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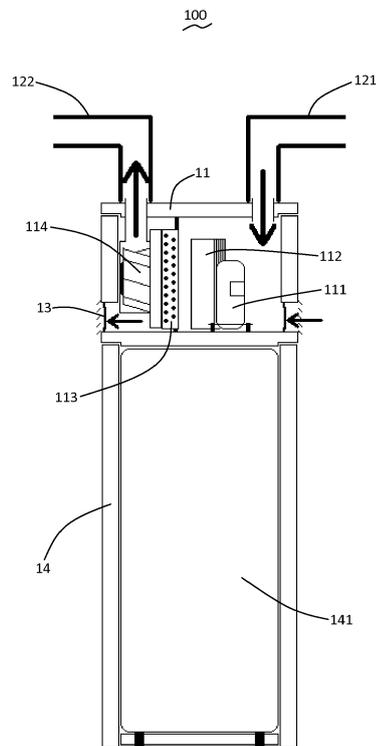
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(54) **DUCTED AIR APPLIANCE WITH VENTILATION CLOSURE MEANS**

(57) The present invention discloses an appliance comprising a casing, a refrigerant circuit disposed in the casing, an air inlet and an air outlet connected with the casing, and a fan disposed in the casing for creating an air flow passing through the air inlet and the air outlet. Wherein, the air flow forms an exchange medium of the refrigerant circuit. The appliance further comprises a ventilation closure means associated with the casing for establishing a leak path when the fan is in an off state and closing said leak path when the fan is in a running state. In this way, the appliance can be air sealed during operation to avoid air losses which will result in a decrease of the performance, and establish a refrigerant leak path when the fan stops or is broken to avoid an accumulation of the leaked refrigerant inside the appliance.



**Fig. 1a**

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**Description**FIELD OF THE INVENTION

**[0001]** The present invention relates to a ducted air appliance having a refrigerant circuit employing ducted air as exchange medium.

BACKGROUND OF THE INVENTION

**[0002]** Refrigerants used in home heating, ventilating and air conditioning (HVAC) units include hydrofluorocarbons (HFCs), chlorofluorocarbons (CFCs) and perfluorocarbons (PFCs). Since there are evidences showing that all these substances contribute very significantly to the global warming, and additionally that CFCs destroy the Earth's ozone layer, there have been attempts to replace them with environment-friendly refrigerants, such as hydrocarbons (HCs) or HFCs with low warming potential. However, these alternative environment-friendly refrigerants are often flammable. If there occurs a refrigerant leakage inside an appliance, the leaked flammable substance can accumulate and reach a concentration value that could cause an explosion.

**[0003]** It is a good practice to provide ventilation openings in the casing of the appliance that would allow the eventually leaked flammable refrigerant out of the appliance to a safe environment. The safe environment could be an outdoor location or a room that is big enough to be safe in case of leakage because the concentration of flammable refrigerant in air will not reach explosive levels. For example, if the amount of hydrocarbon refrigerant in an appliance is below 150gr, a room of 4m<sup>2</sup> is considered as big enough. However, there is still a risk that the leaked flammable refrigerant stays inside the appliance where the volume is small and concentrations may exceed the explosive level. For example, when there is an indoor appliance that is using ducted air as exchange medium, the leakage can happen in the closed ducted volume, since ducted air appliances must be air sealed to avoid losses of air during operation that would cause a decrease of the performance. The complete refrigerant circuit or only part of it may be inside the sealed duct. While these units are working there is an operative air flow through the appliance that takes the leaked flammable refrigerant to a safe environment, but if the leakage happens while the appliance is stopped the refrigerant accumulates inside the duct and dangerous refrigerant concentrations may be reached.

SUMMARY OF THE INVENTION

**[0004]** It is an object of present invention to provide a ducted air appliance with a refrigerant circuit using a ventilation closure means that is open while the appliance is not operated and that is closed while the appliance is in operation.

**[0005]** According to the present invention there is pro-

vided an appliance comprising a casing, a refrigerant circuit disposed in the casing, an air inlet and an air outlet connected with the casing, and a fan disposed in the casing for creating an air flow passing through the air inlet and the air outlet. Wherein, the air flow forms an exchange medium of the refrigerant circuit. The appliance further comprises a ventilation closure means associated with the casing for establishing a leak path when the fan is in an off state and closing said leak path when the fan is in a running state. In this way, the appliance can be air sealed during operation to avoid air losses which will result in a decrease of the performance, and establish a refrigerant leak path when the fan stops or is broken to avoid an accumulation of the leaked refrigerant inside the appliance.

**[0006]** In one embodiment, the casing defines a ventilation opening, and the ventilation closure means comprises a door rotatably attached to the casing about a pivot axis; wherein the door is operable to close the ventilation opening at a closed position and uncover the ventilation opening an open position.

**[0007]** Preferably, the ventilation closure means comprises a retaining device engaged with the door to retain the door at the open position.

**[0008]** Preferably, the retaining device comprises a self-biased device.

**[0009]** In one example, the self-biased device comprises a counterweight rigidly connected to the door and disposed opposite to the door with respect to the pivot axis.

**[0010]** In an alternative example, the self-biased device comprises a torsion spring with two spring arms engaged with the door and the casing respectively.

**[0011]** In a variant embodiment, the retaining means comprises a motor with a motor shaft connected with the door along the pivot axis to actuate the door to move to the open position.

**[0012]** Preferably, the motor is also operable to actuate the door to move to the closed position.

**[0013]** In a variant embodiment, the retaining means further comprises a motor with a motor shaft connected with door along the pivot axis to actuate the door to move to the closed position.

**[0014]** In a further embodiment, the refrigerant circuit is charged with a flammable refrigerant or combined refrigerants containing a flammable refrigerant.

**[0015]** In a further embodiment, the ventilation opening is disposed at a lower portion of the casing.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0016]** For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Fig. 1a is a schematic arrangement diagram of a ducted air appliance in accordance with a first embodiment of present invention, wherein a ventilation

door of the appliance is in a closed position;

Fig. 1b is a schematic arrangement diagram of the ducted air appliance shown in Fig. 1a, wherein the ventilation door is in an open position;

Fig. 2a is a schematic arrangement diagram of a ducted air appliance in accordance with a second embodiment of present invention, wherein a ventilation door of the appliance is in a closed position;

Fig. 2b is a schematic arrangement diagram of the ducted air appliance shown in Fig. 2a, wherein the ventilation door is in an open position;

Fig. 3a is a schematic diagram of a ducted air appliance in accordance with a third embodiment of present invention, wherein a ventilation door of the appliance is in a closed position;

Fig. 3b is a schematic arrangement diagram of the ducted air appliance shown in Fig. 3a, wherein the ventilation door is in an open position;

Fig. 4 is a schematic perspective view showing a first example of a ventilation closure means of the appliance shown in any of the Figs. 1b, 2b, and 3b;

Fig. 5 is a schematic perspective view showing a second example of a ventilation closure means of the appliance shown in any of the Figs. 1b, 2b, and 3b;

Fig. 6 is a schematic perspective view showing a third example of a ventilation closure means of the appliance shown in any of the Figs. 1b, 2b, and 3b.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0017]** Reference will now be made to the drawing figures to describe the preferred embodiments of the present invention in detail. However, the embodiments can not be used to restrict the present invention. Changes such as structure, method and function obviously made to those of ordinary skill in the art are also protected by the present invention.

**[0018]** Referring to Figs. 1a and 2b, in a first embodiment of present invention, a ducted air appliance 100 can be a domestic hot water tank integrated with a heat pump for preparing domestic hot water. The ducted air appliance 100 can stand on the floor with a water tank 141 located at a lower portion thereof and a refrigerant circuit located at an upper portion thereof. The water tank is enclosed by top, bottom, and side insulations 14 to avoid a heat loss of hot water inside the tank 141.

**[0019]** The refrigerant circuit is enclosed by a casing 11 composed by top, bottom, and side insulations for

reducing heat loss on operation of the refrigerant circuit. An air inlet duct 121 and an air outlet duct 122 are connected with the casing 11 to define an air inlet and an air outlet respectively.

**[0020]** The refrigerant circuit typically has a compressor 111, a condenser 112, an expansion device (now shown), and an evaporator 113. These components are generally serially connected via conduits or pipings and are well known in the art. During operation of the appliance, the compressor 111 acts on relatively cool gaseous refrigerant to raise the temperature and pressure of the refrigerant. From the compressor 111, the high temperature, high pressure gaseous refrigerant flows into the condenser 112 where it is cooled and exits the condenser 112 as a high pressure liquid refrigerant. In this embodiment, the condenser 112 is a plate type heat exchanger, and it performs as a heat source for the water tank 141. Water extracted from the water tank 141 passes through the condenser heat exchanger 112 to be heated by the refrigerant in a non-contact way, and then hot water flows back and is stored within the tank 141.

**[0021]** The high pressure liquid refrigerant then flows to an expansion device (now shown), which controls the amount of refrigerant entering into the evaporator 113. In this embodiment, the evaporator 113 takes form of a finned tube exchanger, and a centrifugal fan 114 is disposed in the casing 11 and located adjacent to the evaporator 113. In the evaporator, the low temperature refrigerant absorbs heat from air blown through the air inlet duct 121 by the fan 114 over the evaporator's tubes and exits the appliance via the air outlet duct 122. The suction of the compressor 111 then draws the gaseous refrigerant back to the compressor where the cycle begins again.

**[0022]** In this embodiment, the refrigerant circuit is charged with a flammable refrigerant or combined refrigerants containing a flammable refrigerant. The flammable refrigerant can be HFC or HC substance such as R32, R152a, R290, R600 and the like. A ventilation closure means 13 is associated with the casing 11 for establishing a leak path (as indicated by arrows in Fig. 1b) when the fan 114 is in an off state and closing the leak path (as indicated by arrows in Fig. 1a) when the fan 114 is in a running state. In this way, the appliance can be air sealed during operation to avoid air losses which will result in a decrease of the performance, and establish a refrigerant leak path when the fan stops or is broken to avoid an accumulation of the leaked refrigerant inside the appliance.

**[0023]** Since the flammable refrigerant, like R290, has a atmospheric specific gravity greater than that of air, the ventilation closure means 13 is preferably disposed at a lower portion of the casing 11. The ventilation closure means can be disposed at a lower portion of a side surface of the casing 11. As shown in Figs. 1a and 1b, preferably, the ventilation closure means 13 include two units with the same structure, and they are respectively located at opposite sides of the casing 11. The configuration of the ventilation closure means 13 will be fully described

hereinafter.

**[0024]** Figs. 2a and 2b show a variant embodiment of a ducted air appliance. In this embodiment, the appliance 200 can be an air-to-water heat pump installed in a hidden ceiling 50 for space heating and/or domestic hot water preparation. The appliance 200 includes a casing 21, an air inlet duct and an air outlet duct connected with the casing 21, a refrigerant circuit and an evaporator fan 214 disposed within the casing 21. The refrigerant circuit includes a compressor 211, a condenser 212, an expansion device (now shown), and an evaporator 213. A ventilation closure means 23 disposed at a lower portion of a side surface of the casing 21. Since the parts and components of this appliance is nearly the same as those described in the first embodiment, a detailed explanation is omitted for purpose of brevity and clarity. As the appliance is located in a hidden ceiling 50, in order to avoid leaked refrigerants exiting from the appliance to accumulate in the hidden area, some holes 51 are defined in the ceiling 50 to discharge the leaked refrigerants to a safe area.

**[0025]** Figs. 3a and 3b illustrate a ducted air appliance according to a third embodiment of present invention. In this embodiment, the appliance 300 can be a ducted air treatment and heat recovery heat pump installed in a hidden ceiling 50. The appliance 300 includes a casing 31 with an upper layer 301 and a lower layer 302. Two pairs of air inlet and outlet ducts are connected with the upper layer 301 and the lower layer 302 respectively. A refrigerant circuit includes a compressor 311 and a condenser 312 disposed in the upper layer 301, and an evaporator 313 disposed in the lower layer 302. A condenser fan 314 and an evaporator fan 315 are disposed in the upper layer 301 and the lower layer 302 respectively. A ventilation closure means 33 includes two units each disposed at a lower portion of a side surface of the upper layer 301 or the lower layer 302. The ceiling 50 defines some holes therein for discharging leaked refrigerant exiting from the appliance 300 to a safe area.

**[0026]** Fig. 4 shows a first example of the ventilation closure means which can be used in any of the appliances mentioned in above embodiments, and the ventilation closure means 13 in the first embodiment will be exemplified hereinafter. The casing 11 defines a ventilation opening 110 at a side surface thereof. The ventilation closure means includes a door 131 rotatably attached to the casing 11 above a pivot axis. The pivot axis can be formed by an actual pivot 1311 with its opposite ends connected to a pair of lugs 117 projecting from the side surface of the casing 11.

**[0027]** Referring to Fig. 4, in conjunction with Figs. 1a and 1b, the ventilation closure means 13 includes a pair of counterweights 135 rigidly connected to the door via a pair of rods 1351. Each rod 1351 extends through the side surface and is connected between the door 131 and the counterweight 135. The counterweight 135 is located at an opposite side of the door 131 with respect to the pivot axis 1311. By this means, the counterweight 135

provides a gravitational potential to the door 131 rotating about the pivot axis 1311, so as to retain the door 131 at an open position with the ventilation opening 110 uncovered when the fan 114 is not in operation. In addition, when the appliance 100 is started and the fan 114 is in a running state, the air flow creates a differential pressure between both sides of the door 131, which multiplied by the door area represents a force bigger than the biased force applied by the counter weight 135, thereby closing the door 131 to avoid air losses. In case there exists a leak of refrigerant at the time, the leaked refrigerant is discharged out of the appliance 100 together with air flow by the fan 114.

**[0028]** Fig. 5 illustrates a variant example of the ventilation closure means. The main difference with respect to the first example as shown in Fig. 4 is that, the counterweight 135 can be replaced by a torsion spring 136 to act as a retaining device for retaining a door 132 in an open position where the ventilation opening 110 is uncovered by the door 132. The door 132 has a wing portion 1322 extending from one side thereof. The torsion spring 136 has a main portion encircled around a pivot 1321 and two spring arms 1361, 1362 respectively abutting against the wing portion 1322 of the door 132 and the side surface of the casing 11. In this way, the door 132 can be retained at the open position by a biased force applied by the spring 136 when the fan 114 is not in operation, and moved to the close position by rotating about the pivot axis 1321 when the fan 114 is operated and air pressure is applied onto the door 132.

**[0029]** Fig. 6 illustrates a third example of the ventilation closure means. In this example, a motor 137 is used to act as the retaining device. The motor 137 can include a motor shaft (now shown) rotatably fixed with the door 133 and connected with the door along the pivot axis 1331. The pivot axis 1331 can be a virtual axis in this example, as indicated by the broken line shown in Fig. 6. The motor 137 is controlled with an appropriate signal to actuate the door 133 to move to the open position. In an alternative embodiment, it is possible to have two different signals to drive the motor 137 to actuate the door 133 to move to the open and the closed positions. In another embodiment, the motor 137 can be combined with the self biased device, such as the counterweight 135 or the torsion spring 136 as described in above examples. The counterweight 135 or the torsion spring 136 acts as a retaining device to retain the door 133 in the opening position, and the motor 137 can be controlled by an appropriate signal to drive the door 133 to the closed position.

**[0030]** It would be apparent to those skilled in the art that, the ventilation closure means described above can be used to ducted heat pumps, ducted air conditioners, and ducted air heat recovery appliances for hidden installation or not. In addition, the ventilation closure means can also be used to appliances including the refrigerant circuit charged with nonflammable refrigerant, although which is not necessary for such appliances.

**[0031]** It is to be understood, however, that even though numerous, characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosed is illustrative only, and changes may be made in detail, especially in matters of number, shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broadest general meaning of the terms in which the appended claims are expressed.

## Claims

1. An appliance comprising:
  - a casing;
  - a refrigerant circuit disposed in the casing;
  - an air inlet and an air outlet connected with the casing;
  - a fan disposed in the casing for creating an air flow passing through said air inlet and said air outlet, said air flow forming an exchange medium of the refrigerant circuit; and
  - a ventilation closure means associated with the casing for establishing a leak path when the fan is in an off state and closing said leak path when the fan is in a running state.
2. An appliance according to claim 1, wherein said casing defines a ventilation opening, and said ventilation closure means comprises a door rotatably attached to the casing about a pivot axis; wherein said door is operable to close the ventilation opening at a closed position and uncover the ventilation opening an open position.
3. An appliance according to claim 2, wherein said ventilation closure means further comprises a retaining device engaged with the door to retain the door at the open position.
4. An appliance according to claim 3, wherein said retaining device comprises a self-biased device.
5. An appliance according to claim 4, wherein said self-biased device comprises a counterweight rigidly connected to the door and disposed opposite to the door with respect to the pivot axis.
6. An appliance according to claim 4, wherein said self-biased device comprises a torsion spring with two spring arms engaged with the door and the casing respectively.
7. An appliance according to claim 3, wherein said retaining means comprises a motor with a motor shaft connected with the door along the pivot axis to actuate the door to move to the open position.
8. An appliance according to claim 7, wherein said motor is also operable to actuate the door to move to the closed position.
9. An appliance according to claims 4, 5 or 6, wherein said retaining means further comprises a motor with a motor shaft connected with door along the pivot axis to actuate the door to move to the closed position.
10. An appliance according to claim 1, wherein the refrigerant circuit is charged with a flammable refrigerant or combined refrigerants containing a flammable refrigerant.
11. An appliance according to claims 2, wherein said ventilation opening is disposed at a lower portion of the casing.

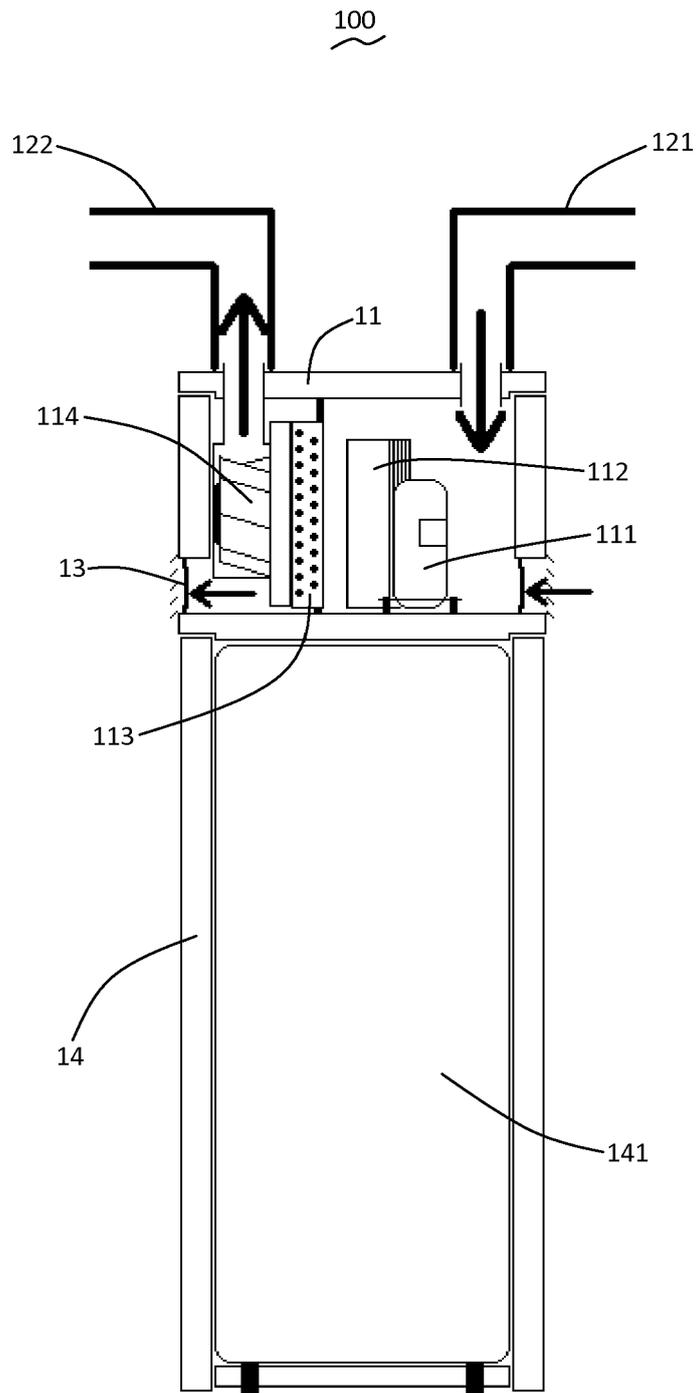
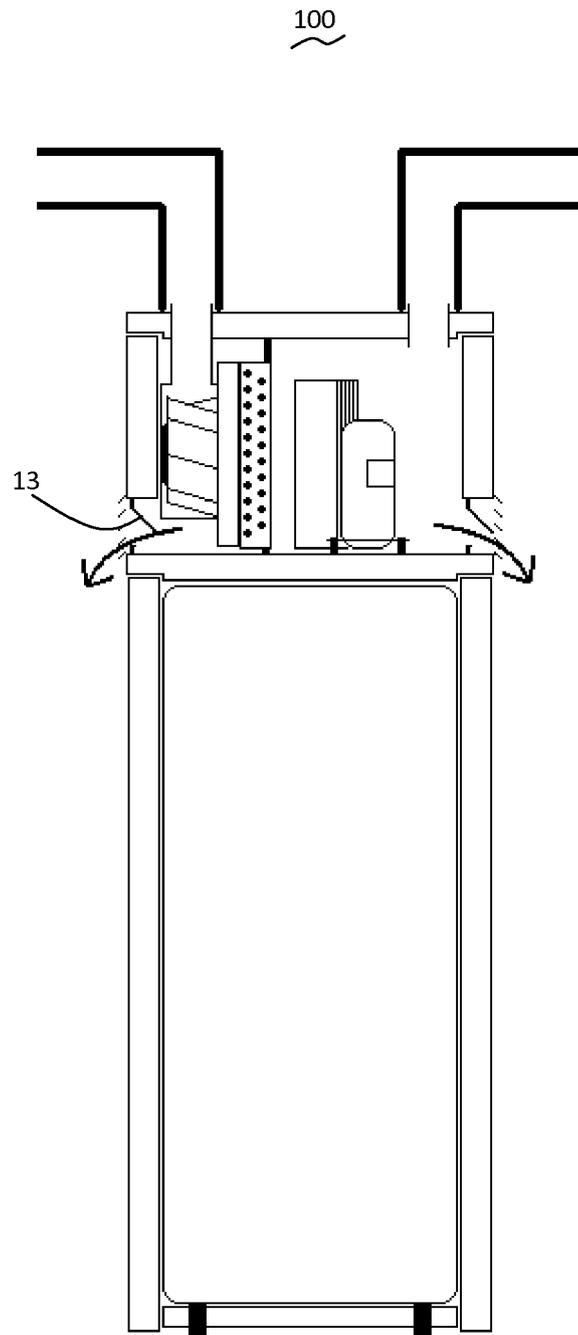


Fig. 1a



**Fig. 1b**

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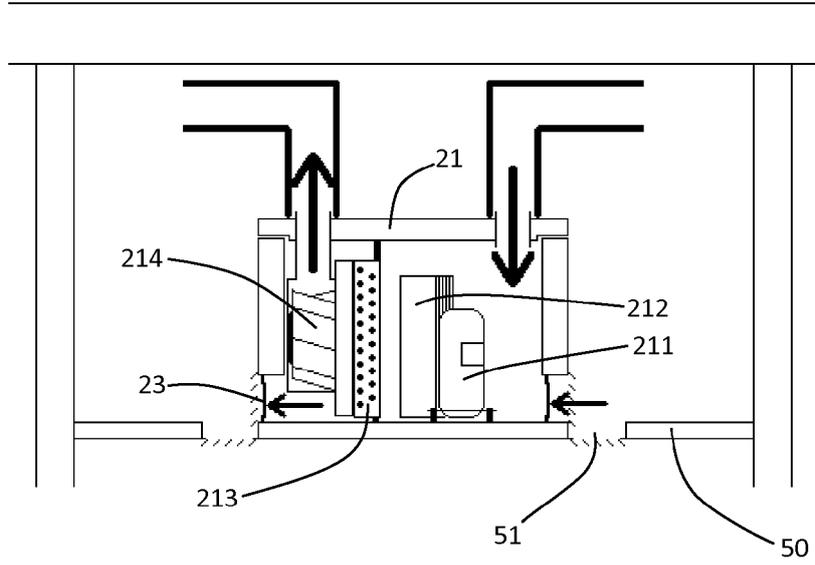


Fig. 2a

200

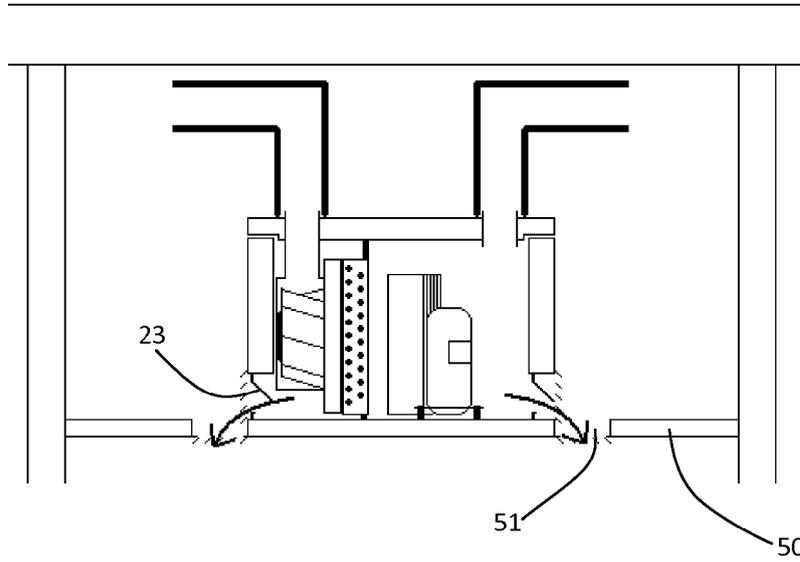


Fig. 2b

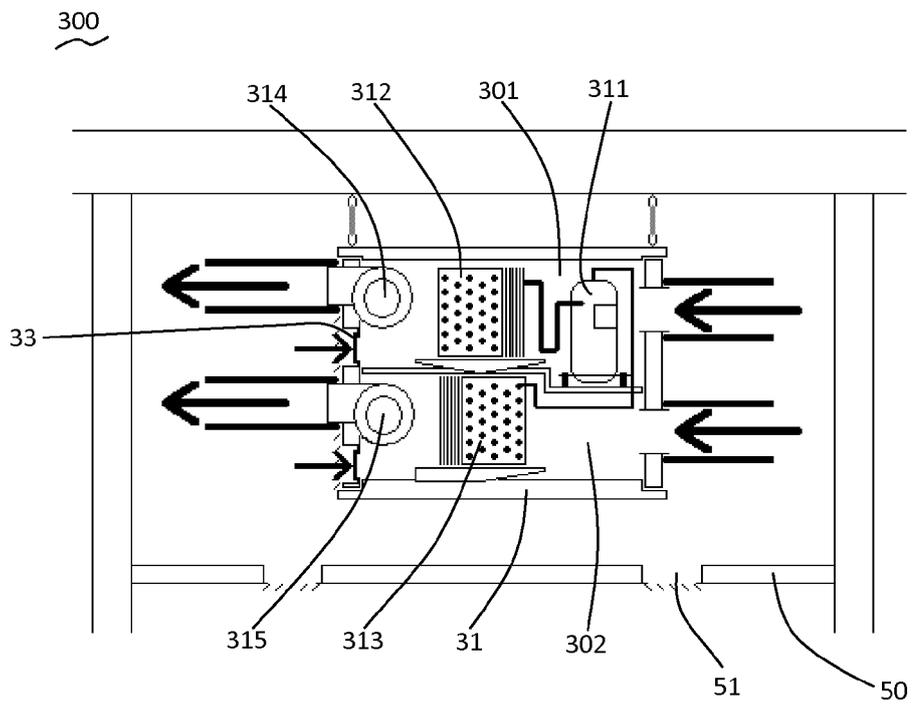


Fig. 3a

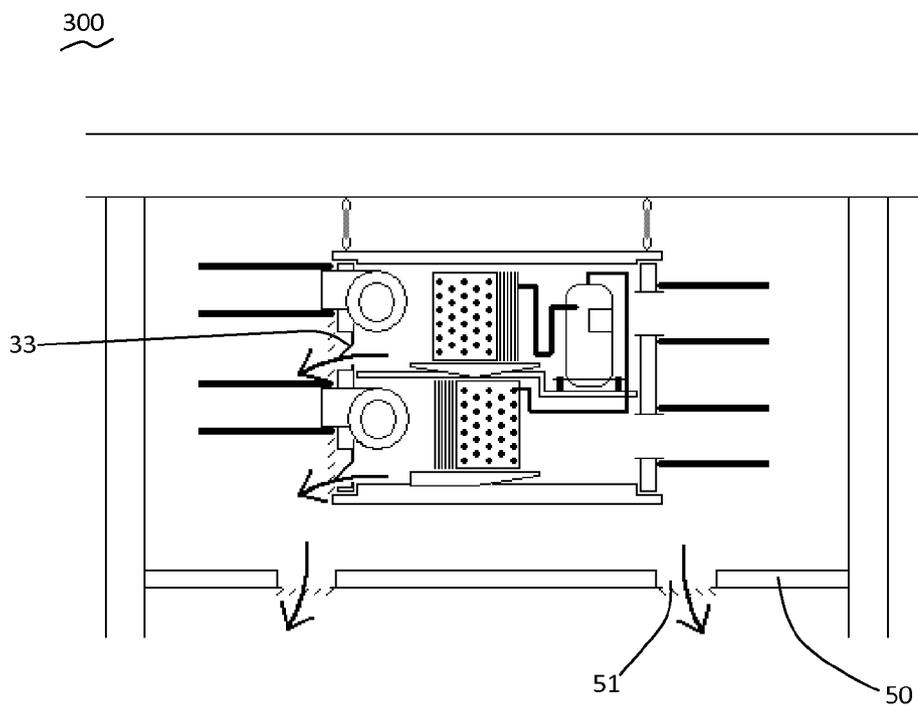


Fig. 3b

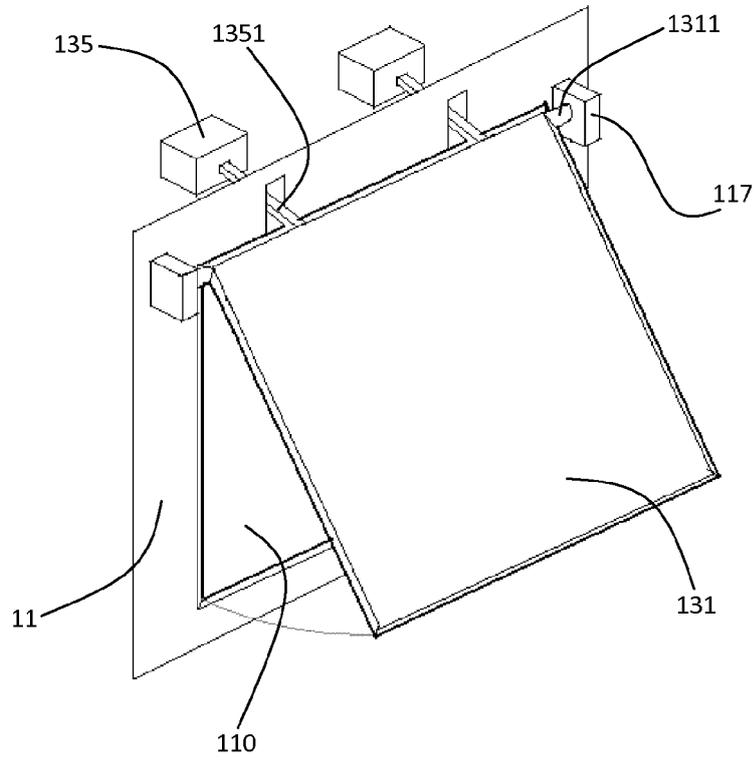
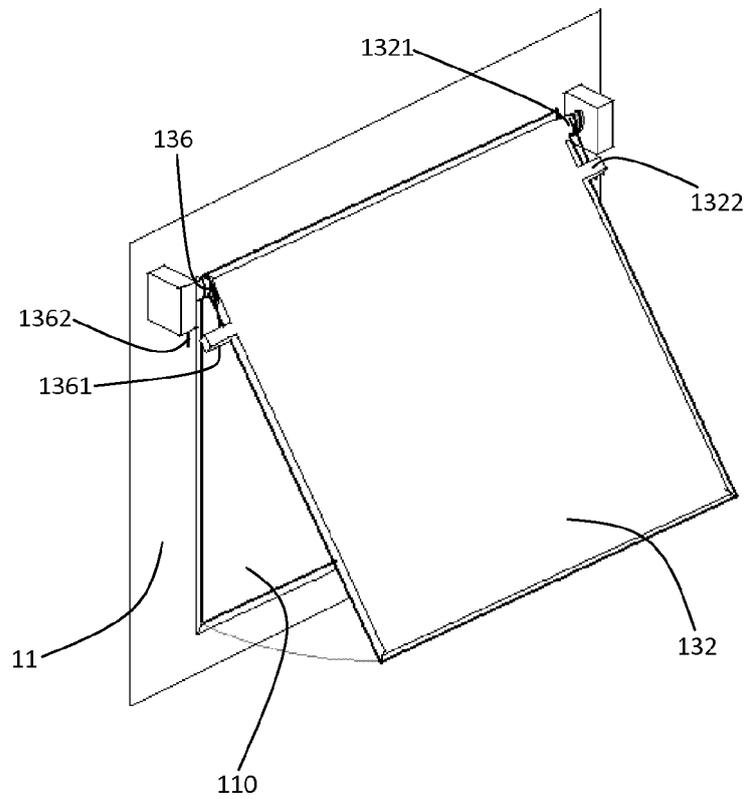
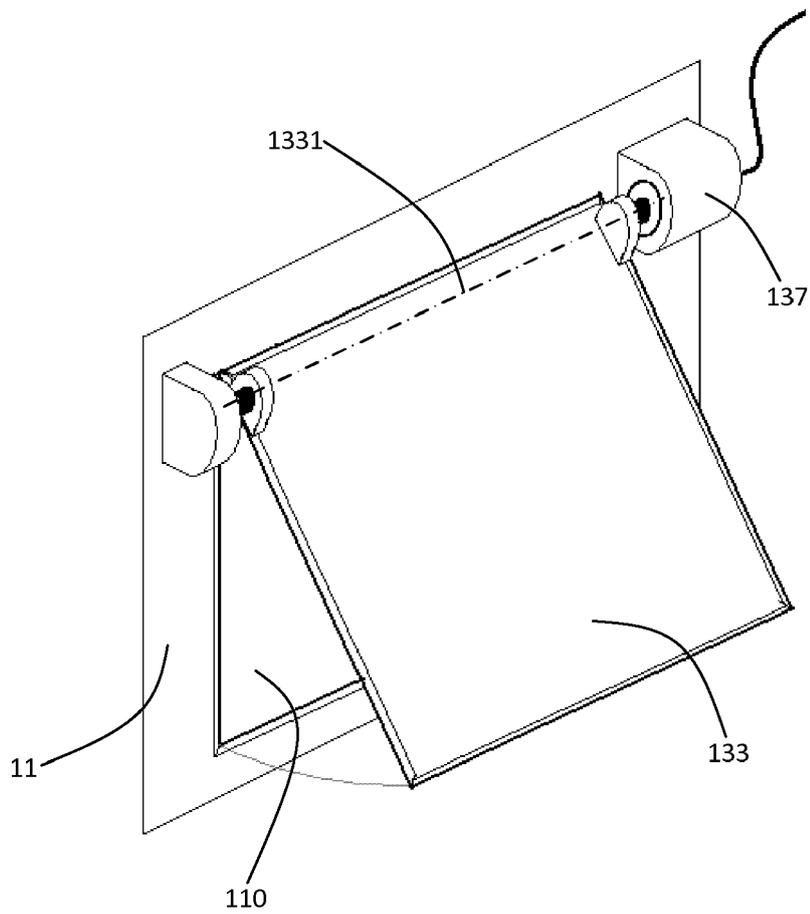


Fig. 4



**Fig. 5**



**Fig. 6**



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