art.

The object is achieved through features, which are specified in the description below and in the claims that follow.

The invention is defined by the independent patent claims. The dependent claims define advantageous embodiments of the invention.

According to the invention, heated air within a glazed balcony is utilized as ventilation air.

In a first aspect of the invention, there is provided a ventilation system arranged in a building structure provided with a glazed balcony. The ventilation system comprises a pre-heating device configured for utilizing radiation from the sun to increase a tempera-ture of a ventilation supply air prior to entering a room of the building structure via an air supply channel extending between the glazed balcony and the room, wherein the pre-heating device comprises the interior space of the glazed balcony.

When radiant heat from the sun that passes through the glass or any other clear barrier of the glazed balcony, heat is absorbed by the mass inside the balcony, and the air inside the glazed balcony will be heated by infrared radiation from the mass. The mass may typ-ically be walls and floor defining the interior space of the glazed balcony, and any objects within the balcony. Therefore, when outside air passes the interior space of the balcony prior to flowing via the air supply channel into the room of the building, a temperature difference between the outside air and the room may be reduced. A reduced tempera-ture difference will reduce the amount of energy needed for heating the room. Thus, the invention is particularly advantageous during daytime on clear, chilly days during the win-ter season.

Although having a best effect on a clear, sunny day, radiant heat from the sun will also have an effect on a cloudy day. During the night, there will not be any radiant heat. However, the air inside the glazed balcony will for a period of time after sunset, be heated by infrared radiation from the mass inside the space of the glazed balcony that has absorbed radiant heat from the sun.

As long as a temperature inside the room is higher that the temperature within the space of the glazed balcony, heat will be transferred from the room through the wall bordering the glazed balcony, and to the glazed balcony. The amount of heat transferred through the wall, depends on a thermal resistance of the wall, a so-called R-value. The higher R-value, the better heat insulation and the less heat is transferred through the wall.

For blocks of flats constructed some decades ago, the R-value through external walls of the building may be relatively low as compared with blocks constructed according to current building regulations. Thus, for such older blocks of flats, a certain temperature raise of the interior space of the glazed balcony may be due to heat transfer through the wall between the room and the glazed balcony. Thus, some of a heat in the room that is lost due to heat transfer through said wall may be “recycled” back into the room.

The temperature within the space of the glazed balcony may be higher than a desired temperature of a ventilation air. This can be remedied by opening one or more windows of the glazed balcony. However, according to the invention, the air supply channel comprises at least one of:
a heat exchanging element comprising a thermal energy storage medium for balancing a temperature of the ventilation air flowing from the interior space of the glazed balcony and through the air supply channel, wherein the thermal energy storage medium material is selected from at least one of a liquid and a solid substance; and
a heating circuit operatively connected to an energy source.

The thermal energy storage medium is preferably configured for so-called sensible heat storage, meaning that the temperature of the material is either increased or decreased by the air flowing through the air supply channel.

As will be discussed in further details below, the heat exchanging element of the air supply channel may be provided with a plurality of spaced apart passages or ducts. A purpose of such ducts is to increase a contact area between the air flowing through the heat exchanging element and the heat storage medium. An effect of providing the air supply channel with a heating circuit operatively connected to an energy source is that a temperature of the ventilation air flowing through the air supply channel may be increased, even if the temperature of any thermal energy storage medium that in one embodiment forms part of the air supply channel, is lower than the air entering the air supply channel from the interior space of the glazed balcony.

When the air supply channel comprises a heating circuit, the heating circuit may be an electric heating cable. Contrary to for example a heating circuit based on a fluid, which according to one embodiment of the invention is an alternative to an electric heating cable, an electric heating cable does not require any pumps for circulating a heat carrying medium such as for example a liquid that may be pumped from a reservoir heated during daytime.

Any such electric cable may be operatively connected to a solar panel, preferably via a battery. A temperature of the ventilation air flowing through the air supply channel will in such a case be raised by means of an electric cable powered from a source of energy being independently from the mains of the building structure.

In an embodiment wherein the system comprises a battery, the battery may be arranged in the glazed balcony. In one embodiment the battery is integrated in a floor or in a wall of the balcony. In an alternative embodiment the battery is arranged inside a room of the flat. Arranging the battery inside a room of the flat may be advantageous in that an operating temperature of the battery is substantially constant. Thus, a capacity of the battery will substantially not be influenced by low outside air temperatures during the wintertime. However, arranging any battery inside a room of the flat may require some safety measures and may also not be allowed by building regulations. Therefore, arranging the battery in the glazed balcony may be preferred.

In an embodiment of the invention wherein the ventilation system is provided with a solar panel, the solar panel is preferably integrated in the parapet of the glazed balcony.

Integrating the solar panel in the parapet will have a positive effect on installation costs since the solar panel in such an embodiment forms part of the glazed balcony.

In an embodiment of the invention wherein the heating circuit comprises a fluid conduit, a pump for circulating the fluid is preferably powered by energy harvested by the solar panel.

Although the ventilation system according to the invention may be used in a balanced ventilation system, a primary use of the invention is in a mechanical ventilation system. A mechanical ventilation system is common for building structures erected some decades ago wherein requirements for heat insulation of the building structures was less stringent that present building regulations.

In a second aspect of the invention, there is provided a method for pre-heating a supply air for a ventilation system according to the first aspect of the invention, wherein the method comprising flowing the ventilation supply air via the interior space of the glazed balcony prior to flowing into the room via the air supply channel provided with at least one of the heat exchanging element, and the heating circuit operatively connected to an energy source.

In the following is described an example of a preferred embodiment illustrated in the accompanying drawings, wherein:

Fig. 1 is a perspective view showing a portion of a glazed balcony according to the invention, wherein a ventilation channel is arranged between the balcony and a room of a building structure;

Fig. 2 shows in larger scale an inlet portion of the air supply channel;

Fig. 3 shows an exploded view of one embodiment of the air supply channel provided with an electric heating cable operatively connected to a solar panel;

Fig. 4a shows in a larger scale a cross-section through A-A from fig. 3 of a first embodiment of a heat exchanging element that may form part of the air supply channel;

Fig. 4b shows in a larger scale a cross-section through A-A from fig. 3 of a second embodiment of a heat exchanging element that may form part of the air supply channel;

Fig. 5a and 5b show a perspective view of a portion of a façade of glazed balcony wherein a solar panel form an integrated part of the parapet of the glazed balcony.

Any positional indications refer to the position shown in the figures.

In the figures, same or corresponding elements are indicated by the same reference numerals. For clarity reasons, some elements may be without reference numerals in some of the figures.

A person skilled in the art will understand that the figures are just principal drawings. The relative proportions of individual elements shown in the figures may also be distorted, and features that are not necessary for explaining the invention may be left out.

In the figures, reference numeral 1 denotes a ventilation system according to the present invention. The ventilation system 1 comprises a preheating device configured for utilizing radiation from the sun to increase a temperature of a ventilation supply air prior to entering a room 5 of the building structure via an air supply channel 10 extending between a glazed balcony 3 and the room 5. The preheating device comprises the interior space of a glazed balcony 3 forming part of a building structure. When subjected to radiation from the sun, the temperature within the glazed balcony 3 will rise.

As shown in fig. 1, the air supply channel 10 is arranged in a wall 4 between the glazed balcony 3 and the neighbouring room 5. The room 5 is in fluid communication with a mechanical vent (not shown) providing a pressure differential between the space of the glazed balcony 3 and the room 5. When the mechanical vent is in operation, the heated air from within the glazed balcony 3, which constitutes at least part of the preheating device, is sucked into the room 5.

For illustrative purposes, a roof of the building structure is not shown in fig. 1.

The glazed balcony 3 is provided with slidable glass elements 31 arranged on top of a parapet 33 of the balcony 3. Between neighbouring and partly overlapping slidable glass elements 31 there will be some clearance allowing outside air to pass into the space of the glazed balcony 3. Thus, air sucked from interior space within the glazed balcony 3 and into the room 5, will be replenished by said air passing through the clearances. However, a portion of the parapet 33 may additionally or alternatively be provided with for example a jalousie (not shown) for regulating the air flow into the glazed balcony 3.

Also shown in fig. 1, an optional solar panel 20 is arranged in a portion of the parapet 33. The solar panel 20 shown, has replaced fixed glass elements 31' of the parapet 33.

The solar panel 20 may be configured for charging a battery 22 (shown in fig. 3) for storing energy provided by the solar panel 20 during daytime. In one embodiment of the invention, the electrical power stored in the battery is used as a power source for a heating cable 15 arranged in the air supply channel 10, as will be discussed below in relation to figures 3-4b.

In the embodiment shown in fig. 1, the battery is integrated in a recess in a floor 35 of the glazed balcony 3. The recess is provided with a lid 37 (indicated by dotted lines). As an alternative to integrating a battery in a recess in the floor 35, any battery for providing power to the heating cable 15, may be arranged within the space of the glazed balcony 3, or in a portion of an outer wall 51 of the building structure, preferably in a recess in a portion of the outer wall 51 defining a portion of the glazed balcony 3. Arranging the battery 22 in a recess is advantageous with respect to reducing any fire hazard that a battery may represent, especially when the recess is provided in a floor 35 or wall 51 made of concrete or any other nonflammable material.

In a glazed balcony 3, at least the lowermost row of glass elements 31' of the parapet 33, may be of a type that at least reduces the transparency from an outside of the glazed balcony 3. By providing such glass elements 31' in a dark colour similar to a colour of any solar panel 20, any negative visual appearance represented by the solar panel 20 on the façade of the glazed balcony 3, may at least be reduced.

Fig. 2 shows a portion of the air supply channel 10 protruding from the wall 4 into the space of the glazed balcony 3, i.e., the inlet of the air supply channel 10. Airflow from the space within the glazed balcony 3 is indicated by arrows F.

Fig. 3 is an exploded view of the air supply channel 10 particularly suitable for the present invention. The air supply channel 10 comprises an open-ended housing 12 configured for, in a position of use, receiving a heat exchanging element 14. The heat exchanging element 14 is configured for accepting, storing, and releasing thermal energy, depending on a temperature difference between air flowing through the heat exchanging element 14 comprising a thermal storage medium 14S, 14L. The thermal storage medium 14S and 14L will be discusses in relation to figures 4a and 4b, respectively.

The open-ended housing 12 shown in fig. 3 is preferably made of a heat insulating material, such as for example but not limited to, rock wool or polystyrene. The thermal energy storage medium 14S, 14L of the heat exchanging element 14 is suitable for balancing a temperature of the ventilation air flowing through the air supply channel 10. By the term “balancing” is meant that heat from the air flowing through the air supply channel 10 is absorbed by the heat exchanging medium 14S, 14L when a temperature of the air is higher than a temperature of the thermal energy storage medium 14S, 14L of the heat exchanging element 14, and that heat is liberated or released from the thermal energy storage medium 14S, 14L to the air flowing through the air supply channel 10 when a temperature of the air is lower than a temperature of the thermal energy storage medium 14S, 14L of the heat exchanging element 14. Thus, the thermal energy storage medium 14S, 14L of the heat exchanging element 14 will typically be heated during daytime and cooled during night. When made from a heat insulation material, the open-ended housing 12 will substantially prevent, or substantially reduce, thermal conduction from the heat exchanging element 14 to the perimeter of the open-ended housing 12, and thus to the wall 4 (see fig. 1) surrounding the air supply channel 10.

In fig. 3, the heat exchanging element 14 comprises a plurality of spaced apart passages or ducts 14’ (sixteen ducts shown), each duct 14’ being surrounded by the thermal energy storage medium 14S, 14L of the heat exchanging element 14. One purpose of providing a plurality of spaced apart ducts 14’ is to facilitate heat transfer between the heat exchanging element 14 and the ventilation air flowing therethrough. Another purpose of the plurality of ducts 14' is to facilitate placement of a heating cable 15 within the ducts 14'. By threading the heating cable 15 through at least some, but preferably through all ducts 14' as shown, no further support for the heating cable within the heat exchanging element 14 may be required.

The heating cable 15 is operatively connected to a battery 22 which is charged by means of the solar panel 20. The solar panel 20 is preferably arranged in a portion of the parapet 33 of the glazed balcony 3, as shown in figures 1, 5a and 5b. The battery 22 is preferably arranged in a recess, for example in a recess in the floor 35 of the glazed balcony 3, as discussed above.

The heating cable 15 may be controlled between an operating condition and a non-operating condition by means of a switch 16. The switch 16 is typically arranged inside the room 5 shown in fig. 1. The switch 16 may be a manually operated switch as indicated in fig. 3. However, a control of the heating cable 15 between the operating condition and a non-operating condition may be automatic. In one embodiment of the invention the switching of the heating cable 15 between the operating condition and the non-operating condition may be operated by a control system configured for measuring a temperature of the ventilation air upstream of the inlet of the air supply channel 10 but within the glazed balcony 3. When a temperature of the ventilation air upstream of the inlet is below a predetermined level, the control system activates power supply to the heating cable 15. In an alternative embodiment the control system is configured for measuring a temperature difference upstream and downstream of the air supply channel 10. When said temperature difference is greater than a predetermined value, and the temperature upstream of the air supply channel 10 is lower than temperature downstream of the air supply channel 10, the control system activates power supply to the heating cable 15. In still another embodiment the control system is configured for measuring a temperature difference between the thermal energy storage medium 14S, 14L forming part of the air supply channel 10, and a temperature downstream of the air supply channel 10. When said temperature difference is greater than a predetermined value, and the temperature of the thermal energy storage medium 14S, 14L is lower than temperature downstream of the air supply channel 10, the control system activates a power supply to the heating cable 15.

End covers and filter of the air supply channel 10 are shown in fig. 3, but are of a type known per se, and will not be discussed herein.

Turning now to figures 4a and 4b showing two alternative embodiments of the heat exchanging element 14 of the air supply channel 10 as seen through the line A-A from fig. 3.

In fig. 4a, the heat exchanging element 14 comprises a solid thermal energy storage medium 14S surrounding each of the duct 14'. The solid thermal energy storage medium 14S may for example be made from soapstone, ceramics, concrete etc. having a specific heat of around 1,0 KJ/(Kg K). Other solid materials suitable for enclosing the ducts 14' may also be used, and a specific heat of such other materials should preferably be above 0.7 KJ/(Kg K).

In fig. 4b, the heat exchanging element 14 comprises a casing 14C holding a liquid thermal energy storage medium 14L surrounding each of the duct 14'. The liquid may typically be water having a specific heat of around 4.2 KJ/(Kg K), or any other suitable liquid medium. Water used as the thermal energy storage medium 14L may comprise a preserving agent.

A heat exchanging element 14 comprising the casing 14C holding a liquid thermal energy storage medium 14L, is typically provided with nozzles (not shown) for draining and filling the liquid.

The ducts 14' shown in figures 4a and 4b, may be straight between their inlets and outlets. However, to increase a length of the ducts 14' running through the heat exchanging element 14, the ducts 14' may be non-straight. In one embodiment, the heat exchanging element 14 comprising a liquid thermal energy storage medium 14L, may comprise at least one duct 14', but preferably two or more ducts 14' running undulating or in spiral between their inlets and outlets. An undulating or spirally formed duct 14' will increase the "retention" time of the air passing through the heat exchanging element 14. Non-straight ducts 14' may also be provided in a heat exchanging element 14 made from a solid material 14S that is made from a cast material.

Fig. 5a and 5b show a façade of the glazed balcony 3, wherein a lower portion of the parapet 33 comprises a solar panel 20. In fig. 5a, the solar panel 20 is arranged along only a portion of the façade as also indicated in fig. 1. In fig. 5b, the several solar panels 20 are interconnected and extend along the parapet 33 of the façade.

From the disclosure herein, it will be appreciated that the invention is particularly suitable for reducing energy consumption for heating building structures constructed some decades ago and wherein the ventilation is based on mechanical ventilation. By providing a preheating device that comprises the interior space of the glazed balcony, a temperature of the ventilation air flowing into the air supply channel, may be raised by means of heat from infrared radiation from the mass inside the space of the glazed balcony. A raised temperature of the ventilation air sucked into the room of the building structure, will reduce the energy needed for heating the room to a comfortable level.

Due to the heat exchange element 14 and/or the heating circuit 15 arranged in the air supply channel 10, an increase in temperature of the ventilation air flowing into the room 5 may take place even during part of the night after the infrared radiation from the interior space of the of the glazed balcony 3 does not have any substantial effect on the temperature of the air within the glazed balcony 3.

By providing the air supply channel 10 with a heating cable 15 that is powered with energy harvested by the solar panel 20, the temperature of the ventilation air entering the room 5 may be raised substantially twenty-four hours a day. In an embodiment wherein the air supply channel 10 comprises both the heating cable 15 and a thermal energy storage medium 14S, 14L, the solar panel 20 may be used for increasing a temperature of the thermal energy storage medium 14S, 14L for example during daytime. During at least part of the night, when no energy is provided by the solar panel 20, a temperature of the ventilation air flowing through the air supply channel 10 and thus the heat exchanging element 14, will be raised.

The ventilation system according to the invention may be retrofitted substantially without any need for structural changes of the building structure.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.

C l a i m s

1. A ventilation system (1) arranged in a building structure provided with a glazed balcony (3), wherein the ventilation system (1) comprises a pre-heating device configured for utilizing radiation from the sun to increase a temperature of a ventilation supply air prior to entering a room (5) of the building structure via an air supply channel (10) extending between the glazed balcony (3) and the room (5), wherein the preheating device comprises the interior space of the glazed balcony (3), c h a r a c t e r i s e d i n that the air supply channel (10) comprises at least one of:
   - a heat exchanging element (14) comprising a thermal energy storage medium (14S, 14L) for balancing a temperature of the ventilation air flowing from the interior space of the glazed balcony (3) and through the air supply channel (10), wherein the thermal energy storage medium (14S, 14L) is selected from at least one of a liquid and a solid substance; and
   - a heating circuit (15) operatively connected to an energy source.

2. The ventilation system (1) according to claim 1, wherein, when the air supply channel (10) comprises a heating circuit, the heating circuit is an electric heating cable (15).

3. The ventilation system (1) according to claim 2, wherein the electric heating cable (15) is operatively connected to a solar panel (20).

4. The ventilation system (1) according to claim 3, wherein the solar panel (20) forms part of a parapet (33) of the glazed balcony (3).

5. The ventilation system (1) according to claim 1, wherein, when the air supply channel (10) comprises a heating circuit, the heating circuit comprises a fluid conduit.

6. The ventilation system (1) according to any of the preceding claims, wherein the ventilation system is a mechanical ventilation system.

7. A method for pre-heating a supply air for a ventilation system (1) according to any one of claims 1-6, the method comprising flowing the ventilation supply air via the interior space of the glazed balcony (3) prior to flowing into the room (5) via the air supply channel (10) provided with at least one of the heat exchanging element (14), and the heating circuit (15) operatively connected to an energy source.

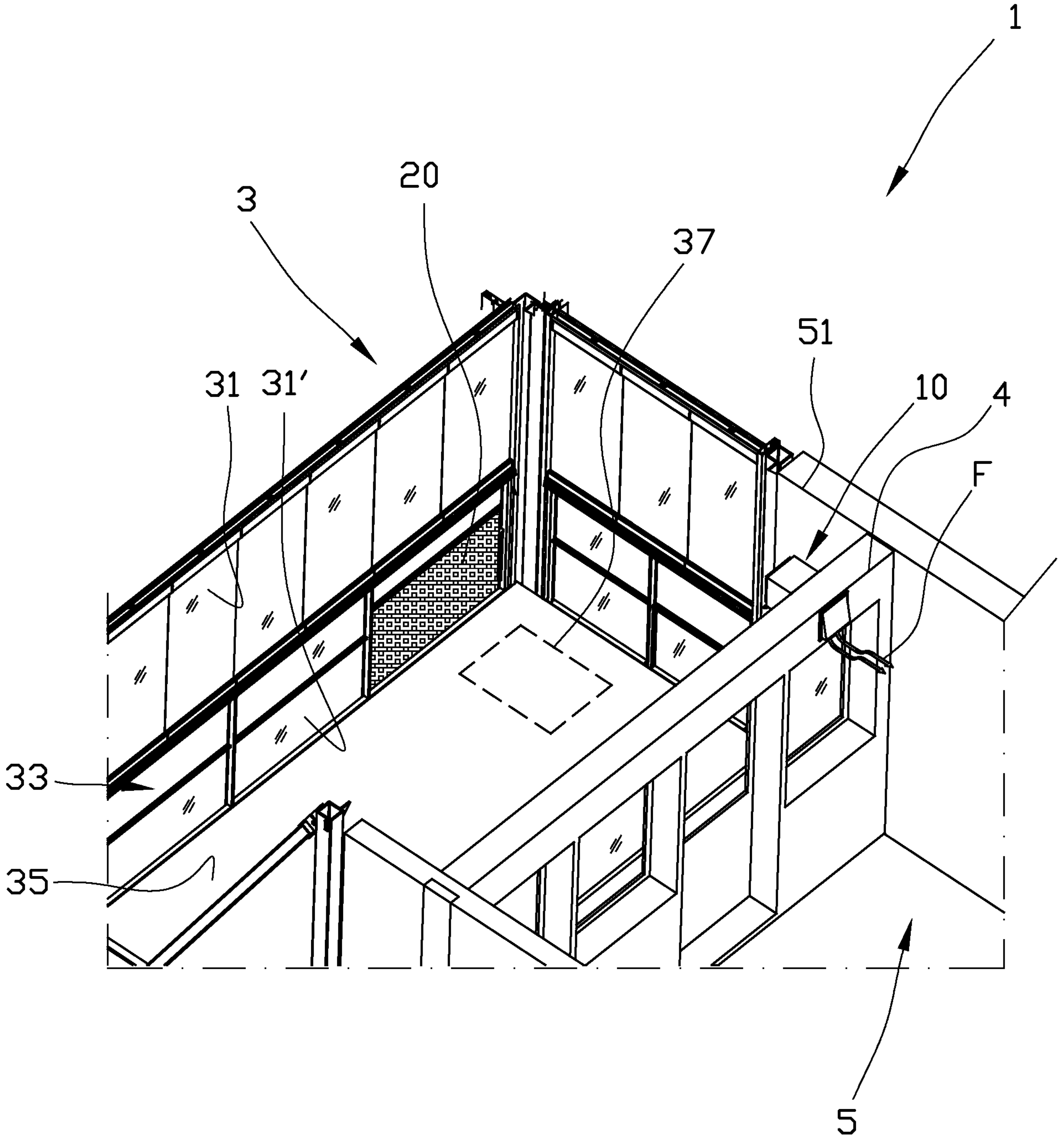


Fig. 1

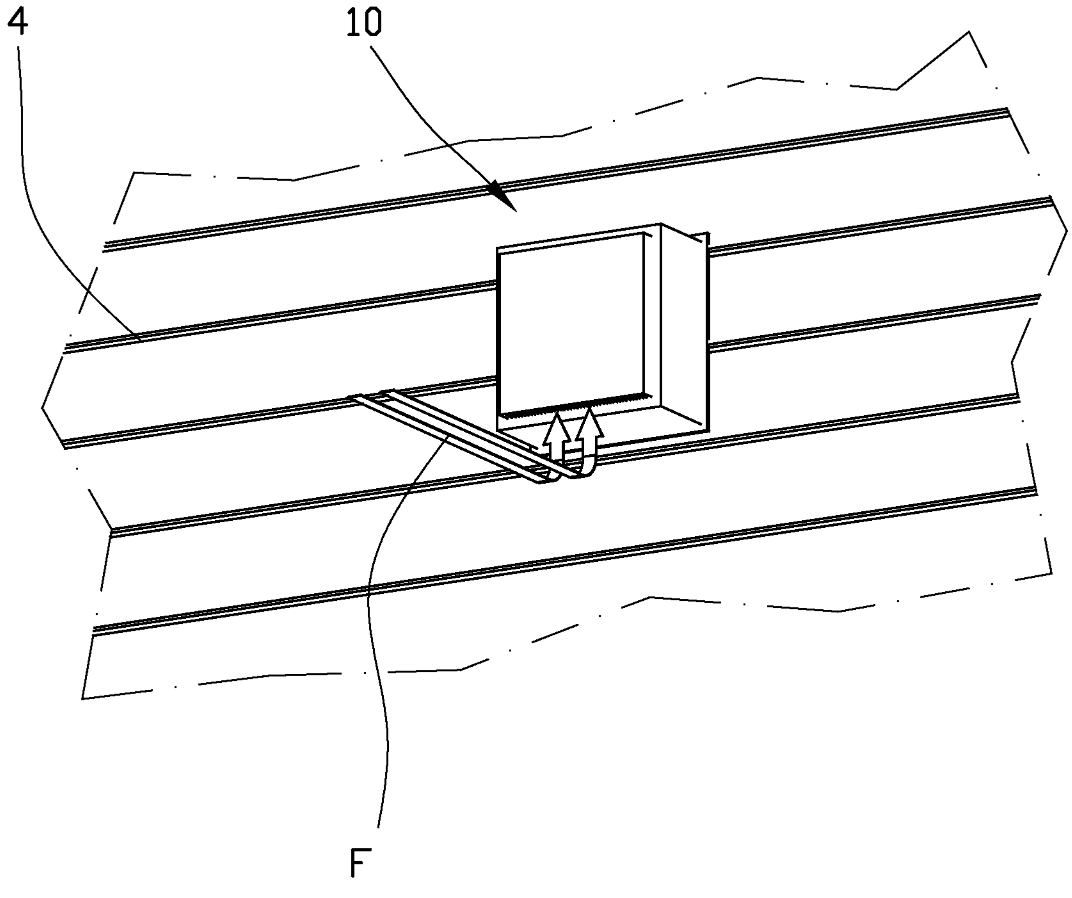


Fig. 2

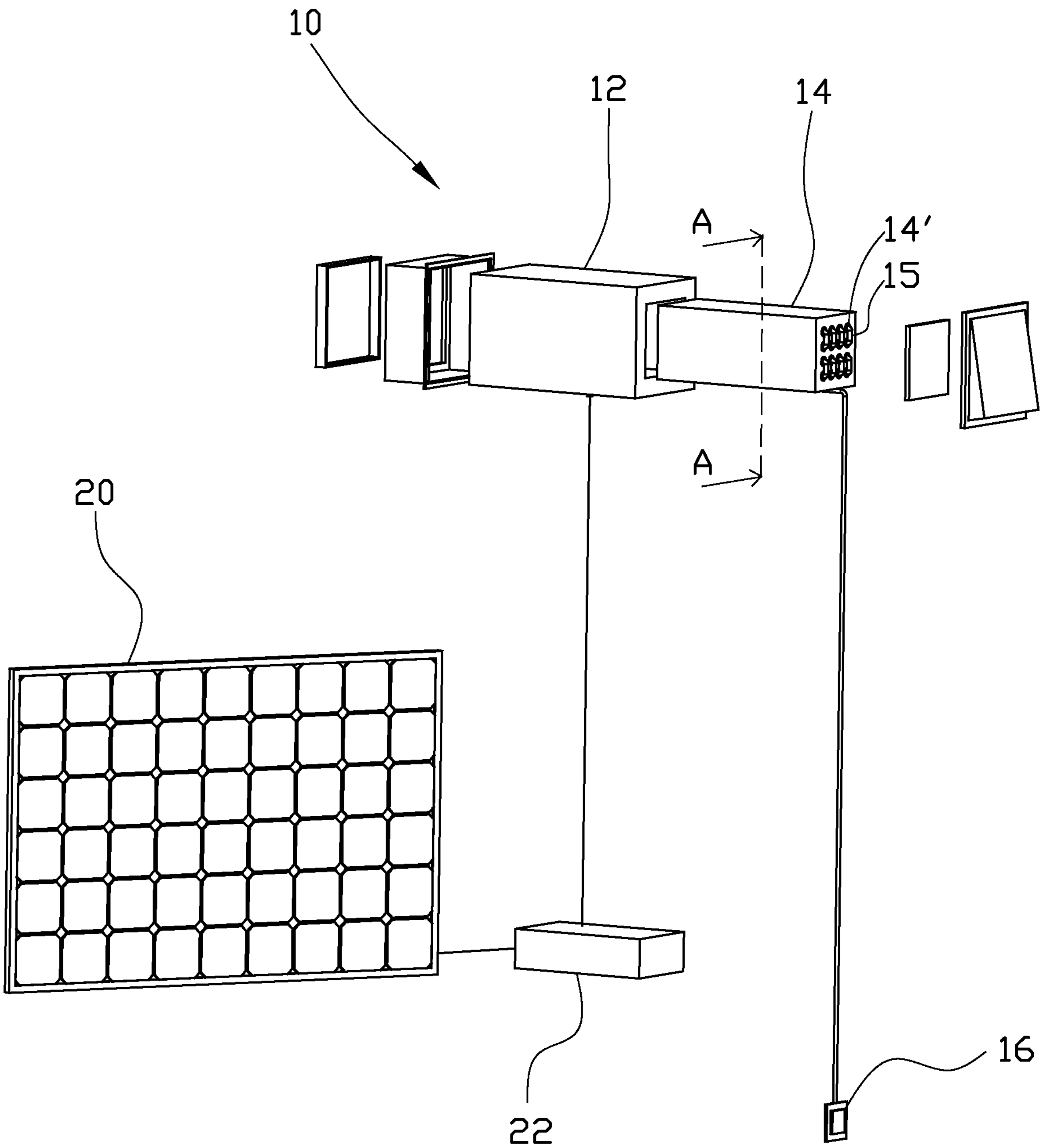


Fig. 3

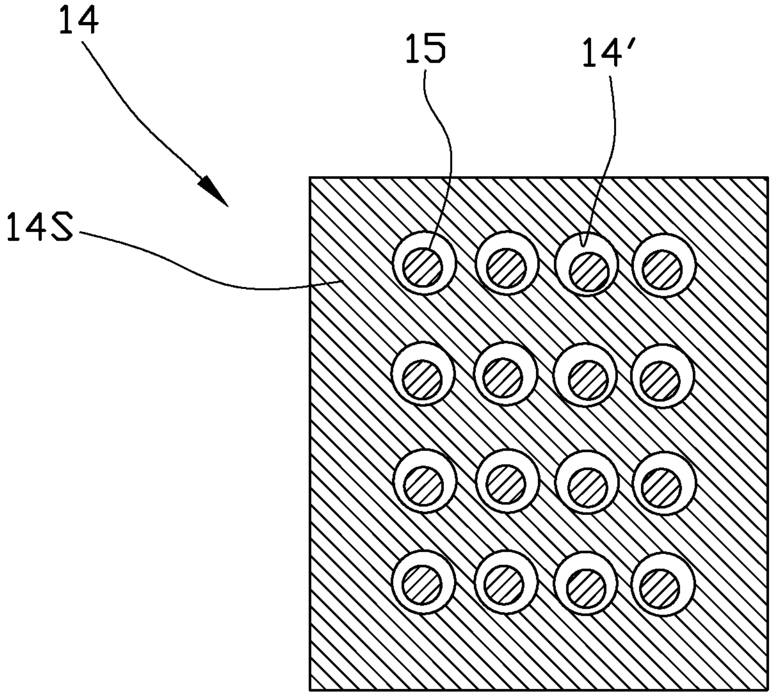


Fig. 4a

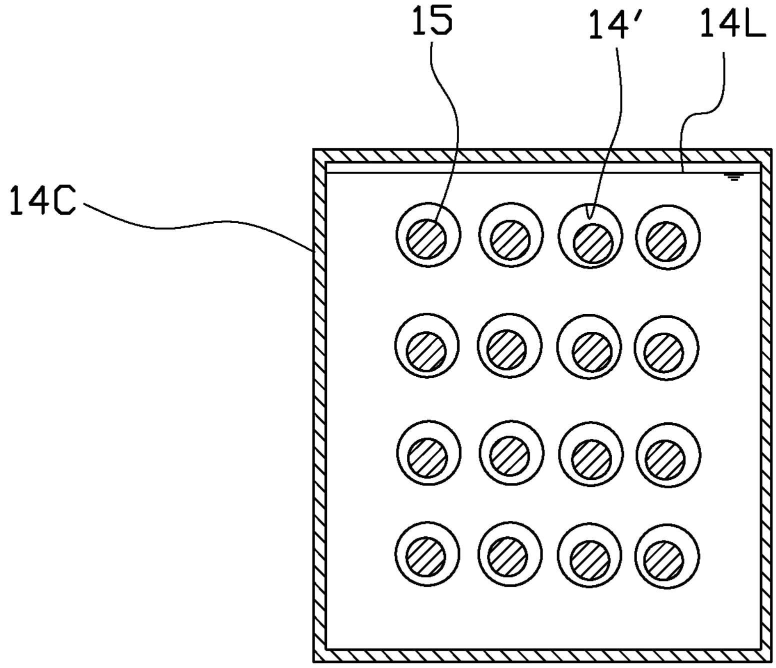


Fig. 4b

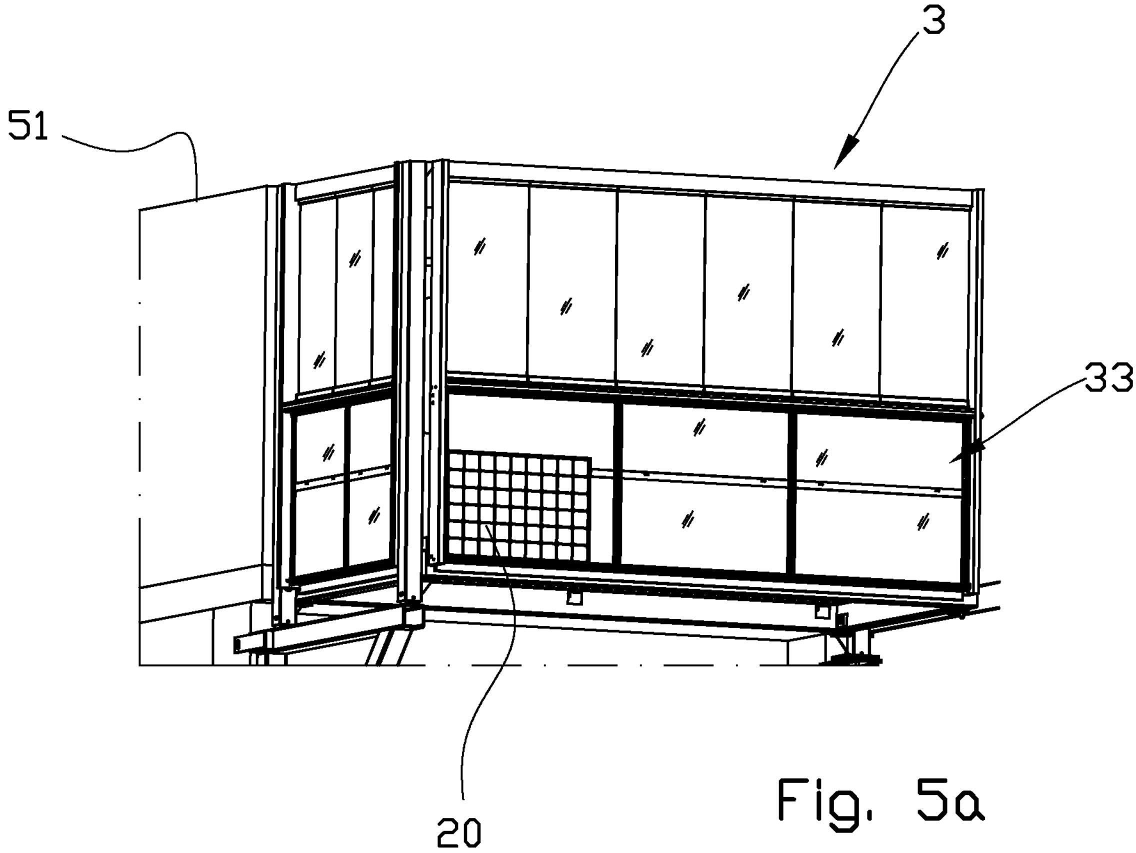


Fig. 5a

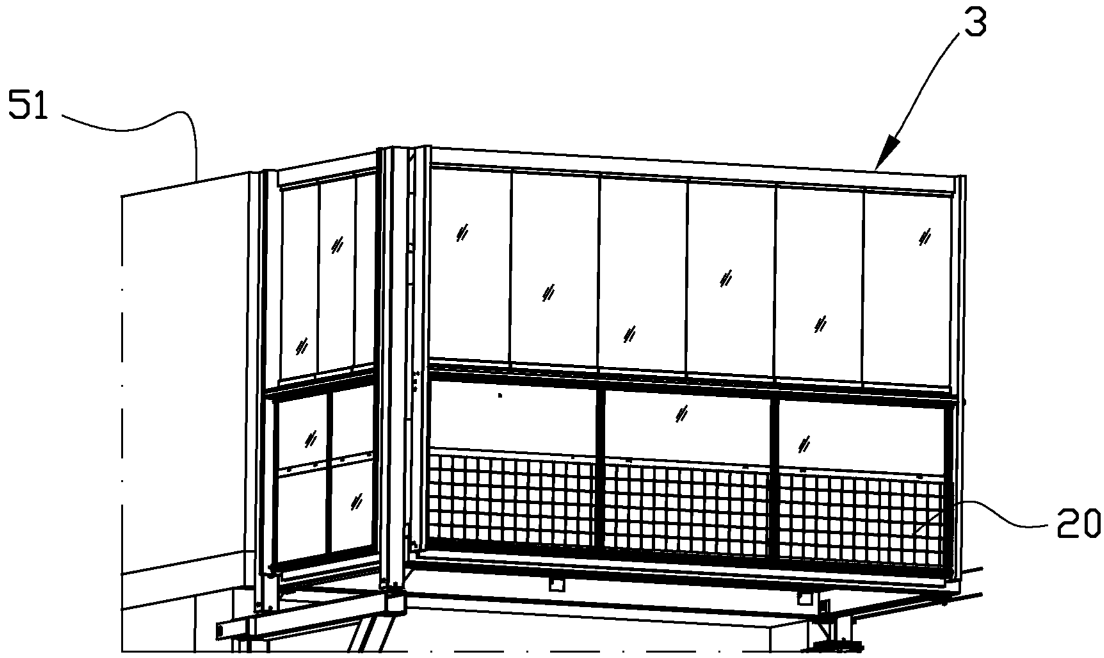


Fig. 5b