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(54) Title: A FAN ASSEMBLY

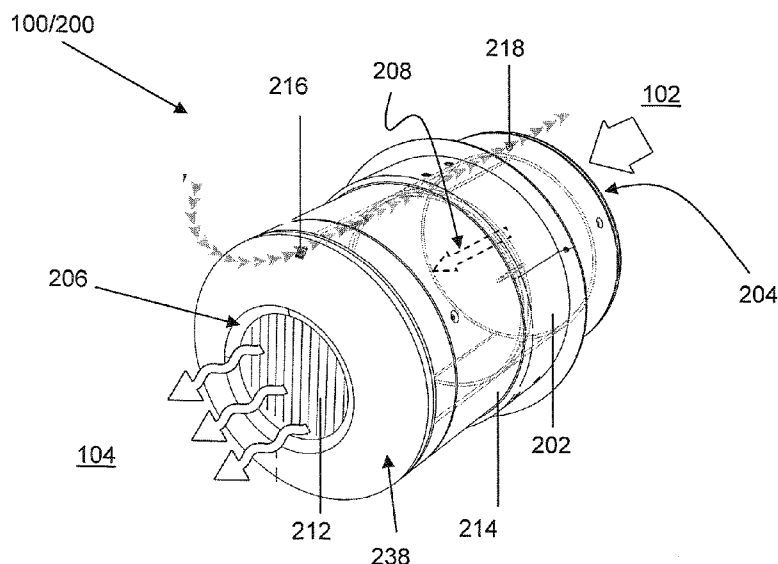


Figure 1

(57) Abstract: A fan assembly 100 is disclosed herein which may be a push-through fan assembly 200 or a draw-through fan assembly 300. In one embodiment, the push-through fan assembly 200 comprises (i) a filter chamber 202 including an air inlet 204 arranged to admit air from a first zone 102, an air outlet 206 arranged to emit pressurized and filtered air into a second zone 104, a fluid passage 208 in fluid communication between the air inlet 204 and the air outlet 206, a flow generator 210 for directing the admitted air through an air filter 212 disposed along the interior fluid passage 208 to generate the pressurized and filtered air through the air outlet 206, and (ii) a bleed channel 214 having a bleed inlet 216 arranged to receive second zone air from the second zone 104 and a bleed outlet 218 arranged to emit the second zone air into the first zone 102 or into the interior fluid passage 208 for circulation through the air filter 212.



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A Fan Assembly

Background and Field

- 5 The invention relates to a fan assembly.

Indoor air quality is a growing area of public health concern. Exposure to harmful particulate matter (PM) containing chemical and biological contaminants (together with volatile organic compounds (VOCs)) may cause
10 serious health effects. These contaminants exist in elevated concentrations indoors in places that are influenced by traffic or industrial emissions or during haze episodes (influx of biomass and peat fires impacted PM emissions). There is therefore a need for mitigation strategies that reduce human exposure to incoming ambient pollutants in naturally ventilated premises such as class
15 rooms, hostels, residential buildings etc., whilst simultaneously meeting ventilation requirements and mitigating thermal discomfort degradation. Furthermore some places, such as schools, which are occupied only during operation hours but otherwise vulnerable to rapid, or sudden, pollution build-up (such as the occurrence of haze episodes) require rapid removal of indoor
20 contaminant levels for safe operation at commencement of scheduled operation times.

Thus, it is desirable to provide a fan assembly which addresses at least one of the above problems and/or to provide the public with a useful choice.

25

Summary

In a first aspect, there is provided a fan assembly comprising (i) a filter chamber including an air inlet arranged to admit air from a first zone, an air outlet
30 arranged to emit pressurized and filtered air into a second zone, a fluid passage in fluid communication between the air inlet and the air outlet, a flow generator for directing the admitted air through an air filter disposed along the fluid passage to generate the pressurized and filtered air through the air outlet, and

(ii) a bleed channel having a bleed inlet arranged to receive second zone air from the second zone and a bleed outlet arranged to emit the second zone air into the first zone or into the fluid passage for circulation through the air filter.

- 5 The described embodiments may provide a dynamically responsive fan assembly for removing contaminants from outdoor air and to provide adequately filtered and pressurized air into indoor environment.

10 Preferably, the bleed channel may comprise a ring bleed chamber arranged concentrically around the filter chamber. Alternatively, the bleed channel may comprise an elongate bleed conduit arranged along a longitudinal axis of the filter chamber.

15 Preferably, the fan assembly may further comprise a sensor arranged to detect at least one of the following parameters in the second zone: carbon dioxide, particulate matter, environmental contaminants, static pressure and temperature; and a controller arranged to control the flow generator based on the detection of at least one of the aforesaid parameters. The fan assembly may also comprise a bleed flow generator and a recirculation mechanism both of
20 which may be controlled by the controller.

Advantageously, the bleed inlet's opening is adjustable, and the bleed flow regulator is further arranged to adjust a size of the bleed inlet's opening based on the detected value of at least one parameter, and the recirculation
25 mechanism is arranged to either emit the air to the first zone or to recirculate the air to the second zone through the air filter. This may be useful to accommodate a control strategy that optimizes the operation of the fan assembly from an energy and filtration perspective. For example, when the second zone (indoor) environmental conditions permit, it would be
30 advantageous to recirculate the second zone air through the air filter to achieve the desired indoor PM2.5 concentration levels more rapidly. An envisaged situation is one when the second zone (indoors) PM2.5 levels are high, it is advantageous to operate the fan filter in a full recirculation mode until the

desired PM2.5 level is achieved before switching to taking air from the first zone (outdoor).

5 In the alternative, if the bleed inlet's opening is adjustable, the bleed flow regulator may be further arranged based on the detected parameter or parameters, to adjust the size of the bleed inlet's opening and the recirculation mechanism acts to simultaneously adjust the relative proportion of such bled air to the first zone and recirculated to the second zone through the filter. With such a configuration, this provides for dynamic adjustment of the fan assembly
10 operation to achieve an optimal mix (proportion) of air taken from the first zone (outdoors) and recirculated from the second zone (indoors) when the PM2.5 levels in the second zone has achieved desired concentration level and when the ventilation requirement is not compromised by decreasing the amount of air being taken in from the first zone.

15 The fan assembly of the first aspect may be modified not to include the bleed channel and this is provided by a second aspect which relates to a fan assembly comprising a filter chamber including an air inlet arranged to admit air from a first zone, an air outlet arranged to emit pressurized and filtered air into a
20 second zone, an interior fluid passage in fluid communication between the air inlet and the air outlet, and a flow generator for directing the admitted air through an air filter disposed along the interior fluid passage to generate the pressurized and filtered air through the air outlet.

25 For the aspects mentioned above, the flow generator may include a fan disposed upstream of the filter to blow the admitted air from the first zone through the fan filter. In the alternative, the flow generator may include a fan disposed downstream of the fan filter to suck or draw the admitted air from the first zone through the fan filter.

30 In the aspects discussed above, the fan assembly may further comprise an acoustic casing disposed along the fluid passage and the acoustic casing may be arranged to reduce noise caused by the air flow generated by the flow

generator. Specifically, the acoustic casing may be arranged adjacent to an acoustic absorbent and the acoustic casing may include a plurality of spiral perforations arranged to allow noise to be absorbed by the adjacent acoustic absorbent. The flow generator may be arranged to generate a vortex air flow, and advantageously, curvature of the spiral perforations is aligned to the vortex air flow. Further, the acoustic casing may taper from the flow generator towards the air outlet.

According to a third aspect, there is provided a method of retrofitting a window with a fan assembly of any of the above aspects, the method comprising covering the window with a panel having a panel opening; and attaching the air inlet of the filter chamber to the panel opening, so that the air from the first zone is admitted via the panel opening.

In one variation, the air inlet of the filter chamber may be attached directly to the panel opening. In another variation, the fan assembly may further comprise a window attachment device having an air inlet connector, a panel opening connector and an attachment device conduit between the air inlet connector and the panel opening connector, and wherein the method may further comprise coupling the air inlet connector to the air inlet of the filter chamber; and coupling the panel opening connector to the panel opening of the panel to create an attachment fluid passage between the panel opening and the air inlet of the fan assembly via the attachment device conduit.

For ease of installation, the air inlet connector and the air inlet of the filter chamber may form a magnetic snap-fit connection. Similarly, the panel opening connector and the panel opening may also form a magnetic snap-fit connection. It should be appreciated that alternative connections are envisaged, not just magnetic.

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In one embodiment, the panel may include a panel frame for affixing the panel to a window frame of the window; and the panel frame may comprise a number

of corner joints and elongate frame members connected to respective corner joints using dowel joints, or other forms of joining.

It should be appreciated that features relevant to one aspect may also be
5 relevant to the other aspects.

Brief Description of the Drawings

10 Exemplary embodiments will now be described with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a fan assembly which is a push-through fan assembly according to a first embodiment;

15 Figure 2 is an exploded unassembled perspective view of the push-through fan assembly of Figure 1;

Figure 3 is an enlarged view of a front acoustic casing used in the push-through fan assembly of Figure 2;

20 Figure 4 is a schematic block diagram of a control circuitry which may form part of the fan assembly of Figure 1;

Figure 5 illustrates a window attachment device which may be used to retrofit the fan assembly of Figure 1 to a window;

25 Figure 6 is a closed-up partial view of the window attachment device of Figure 5 arranged to cooperate with a panel connector which is fitted to the window;

Figure 7 a perspective view of a fan assembly which is a draw-through fan assembly according to a second embodiment;

Figure 8 is an exploded unassembled perspective view of the draw-through fan assembly of Figure 7; and

30 Figure 9 show perspective views of a push-through fan filter assembly and a draw-through fan filter assembly without a bleed channel, which is incorporated in the fan assembly of Figures 1 and 2;

Detailed Description of Preferred Embodiments

Figure 1 is a perspective view of a fan assembly 100 which is a push-through fan assembly 200 according to a first embodiment. The push-through fan assembly 200 includes a filter chamber 202 including an air inlet 204 arranged to admit air from a first zone 102 such as outdoor unfiltered air from outside of a building. The filter chamber 202 further comprises an air outlet 206 arranged to emit pressurized and filtered air into a second zone 104 such as an indoor environment or room. The filter chamber 202 also includes a fluid passage 208 in fluid communication between the air inlet 204 and the air outlet 206 and a flow generator 210 for directing the admitted air from the air inlet 204 through an air filter 212 disposed along the fluid passage 208 to generate the pressurized and filtered air through the air outlet 206 (see Figure 2 for pictorial illustration of the flow generator 210). The push-through fan assembly 200 further includes a bleed channel 214 having a bleed inlet 216 arranged to receive second zone air from the second zone 104 and a bleed outlet 218 arranged to emit the second zone air into the first zone 102 or into the fluid passage 208 for circulation through the air filter 212.

In this embodiment, the bleed channel 214 comprises a ring bleed chamber arranged concentrically around the filter chamber 202 to form a two-chamber configuration.

Figure 2 is an exploded unassembled perspective view of the push-through fan assembly 200 of Figure 1. The push-through fan assembly 200 includes a main fan casing 220 which houses the flow generator 210 such as a fan located within the filter chamber 202. The main fan casing 220 includes a rear portion 220a for receiving the admitted air from the air inlet 204 and a front portion 220b for directing the air flow towards the air outlet 206. The push-through fan assembly 200 includes front acoustic absorbent 222 and rear acoustic absorbent 224 coupled to respective front and rear portions 220b, 220a of the main fan casing 220. In this embodiment, the push-through fan assembly 200 also includes a front and rear acoustic casing 226, 228 at the respective front

and rear portions 220b, 220a of the main fan casing 220 to admit airborne sound onto the acoustic absorbent 222, 224 to achieve sound attenuation for reduced noise along the fluid passage 208. Vibration isolators are placed at interface between the flow generator 210 and the fan casing 220 to damp vibrations from the flow generator 210. It should be appreciated that the front acoustic casing 226 at the front portion 220b of the main fan casing 220 extends near to the air outlet 206 and the rear acoustic casing 228 at the rear portion 220a of the main casing 220 extends near to the air inlet 204 to reduce noise further.

Figure 3 is an enlarged perspective view of the front acoustic casing 226 of Figure 2 and just like the rear acoustic casing 228, the front acoustic casing 226 is perforated. Specifically, the front acoustic casing 226 is arranged along the fluid passage 208 and has two sections: a mid-acoustic section 226a which sits within the main fan casing 220 (and thus, not visible from Figure 2) and a main acoustic section 226b which extends out of the main fan casing 220 (and thus, visible from Figure 2) and converges or tapers towards the air outlet 206. The front acoustic casing 226 includes a series of regularly spaced apart spiral strips 227 to define spiral perforations 229 between adjacent pairs of spiral strips 227.

As the air admitted from the first zone 102 is struck by the flow generator 210, the air flow is altered by the impact and leaves the flow generator 210 in a vortex air flow (see spiraling arrow AA) along the fluid passage 208, it has been found that if the curvature of the spiral perforations 229 are aligned to the axis of the vortex air flow, this may maximize the attenuation of noise by the front acoustic absorbent 222. Accordingly, the arrangement of the perforations 229 of the front acoustic casing 226 enhances contact between the vortex air flow BB and the front acoustic absorbent 222 recessed behind the perforations 229, thus providing a more effective attenuation of airborne sound carried by the air flow along the fluid passage 208 and towards the air outlet 206. Further, as the air flow moves further outwards from the flow generator 210 and in the direction of the air outlet 206, the converging main acoustic section 226b of the front acoustic casing 226 continues to maximize acoustic contact between the airborne noise and the front acoustic absorbent 222. Also, the converging main

acoustic section 226b is arranged to accelerate the exiting air flow to increase its forward momentum in the direction of the air outlet 206 of the fan assembly 200.

- 5 As it can be appreciated from the above, the front and rear acoustic casings 226,228 and the corresponding front and rear acoustic absorbents 222,224 form an acoustic attenuator. The acoustic casings' are perforated in spiral vortex arrangement to increase the dissipation of noise carried by the vortex air flow BB exiting from the flow generator 210. The main acoustic section 226b of
10 the front acoustic casing 226 is arranged to converge as distance increases away from the flow generator 210 towards the air outlet 206 to optimize the reduction of noise.

- Coming back to Figure 2, The push-through fan assembly 200 further includes a
15 front-mid dual chamber casing 230 for enclosing the front acoustic absorbent 222 and a rear-mid dual chamber casing 232 for enclosing the rear acoustic absorbent 224. As it can be appreciated, the front-mid dual chamber casing 230 and the rear-mid dual chamber casing 232 house the bleed channel 214 arranged concentrically around the filter chamber 202. The push-through fan
20 assembly 200 also includes a front inner casing 234 for attaching to the main fan casing 220 via the front-mid dual chamber casing 230 and a rear inner casing 236 for attaching to the main fan casing 220 via the rear-mid dual chamber casing 232. The push-through fan assembly 200 also includes a front casing 238 for mounting to the front-inner casing 234 and a rear casing 240 for
25 mounting to the rear-inner casing 236 and once assembled, a compact fan assembly 200 illustrated in Figure 1 is formed. In this embodiment, the air filter 212 of a suitable MERV rating is located at the front inner casing 234 and before the front casing 238.

- 30 Turning to Figure 1, air from the first zone 102 is drawn in by the flow generator 210 through the fluid passage 208 and then forced through the air filter 212 as filtered and pressurized air into the second zone, which is preferably a ventilated premise. Suction force generated by the flow generator 210 thus

pressurizes the air in the second zone which reduces infiltration of outdoor air from other sources (such as cracks or window gaps etc).

To maintain the air in the second zone at a desired air quality, the bleed channel 214 admits air from the second zone into the bleed inlet 216 and depending on the requirements, the second zone air may be selectively emitted out into the first zone 102 or into the fluid passage 208 for circulation through the air filter 212.

It should be apparent that it is advantageous to maintain a suitable static pressure within the second zone to achieve an application specific ventilation rate, such as ventilation rates being determined based on air change requirements or desired thermal conditions. Accordingly, the fan assembly 200 of this embodiment includes a control circuitry 242 as illustrated in Figure 4, and the control circuitry 242 includes a sensor 244, a controller 246, a recirculation mechanism 248 and a bleed flow regulator 250, which may be a valve or damper.

In this embodiment, the sensor 244 (not shown in Figures 1 and 2) may be mounted to the front casing 238 and includes a number of sensing units for detecting respectively concentration level of particulate matter (PM), and/or carbon dioxide, and/or environmental or other contaminants, and/or static pressure and/or temperature. The sensor 244 may be calibrated to indicate if operational indoor environmental quality (IEQ) requirements based on specific applications are met. It should be appreciated that the sensor 244 or the sensing units may not be mounted to the fan assembly 200 and may be located at a suitable location within the second zone or incorporated into a hand-held controller, for example, as long as the sensor 244 can detect the air quality within the second zone.

30

Based on the detected indoor air quality, the sensor 244 provides a sensing signal to the controller 246 which determines whether or not to modulate the speed of the flow generator 210 and/or actuate the bleed flow regulator 250

which in turn controls the size of the opening of the bleed air inlet 216. The speed of the flow generator 210 in combination with the amount of opening of the bleed air inlet 216 thus regulates the amount of air admitted into the fan assembly 200 to vary volume of supply and exhaust air to attain the operational
5 IEQ and ventilation requirements.

The recirculation mechanism 248 controls the relative portion of outdoor air and recirculated room air. Specifically, the recirculation mechanism 248 is arranged to control whether the second zone air admitted via the bleed inlet 216 is
10 channeled to the bleed outlet 218 and emitted into the first zone or the second zone air is channeled into the fluid passage 208 and pushed through the air filter 212 and recirculated through the air outlet 206 as filtered and pressured air. The recirculation mechanism 248 may be an air valve or damper which changes position to channel the second zone air selectively between the bleed
15 outlet 218 and the fluid passage 208 and also regulates the amount of air between both positions. Of course, the recirculation mechanism may also shut off the air flow in one direction and channel all the second zone air to the other direction depending on the application and requirement. The operation of the recirculation mechanism 248 is controlled by the controller 246 depending on
20 the sensing signal received from the sensor 244 (based on detecting the environment parameters of the second zone 104).

As an example, the sensor 244 may be arranged to detect static pressure in the room (i.e. second zone), and based on the sensing signal, the controller 246
25 determines if there should be an increase or decrease in the volume of outdoor air brought into the fan assembly 200 (or perhaps to maintain an existing amount of admitted air) and modulates the speed of the flow generator 210 accordingly. Also, if the room is very air tight, the static pressure would increase and if the volume of outdoor air admitted into the fan assembly 200 is too low,
30 the controller 246 may control the bleed flow regulator 250 and the recirculation mechanism 248 to bleed the indoor air (i.e. from the second zone) to outdoors (i.e. to the first zone). Further, if the controller 246 determines that the indoor air quality is acceptable based on the sensing signal, the controller 246 may adjust

the recirculation mechanism 248 to allow an amount of air from the bleed channel 214 to be recirculated into the filter chamber 202 and through the filter 212.

- 5 The recirculation mechanism 248 is meant to accommodate a control strategy that optimizes the operation of the fan assembly 200 from an energy and filtration perspective. For example, when the second zone (indoor) environmental conditions permit, it would be advantageous to recirculate the second zone air through the air filter to achieve the desired indoor PM2.5
- 10 concentration levels more rapidly. An envisaged situation is one when the second zone (indoors) PM2.5 levels are high, so it might be advantageous to operate the fan filter in a full recirculation mode until the desired PM2.5 level is achieved before switching to taking air from the first zone (outdoor).
- 15 Also, with the bleed inlet's opening being adjustable, the controller 246 may be further arranged based on the detected parameter or parameters from the sensor 244, to adjust a size of the bleed inlet's opening and to simultaneously adjust the relative proportion of such bled air to the first zone 102 and recirculated to the second zone 104 through the air filter 212. With such a
- 20 configuration, this provides for dynamic adjustment of the fan assembly operation to achieve an optimal mix (proportion) of air taken from the first zone (outdoors) and recirculated from the second zone (indoors) when the PM2.5 levels in the second zone 104 has achieved desired concentration level and when the ventilation requirement is not compromised by decreasing the amount
- 25 of air being taken in from the first zone 102.

The acceptable indoor air quality may vary from country to country and also depends on the implementation, size of room etc. As a guide, the World Health Organisation (WHO) Interim target-3 (IT-3) guideline value of $37.5 \mu\text{g}/\text{m}^3$ might

30 be useful, and in certain countries, local target values may be regarded as acceptable indoor air quality. It is envisaged that onsite calibration may be carried out to program the sensor 244 and/or the controller 246 on the level of air quality or parameter value which is acceptable.

The sensing signal from the sensor 244 also allows the controller 246 to control the flow generator 210 to regulate the air flow speed or velocity of the filtered and pressured air emitted from the air outlet 206. It should be appreciated that
5 the control circuitry is arranged to maintain requisite static pressure and ventilation rate to attain the functional performance of the fan assembly 200 in terms of pressurization, ventilation, thermal conditions, and PM concentration levels.

10 Thermal control (cooling and/or heating) mechanism may be incorporated to enhance thermal performance to further alleviate thermal discomfort in the space

The control circuitry 242 may be incorporated within the fan assembly 200 and
15 there may be a user interface which allows a user to set or change manually the flow generator speed, levels of acceptable carbon dioxide, recirculation timings and particulate matter, static pressure or appropriate contaminant or environmental parameters. The control circuitry 242 may also be operated via a wireless handheld controller (not shown) and if this is the case, requisite
20 electronics and wireless components may be incorporated in the fan assembly 200.

Being compact, the fan assembly 200 is portable and versatile and may be affixed to a wall, façade or window. Taking the window as an example, the
25 window may have a window opening adapted to match the air inlet 204 of the fan assembly in order for the air inlet 204 to receive outdoor air. To facilitate ease of such an installation, the fan assembly 200 includes a window attachment device 252 to facilitate its portable deployment and this is illustrated in Figure 5.

30

The window attachment device 252 includes an air inlet connector 254 which may be cylindrical in shape and the air inlet connector 254 is coupled to a device duct (or attachment device conduit) 256 which connects the air inlet

connector 254 to a panel opening connector 258. The air inlet connector 254 is preferably magnetic and is arranged to cooperate with the rear inner casing 236 of the fan assembly 200. Specifically, the rear casing 240 of the fan assembly 200 is removed, and the air inlet connector 254 is arranged to snap-fit to the rear inner casing 236 via magnetic connection. It should be appreciated that other forms of connection are possible, not just magnetic.

In this way, the air inlet 204 is in fluid communication with an opening 260 of the panel opening connector 258 via the device duct 256.

10

The frame of the window is next installed with a panel 262 having a panel opening 264 defined by a panel connector 266 sized to match with the size of the panel opening connector 258 of the window attachment device 252. In this embodiment, the panel 262 includes a polypropylene corrugated board 262a although other types of material may be used.

15

The panel 262 includes a panel frame 268 which fits snugly to the window frame (not shown). In this embodiment, the panel frame 268 is not a single piece but includes an outer frame 270 carrying the corrugated board 262a and an inner frame 272 for attaching to the window frame.

20

The outer frame 270 includes a number of outer corner joints 274 and outer elongate frame members in the form of outer customized PVC cable trays 276 connected to the respective outer corner joints 274 using outer dowel joints 278. With the inner frame 272 adapted to be attached to the window frame, the inner frame 272 is further attached to the outer frame 270. In this embodiment, the inner frame 272 includes inner elongate frame members in the form of inner customized PVC cable trays 280 connected to respective inner corner joints 282 also using inner dowel joints 284. The inner frame 272 may include adhesive (such as double sided tape) to be adhered to the outer frame 270.

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With the panel 262 located snugly into the window frame via the panel frame 268 (comprising the outer frame 270 and the inner frame 272), the window attachment device 252 is ready to be attached to the panel 262.

- 5 In this embodiment, the panel connector 266 and the panel opening connector 258 form a magnetic connection. Further, the panel connector 266 includes a number of female apertures 267 regularly spaced around the perimeter of the panel connector 266 and the panel opening connector 258 includes a number of male studs 259 for locating in the corresponding female apertures 267 to form a snap fit connection, as illustrated in Figure 6. Thus, it is a simple task of moving
10 the panel opening connector 258 near enough to the panel connector 266 (see arrow AA in Figure 5), locating the male studs 259 into the corresponding female apertures 267 and allowing the magnetic connection to take place. As a result, the cooperation between the male studs 259 and the female apertures
15 267 form a snap-fit connection to minimize any rotational movement when the panel connector 266 is magnetically connected to the panel opening connector 258 and in this way, a more secured and yet detachable connection is achieved.
- 20 It can thus be appreciated that once the window attachment device 252 is secured to the panel 262, and the fan assembly 200 is in use, air from outside of the window is admitted via the panel opening 264, through the device duct 256, into the air inlet 204 to be pressurized and filtered by the push-through fan assembly 200 and eventually emitted through the air outlet 206 into a room, for
25 example.

It should be appreciated that the push-through fan assembly 200 while coupled to the window attachment device 252 may be supported by a stand, although this is not illustrated.

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As it can be appreciated, the magnetic snap-fit window attachment device 252 allows intake of outdoor air into the suction side of the push-through fan assembly 200, and readily snaps in place onto the push-through fan assembly

200 and the window where corresponding matching fits are mounted. The polypropylene (or equivalent material) corrugated board is located snugly into the window or wall frame secured by cable trays, thus providing a good fitting that readily secures onto the window frame.

5

Figure 7 illustrates a second embodiment of the fan assembly 100 in the form of a draw-through fan assembly 300 which is very similar to the push-through fan assembly 200 (except the location of an air filter) and like parts will have like reference numerals with the addition of 1000. Just like the first embodiment, the draw-through fan assembly 300 includes a filter chamber 1202 including an air inlet 1204 arranged to admit air from a first zone 1102 such as outdoor unfiltered air from outside of a building. The filter chamber 1202 further comprises an air outlet 1206 arranged to emit pressurized and filtered air into a second zone 1104 such as an indoor environment or room. The filter chamber 1202 also includes a fluid passage 1208 in fluid communication between the air inlet 1204 and the air outlet 1206 and a flow generator 1210 for drawing the admitted air from the air inlet 1204 through an air filter 1212 disposed along the fluid passage 1208 to generate the pressurized and filtered air through the air outlet 1206 (see Figure 8 for pictorial illustration of the flow generator 210).

20

Unlike the first embodiment, the air filter 1212 is located near the air inlet 1204 instead of near the air outlet 1206. This may be seen more clearly in Figure 8 which is an exploded unassembled view of the draw-through fan assembly 300 of Figure 7 and is an almost exact arrangement as that in Figure 2 of the push-through fan assembly 200 for easy comparison.

25

Parts of the draw-through fan assembly 300 are almost identical to the push-through fan assembly 200 but for the sake of completeness, the draw-through fan assembly 300 includes the following parts, just like the push-through fan assembly 200:

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- 1) 1220: a main fan casing;
- 2) 1210: a flow generator such as a fan located within the filter chamber 1202;

- 3) 1220a: a rear portion of the main fan casing 1220;
- 4) 1220b: a front portion of the main fan casing 1220;
- 5) 1222: front acoustic absorbent;
- 6) 1224: rear acoustic absorbent;
- 5 7) 1226: front acoustic casing;
- 8) 1128: rear acoustic casing;
- 9) 1230: front-mid dual chamber casing;
- 10)1232: rear-mid dual chamber casing;
- 11)1234: front inner casing;
- 10 12)1236: rear inner casing;
- 13)1238: front casing;
- 14)1240: rear casing.

It should be appreciated that the location of the air filter 1212, which again may
15 be of a suitable MERV rating is located at rear inner casing 1236 instead of at
the front inner casing 1234. Thus, air from the air inlet 1204 is drawn through
the air filter 1212 by the flow generator 1210 and then channeled to the air
outlet 1206. In other words, in the second embodiment, the air filter 1212 is
located upstream of the airflow in the fluid passage 1208, whereas in the first
20 embodiment, the air filter 212 is located downstream of the air flow in the fluid
passage 208 of the push-through fan assembly 200.

Referring to Figures 7 and 8, just like the push-through fan assembly 200, the
draw-through fan assembly further includes a bleed channel 1214 having a
25 bleed inlet 1216 arranged to receive second zone air from the second zone
1104 and a bleed outlet 1218 arranged to emit the second zone air selectively
into the first zone 1102 or into the fluid passage 1208 for circulation through the
air filter 1212. Needless to say, the air to be recirculated needs to flow past the
air filter 1212 (i.e. between the rear inner casing 1236 and the rear casing 1240)
30 and channeled into the fluid passage 1208 and drawn through the air filter 1212.

In this second embodiment, the bleed channel 1214 also comprises a ring bleed chamber arranged concentrically around the filter chamber 1202 to form a two-chamber configuration, as shown in Figure 8.

5 It should also be appreciated that the control circuitry 242, the window attachment device 252 and the installation method described earlier and illustrated in Figures 5 and 6, and also the structure of the front acoustic casing 230 illustrated in Figure 3 also apply for the second embodiment.

10 As it can be appreciated, the fan assembly 100 of the described embodiments (be it the push-through or draw-through embodiments 200,300), is dynamically responsive for removing contaminants from outdoor air and to provide adequately filtered airflow into otherwise naturally ventilated indoor environments by achieving sufficient pressurization to inhibit outdoor particulate
15 matter infiltration, requisite ventilation for indoor environmental quality, and thermal discomfort alleviation.

More specifically, the described embodiments may be useful to remove particulate matter (PM) and microorganisms to mitigate against high indoor
20 contaminant levels during haze episodes (influx of biomass and peat fires impacted PM emissions) and chronic outdoor pollution (such as those related to traffic and industries). Clean (filtered) and pressurized air is supplied into an enclosed, but otherwise naturally ventilated indoor environment; and therefore the described embodiments may be used in a range of indoor environments
25 including homes, schools, hostels and hospitals. Also, the fan assembly is versatile enough to be affixed to a room infrastructure or via a flexible window attachment snap-fit system connection system (such as the window attachment device 252 of Figure 5).

30 With the described embodiments, clean (filtered) outdoor air may be supplied to naturally ventilated premises simultaneously with pressurization control to prevent contaminant infiltration during haze or high outdoor pollution conditions - with the indoor environment generally enclosed during such situations, i.e. with

all doors, windows and operable openings closed. With the recirculation mechanism 248 and sensor 244, rapid removal of contaminants, primarily PM2.5 particles, so as to attain acceptable operational environmental conditions at commencement of operation may be achieved, and thereafter, to enable
5 operation adjustment of ventilation and recirculation proportions commensurate with energy efficiency and indoor environmental quality objectives. The acoustical attenuator 222,224,226,228,1222,1224,1226,1228 and motor vibration isolators to attenuate sound for quieter, or acceptable noise level operation also allows the fan assembly 100 to be used in low-noise
10 environments. Indeed, the fan assembly 200 of the described embodiments may be employed when a quieter environment is desired. Specifically, all the windows and doors of a room may be shut to reduce outdoor noise and ventilation of the room would be provided via the fan assembly 200.

15 The described embodiments may also be useful to provide a dynamically responsive pressure control solution to varying air-tightness of an enclosed premise, but otherwise naturally ventilated, to attain the required air change rate (ACH).

20 The fan assembly 100 of the described embodiments may be used to improve indoor conditions simultaneously specifically by removing PM2.5 (aerodynamic particle size $\leq 2.5 \mu\text{m}$) from outdoor air and supply such filtered outdoor air for ventilation, and to partially alleviate the degradation of thermal comfort in an otherwise unventilated situation.

25 Appropriately selected filters (MERV rating) for the air filters 212,1212 are incorporated in the described embodiments comprising the filter chamber 202,1202 and the bleed channel 214,1214 may achieve room pressurization and supply filtered outdoor air and inhibit ingress of external pollutants. In
30 addition to filtering, the air filters 212,1212 may also remove unpleasant odour from the air or incorporate fresheners. For example, the air filters 212,1212 may be particular charcoal filters. In association with the bleed channel 214,1214, the recirculation mechanism 248 working in conjunction with the sensor 244, the

bleed flow regulator 250 and the flow generator 210,1210, may enable the fan assembly to operate over a range of room air-tightness with required volumetric flow rates i.e. air change rate (ACH). The sensor 244 may be a single sensing unit or a number of sensing units which detect one or a combination of carbon dioxide or particulate matter or other appropriate environmental or contaminant sensors to control the speed of the flow generator and when advantageously, the amount of opening in the bleed channel 214,1214, which may be physically separated from the filter chamber 202,1202, and the proportional of bled air to be recirculated Outdoor air is thus provided as ventilation and controlled such that requisite ventilation rates are achieved; simultaneously by exchanging air from the outdoor, and the otherwise adverse thermal conditions indoors is partially alleviated to mitigate degradation of thermal comfort. Specifically, the re-circulation mechanism 248 may enable control of the relative portion of outdoor air and recirculated room air.

15

The described embodiments should not be construed as limitative. In the first embodiment, outdoor air is directly drawn in by the flow generator 210 and then forced through the air filter 212 located downstream of the airflow and into the ventilated premise. In the second embodiment, the outdoor air is sucked into the filter chamber 1202 by suction force provided from the flow generator 1210 in order to draw the outdoor air through the air filter 1212 located upstream of the airflow and then into the ventilated premises. Whichever the case, the suction force pressurizes the ventilated premises, preventing the infiltration of outdoor air. Both embodiments include the bleed channel 214,1214 which includes a concentric bleed chamber which surrounds the inner filter chamber. However, the bleed channel 214,1214 may simply be an elongate conduit (instead of a concentric chamber) which runs along the longitudinal axis of the push-through or draw-through fan assembly 200,300. Similarly, the conduit, together with the filter chamber, provides a two-way path for air in the room (second zone air) to either be recirculated to the suction side of the fan assembly, or to bleed through the bleed outlet 218,1218 to the outside of the room, house or building, thus achieving enhanced recirculation with lesser

30

outdoor air intake in the first arrangement, or enhanced outside air intake to increase air change rate in the room in the second arrangement.

Further, the fan assembly 100 may be simplified further by omitting the bleed
5 channel 214/1214 and thus, the fan assembly 100 operates to generate filtered
and pressured air without any recirculation capability. Figure 9 illustrates a
push-through fan filter assembly 400 and a draw-through fan filter assembly 500
which are similar to the push-through fan assembly 200 and the draw-through
fan assembly 300 described earlier but without the bleed channel 214/1214. In
10 this case, if the control circuitry 242 is used, then the recirculation mechanism
248 is not necessary but the sensor 244 may still be relevant to control the air
flow regulator 250 and the flow generator 210. Likewise, the window attachment
device 252 and the retrofitting or installation method described and illustrated in
Figures 5 and 6 is still relevant for the push-through fan filter assembly 400 and
15 the draw-through fan filter assembly 500 of Figure 9.

Although the described embodiments describe admitting outdoor air (from the
first zone 102,1102) and filtering and pressurizing the air to generate the filtered
and pressurized air for indoors (the second zone 104,1104), the first zone may
20 be another room, or environment, depending on the implementation.

The fan assembly 100 may be directly coupled to the panel opening 264 via the
panel connector 266 without a need for the window attachment device 252.
Also, the arrangement of the fluid chamber 202,1202 and the bleed channel
25 214,1214 may be other configurations. For example, the fluid chamber
202,1202 may be arranged at the outer region of the concentric arrangement,
and the bleed channel 214,1214 may be arranged inner to the fluid chamber
202,1202. It is also envisaged that both the fluid chamber 202,1202 and the
bleed channel 214,1214 may be conduits adjacent to each other.

30

To reiterate, the described embodiments may achieve the following advantages:

- achieve acceptable indoor PM levels, ventilation rates and alleviates adverse thermal conditions via two different designs 1) Draw through and 2) Push through for naturally ventilated premises which are enclosed for protection against high outdoor particulate matter conditions.
- 5
- The pressure control mechanism achieves dynamic response and maintains the fan assembly 100 operational over a range of room air-tightness.
- 10
- rapidly achieves acceptable indoor PM conditions, and thereafter enables operation adjustment of ventilation and recirculation proportions commensurate with energy efficiency and indoor environmental quality levels.
- 15
- achieves room pressurization to inhibit ingress of external pollutants.
 - presence of acoustical insulation and motor vibration isolators to attenuate sound for quieter operation.
- 20
- Influx of particulate matter (PM 2.5 and PM 1) may be reduced.
 - achieves desired volumetric flow rate without compromise to filtration efficiency across a range of room air-tightness.
- 25
- achieves desired volumetric flow rate thus alleviating adverse degradation of thermal comfort conditions in enclosed premises.
 - may be applied during low outdoor pollution conditions for improving room ventilation and thermal comfort levels in warm climates.
- 30
- versatile to be incorporated as part of the building's structure, or operated as portably located units with the suction side of the fan assembly 100 flexibly connected to an appropriate opening in the wall or façade.

- the window attachment device 252 may be readily deployed to secure the fan assembly 100 to a window frame, providing a secure system for easy, portable deployment of the fan assembly. Further, the window attachment device 252 is flexible and provides an effective “plug and play” mitigation solution to the wider population in residential settings, homes etc.

Having now fully described the invention, it should be apparent to one of ordinary skill in the art that many modifications can be made hereto without departing from the scope as claimed.

CLAIMS

1. A fan assembly comprising
 - (i) a filter chamber including
 - an air inlet arranged to admit air from a first zone,
 - an air outlet arranged to emit pressurized and filtered air into a second zone,
 - a fluid passage in fluid communication between the air inlet and the air outlet,
 - a flow generator for directing the admitted air through an air filter disposed along the fluid passage to generate the pressurized and filtered air through the air outlet, and
 - (ii) a bleed channel having a bleed inlet arranged to receive second zone air from the second zone and a bleed outlet arranged to emit the second zone air into the first zone or into the fluid passage for circulation through the air filter.
2. A fan assembly according to claim 1, wherein the bleed channel comprises a ring bleed chamber arranged concentrically around the filter chamber.
3. A fan assembly according to claim 1, wherein the bleed channel comprises an elongate bleed conduit arranged along a longitudinal axis of the filter chamber.
4. A fan assembly according to any of claims 1 to 3, further comprising a sensor arranged to detect at least one of the following parameters in the second zone: carbon dioxide, particulate matter, environmental contaminants, static pressure and temperature; and
 - a controller arranged to control the flow generator based on the detected at least one parameter.
5. A fan assembly according to claim 4, wherein the bleed inlet's opening is adjustable, and the controller is further arranged to adjust a size of the bleed inlet's opening based on the detected at least one parameter, and to either emit

the air to the first zone or to recirculate the air to the second zone through the air filter.

6. A fan assembly according to claim 4, wherein the bleed inlet's opening is adjustable, and the bleed flow regulator is further arranged to adjust a size of the bleed inlet's opening based on the detected parameter or parameters, and a recirculation mechanism to simultaneously adjust the relative proportion of such bled air to the first zone and recirculated to the second zone through the filter.

7. A fan assembly comprising a filter chamber including an air inlet arranged to admit air from a first zone, an air outlet arranged to emit pressurized and filtered air into a second zone, an interior fluid passage in fluid communication between the air inlet and the air outlet, and a flow generator for directing the admitted air through an air filter disposed along the interior fluid passage to generate the pressurized and filtered air through the air outlet.

8. A fan assembly according to any of claims 1 to 7, wherein the flow generator includes a fan disposed upstream of the filter to blow the admitted air from the first zone through the fan filter.

9. A fan assembly according to any of claims 1 to 7, wherein the flow generator includes a fan disposed downstream of the fan filter to suck or draw the admitted air from the first zone through the fan filter.

10. A fan assembly according to any of claims 1 to 9, further comprising an acoustic casing disposed along the fluid passage, the acoustic casing arranged to reduce noise caused by the air flow generated by the flow generator.

11. A fan assembly according to claim 10, wherein the acoustic casing is arranged adjacent to an acoustic absorbent and the acoustic casing includes a

plurality of spiral perforations arranged to allow noise to be absorbed by the adjacent acoustic absorbent.

12. A fan assembly according to claim 11, wherein the flow generator is arranged to generate a vortex air flow, and curvature of the spiral perforations is aligned to the vortex air flow.

13. A fan assembly according to any of claims 10 to 12, wherein the acoustic casing tapers from the flow generator towards the air outlet.

10

14. A method of retrofitting a window with a fan assembly of any of claims 1 to 13, the method comprising
covering the window with a panel having a panel opening; and
attaching the air inlet of the filter chamber to the panel opening, so that
the air from the first zone is admitted via the panel opening.

15. A method of claim 14, wherein the air inlet of the filter chamber is attached directly to the panel opening.

16. A method of claim 14, wherein the fan assembly further comprises a window attachment device having an air inlet connector,
a panel opening connector and an attachment device conduit between the air inlet connector and the panel opening connector, and
wherein the method further comprises
coupling the air inlet connector to the air inlet of the filter chamber;
and
coupling the panel opening connector to the panel opening of the panel to create an attachment fluid passage between the panel opening and the air inlet of the fan assembly via the attachment device conduit.

30

17. A method of claim 16, wherein the air inlet connector and the air inlet of the filter chamber forms a magnetic snap-fit connection.

18. A method of claim 16 or 17, wherein the panel opening connector and the panel opening forms a magnetic snap-fit connection.

19. A method of any of statements 14 to 18, wherein the panel includes a
5 panel frame for affixing the panel to a window frame of the window; and the panel frame comprises a number of corner joints and elongate frame members connected to respective corner joints using dowel joints.

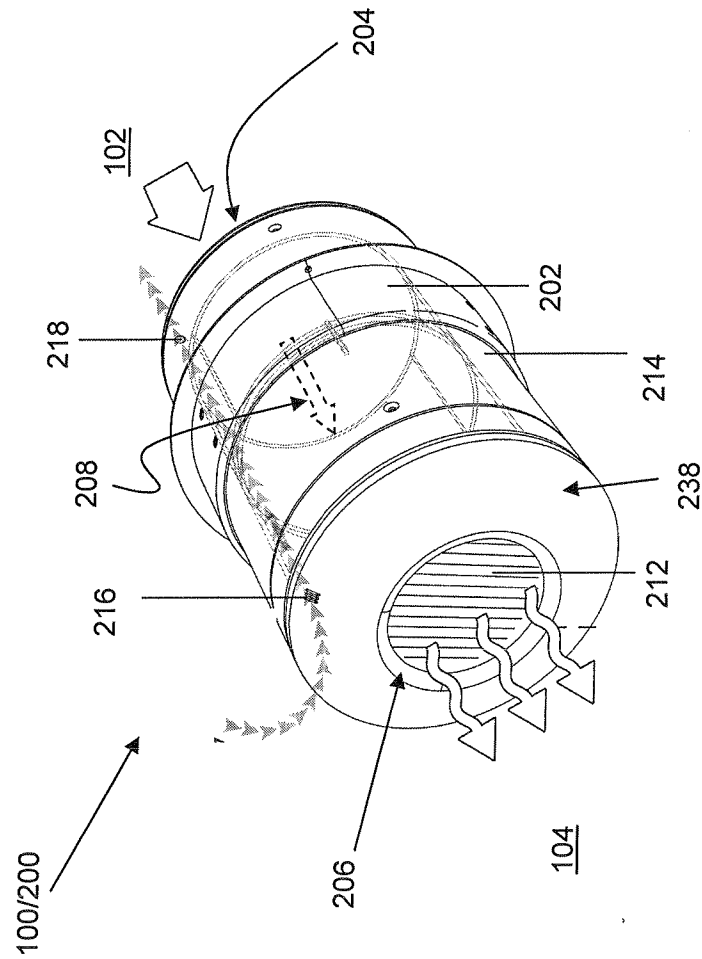


Figure 1

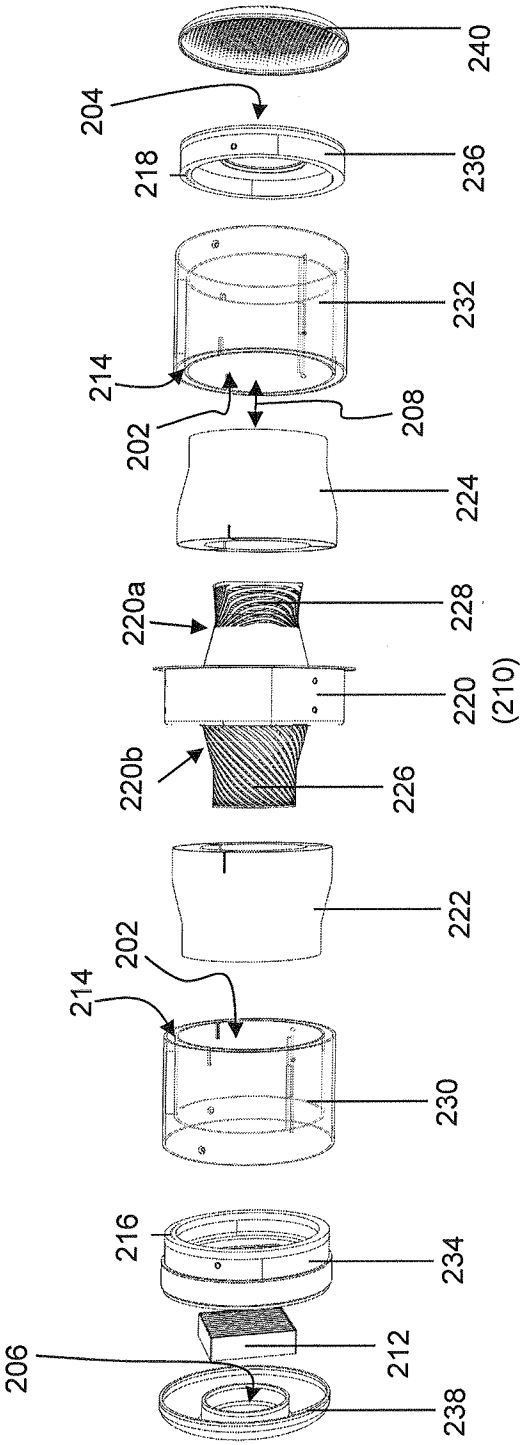


Figure 2

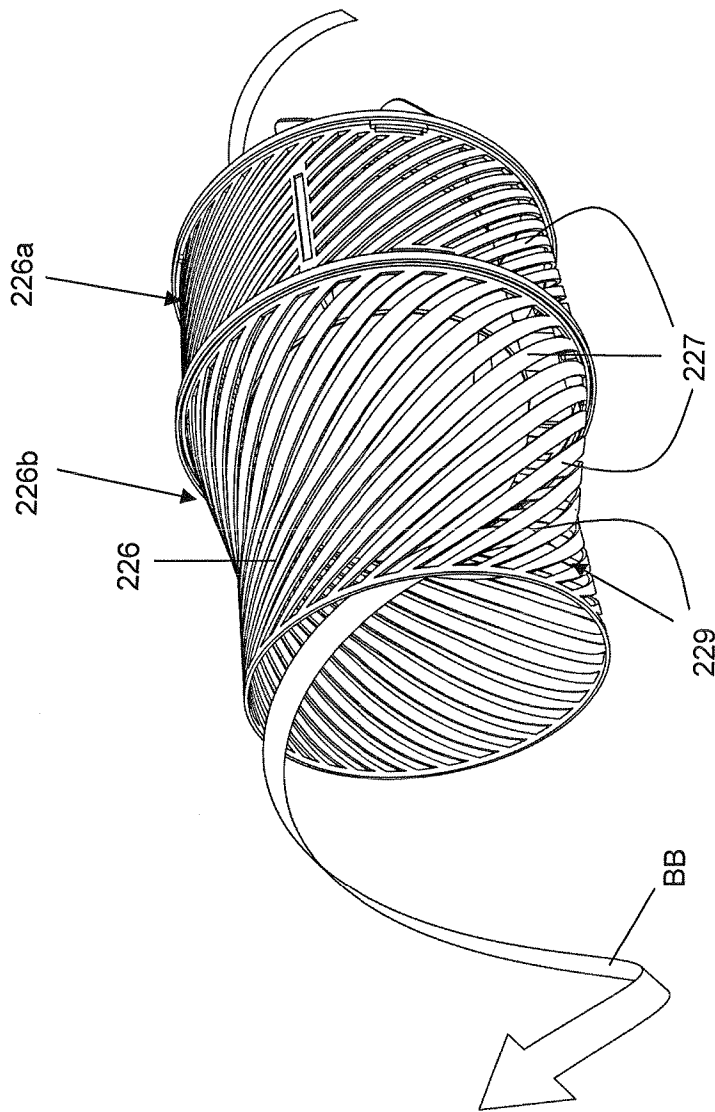
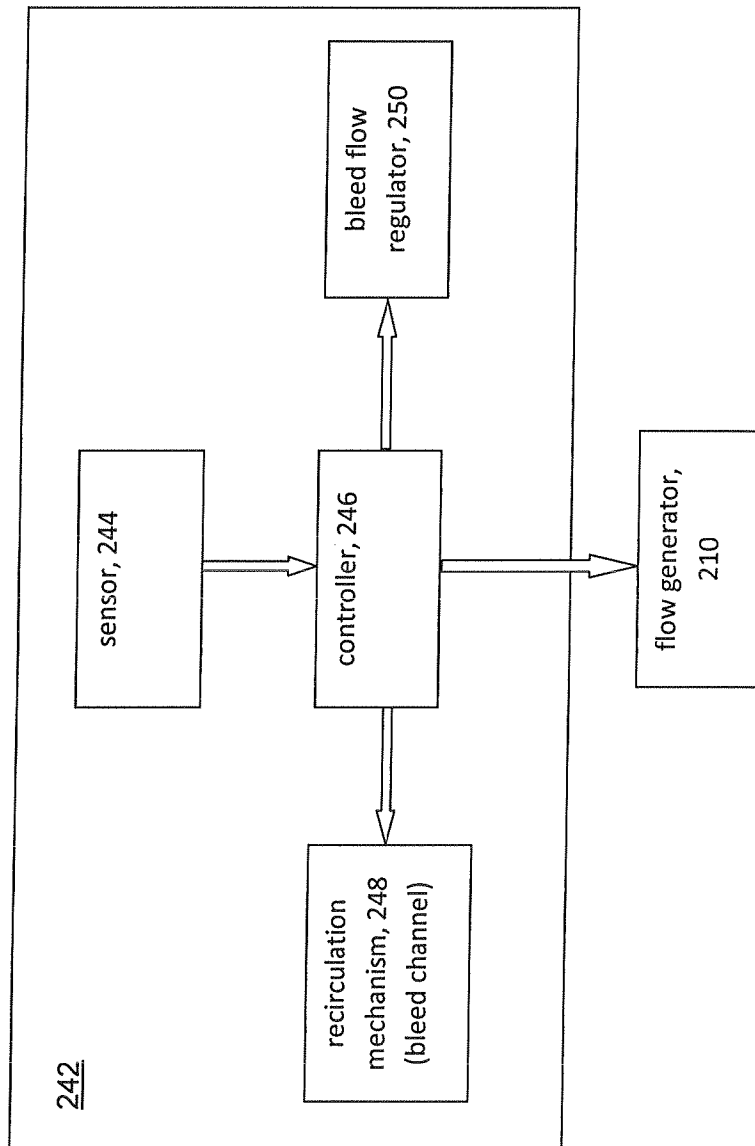


Figure 3

Figure 4

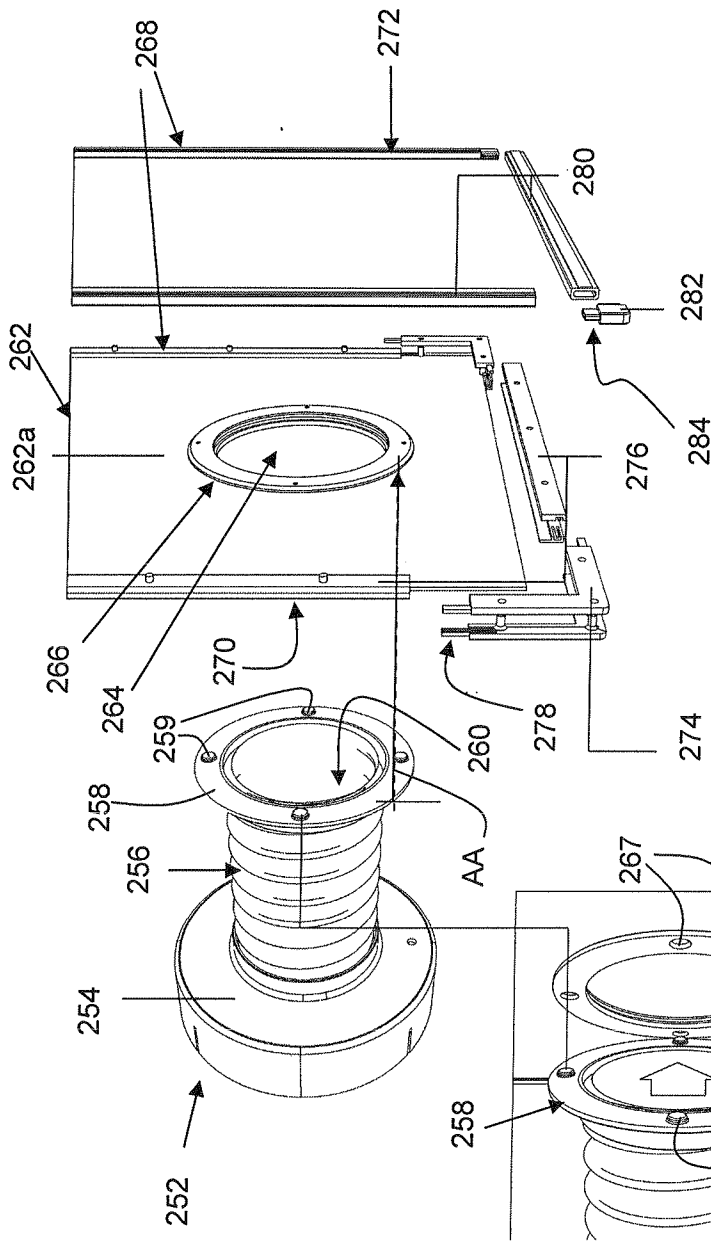


Figure 5

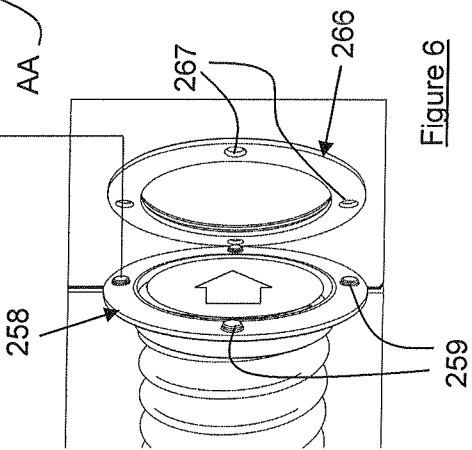


Figure 6

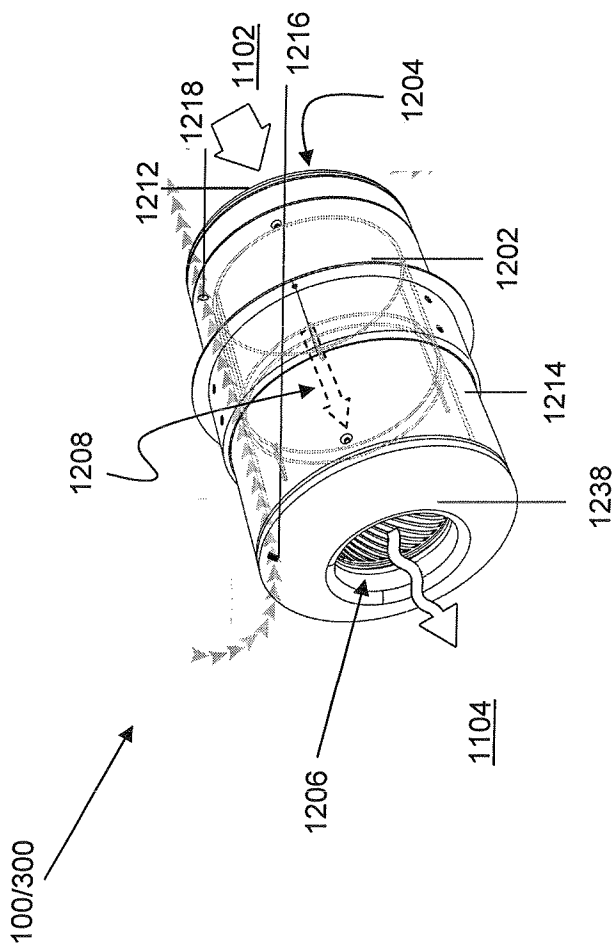


Figure 7

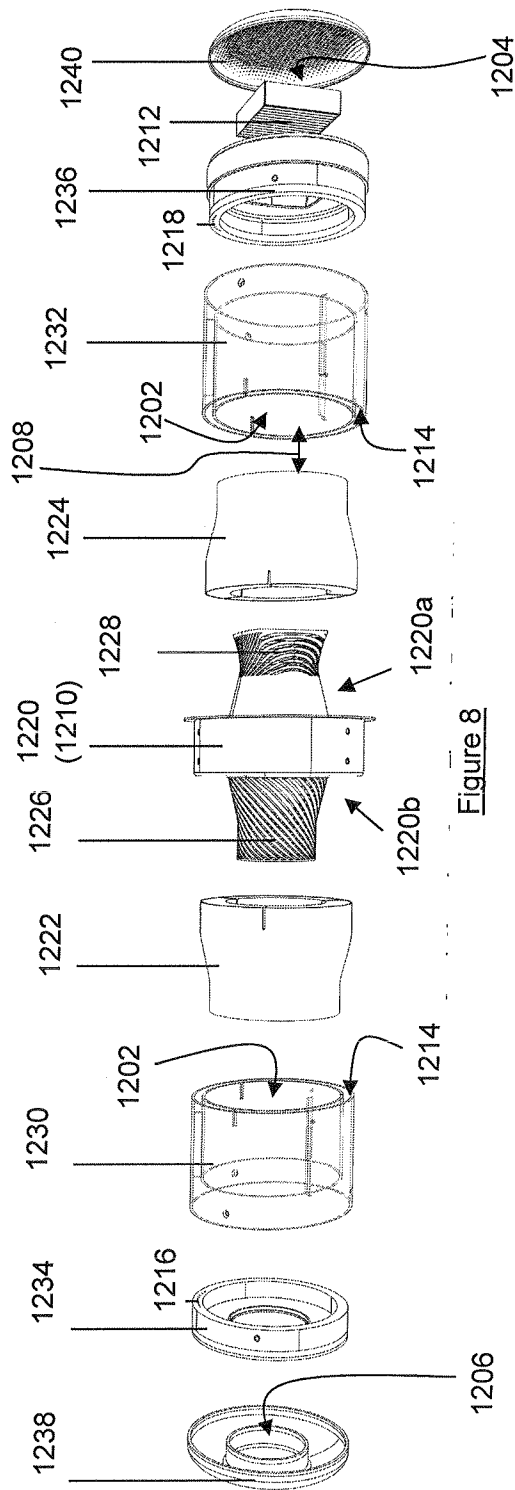


Figure 8

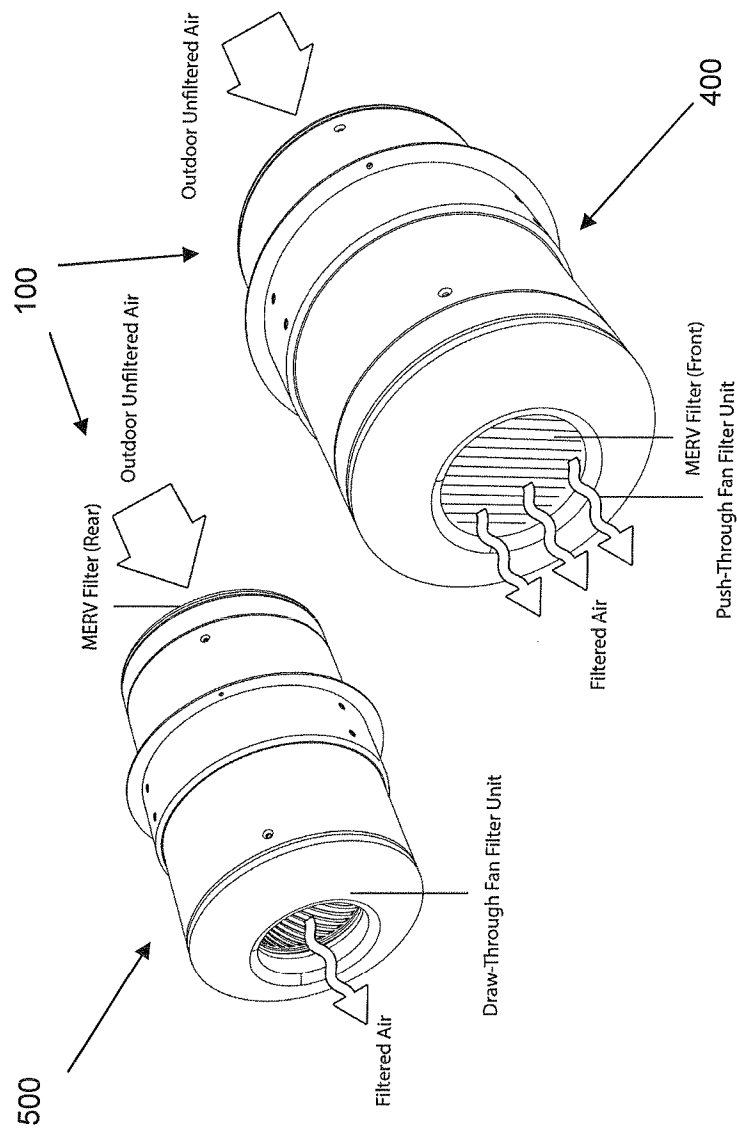


Figure 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2016/050519

A. CLASSIFICATION OF SUBJECT MATTER

B60H 3/06 (2006.01)

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

FAMPAT, SCOPUS: fan, filter, remove, purify, clean, air, inlet, outlet, outer, concentric, bleed, chamber, channel, passage, duct, flow, generator, direction, sensor, controller, contamination, circulation, adjust, opening, acoustic, noise, 空气, 净化, 过滤, 风扇, 管道, 通道, 双层, 外层 and other related terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 204513596 U (LI Z.) 29 July 2015 Fig. 1 of the original non-English language document (a machine translation is enclosed only for your reference)	1-19
X	CN 104406243 A (HAO C. ET AL.) 11 March 2015 Fig. 1; Paras. [0031]-[0037] of the original non-English language document (a machine translation is enclosed only for your reference)	1-19
X	CN 104764108 A (BEIJING SANMENG MINING EQUIPMENT FACTORY) 8 July 2015 Fig. 1 of the original non-English language document (a machine translation is enclosed only for your reference)	1, 7, 14

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

03/01/2017

(day/month/year)

Date of mailing of the international search report

18/01/2017

(day/month/year)

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2016/050519

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0173188 A1 (MOREDOCK J. G. ET AL.) 26 July 2007 Fig. 1	7, 14
A	US 6711470 B1 (HARTENSTEIN S. D. ET AL.) 23 March 2004 The whole document, especially Col. 2 line 57- col. 4 lines 38	
A	CN 204051911 U (ZHEJIANG LEO ELECTRONIC TECHNOLOGY) 31 December 2014 The whole document, especially Paras. [0004]-[0007] of the original non-English language document (a machine translation is enclosed only for your reference)	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2016/050519

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 0241095 A1	23/05/2002
CN 204051911 U	31/12/2014	NONE	