



(51) International Patent Classification:

B01D 46/10 (2006.01) F04D 29/70 (2006.01)

(21) International Application Number:

PCT/GB2020/050848

(22) International Filing Date:

30 March 2020 (30.03.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1906929.3 16 May 2019 (16.05.2019) GB

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

(54) Title: A FILTER ASSEMBLY

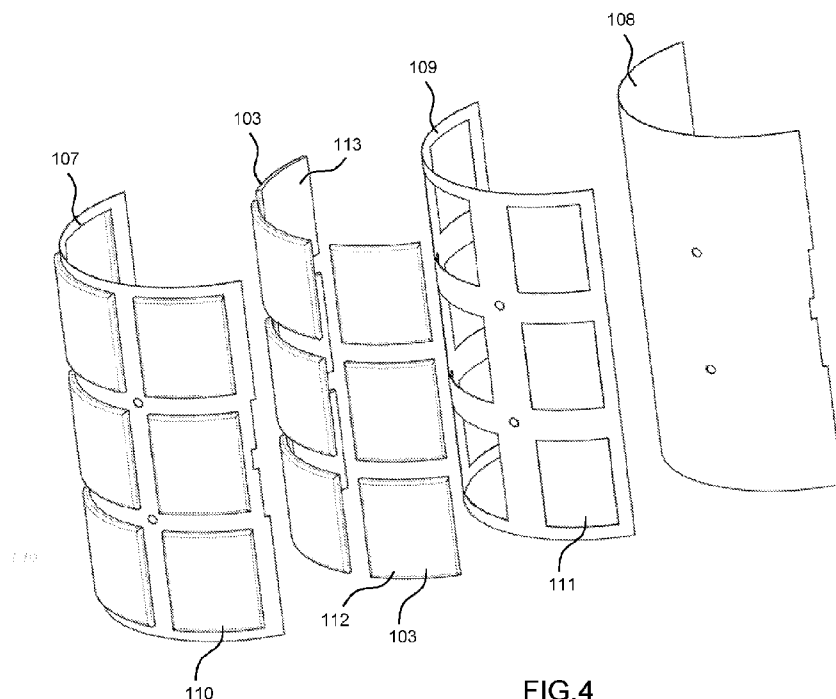


FIG. 4

(57) Abstract: The present invention provides a filter assembly for an air treatment apparatus, the filter assembly comprising a first layer of air permeable mesh, a second layer of air permeable mesh, and a filter frame that is arranged to be mounted to the air treatment apparatus and that is arranged to support both the first layer of air permeable mesh and the second layer of air permeable mesh. The frame defines an array of openings that are distributed across an area bounded by an exterior portion of the filter frame. The filter assembly then further comprises a plurality of separate sheets of solid foam filter media, each of the plurality of separate sheets of solid foam filter media being disposed within a corresponding opening in the filter frame and being at least partially compressed between the first layer of air permeable mesh and the second layer of air permeable mesh.



SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

A FILTER ASSEMBLY

FIELD OF THE INVENTION

The present invention relates to a filter assembly for an air treatment apparatus and to an air
5 treatment apparatus comprising the filter assembly.

BACKGROUND OF THE INVENTION

An air purifier is an air treatment apparatus which removes contaminants from the air. Conventional air purifiers solely use particulate filters that physically capture airborne particles by
10 size exclusion, with a high-efficiency particulate air (HEPA) filter removing at least 99.97% of 0.3 μm particles. More advanced air purifiers might also make use of additional technologies to remove additional contaminants. For example, some more advanced air purifiers use ultra-violet (UV) light to kill microorganisms, such as viruses, bacteria and moulds, which may be present in the air.

15 Some air purifiers use activated carbon filters to filter volatile chemicals from the air. Activated carbons are well known carbonaceous materials that are processed to have a large number of open or accessible micropores and mesopores that increase the surface area available for adsorption. For example, WO2016/128734 describes a fan assembly that has a tubular, barrel-type filter that is mounted on the cylindrical body of the fan assembly. The filter comprises a two-
20 layer structure of filter media that includes an outer layer of a pleated HEPA filter surrounding an inner layer of activated carbon cloth.

25 Whilst activated carbon filters can be quite effective against some of the large volatile organic compounds (VOCs), they do not provide an effective means of removing smaller, more polarised compounds. For example, formaldehyde (CH_2O) is one such compound, the levels of which are of growing international concern due to the associated health risks, particularly in relation to indoor air. In addition, when used for air purification, activated carbons filter out contaminants by adsorption, and therefore only have a limited capacity, such that activated carbon filters eventually
30 require replacement or regeneration if filtering performance is to be maintained.

SUMMARY OF THE INVENTION

It is therefore desirable to provide a filter assembly that can be conveniently mounted to a fan assembly and that can effectively remove one or more gaseous pollutants, such as volatile
35 organic compounds (VOCs), without the requirement for the filter assembly to be replaced or regenerated during the operational or service life of the fan assembly. By incorporating a thermal catalyst that is capable of oxidative decomposition of volatile organic compounds at ambient/room

temperature, as opposed to a photocatalyst that requires light to catalyse a reaction, it is possible to provide a filter assembly that can permanently oxidise VOCs, such as formaldehyde, to carbon dioxide (CO₂) using atmospheric oxygen. This approach has many benefits over the conventional solution of using carbon capture as it overcomes the issues of saturation and the potential for off-gassing of a harmful compound. However, the present inventions have recognised that mounting such a catalyst within a conventional air treatment apparatus is not necessarily straightforward. In particular, these catalysts are typically provided in particular form and therefore need to be mounted or retained within some form of substrate. Furthermore, in order to treat the air, this substrate must be suitably permeable to air so that air can pass through the substrate material at sufficient flow rates and pressures whilst still retaining the catalyst.

One possible solution is to mount the catalyst within a solid foam material. However, to provide a sufficient removal rate for the targeted chemical pollutants the solid foam material needs to be of sufficient thickness to ensure that the air flowing through the filter assembly is exposed to a sufficient concentration of the catalyst. The thickness of the solid foam material then impacts on the ease with which the media can be incorporated into a conventional air treatment apparatus that may have limitations on the space available. This is particularly true when seeking to retrofit such a catalytic filter media into an existing air treatment apparatus.

Consequently, it is an object of the present invention to provide a filter assembly that optimally allows a solid foam filter media to be mounted within an air flow that passes through an air treatment apparatus or fan assembly. Therefore, according to a first aspect there is provided a filter assembly for an air treatment apparatus, the filter assembly comprising a first layer of air permeable mesh, a second layer of air permeable mesh, and a filter frame that is arranged to be mounted to the air treatment apparatus and that is arranged to support both the first layer of air permeable mesh and the second layer of air permeable mesh. The frame defines an array of openings that are distributed across an area bounded by an exterior portion of the filter frame. The filter assembly then further comprises a plurality of separate sheets of solid foam filter media, each of the plurality of separate sheets of solid foam filter media being disposed within a corresponding opening in the filter frame and being at least partially compressed between the first layer of air permeable mesh and the second layer of air permeable mesh. The present inventors have surprisingly found that it is possible to compress a catalytic filter media that makes use of a solid foam substrate, and therefore reduce the space consumed by the filter media, without detrimentally impacting on the removal performance of the catalyst that is supported by and/or embedded within the solid foam substrate. This is particularly surprising as compressing such a catalytic filter media reduces the thickness of the material and consequently reduces the residence time of the air that flows through the catalytic filter media.

This arrangement also provides a filter assembly that optimises the efficiency with which the solid foam filter media is utilised. Moreover, this arrangement is particularly advantageous when the solid foam filter media is to be compressed within the filter assembly as it is easier to ensure that each of the pieces in the array are evenly compressed across their entire surface area than it would be for a single piece of the solid foam filter media having the same surface area as the array. In particular, this arrangement provides that the filter frame can make use of a framework, arranged as a grid, grille or lattice, which extends across the area of the filter frame in order to ensure a more consistent compression of the solid foam filter media whilst minimising or avoiding the impingement of the filter frame on the solid foam filter media so as to avoid wastage of the potentially expensive material.

Each of the plurality of separate sheets of solid foam filter media may have an at least partially compressed thickness or depth. Each of the plurality of separate sheets of solid foam filter media may have an uncompressed thickness or depth (i.e. when not retained within the filter frame) that is greater than a compressed thickness or depth. Preferably, at least a portion (i.e. one or more regions or areas) of each of the plurality of separate sheets of solid foam filter media is compressed such that a compressed thickness of a compressed portion is less than an uncompressed thickness of an uncompressed portion. More preferably, an entirety of each of the plurality of separate sheets of solid foam filter material is compressed such that a compressed thickness is less than an uncompressed thickness.

Each of the plurality of separate sheets of solid foam filter media may comprise a first surface and an opposing second surface and at least a portion (i.e. one or more regions/areas) of the each of the plurality of separate sheets may be compressed such that a distance between the first surface and the second surface of a compressed portion is less than the distance between the first surface and the second surface of an uncompressed solid foam filter media.

Each of the plurality of separate sheets of solid foam filter media may have an uncompressed thickness of from 6 mm to 10 mm, and preferably of from 7 mm to 9 mm, and a compressed thickness of from 3 mm to 5 mm, and preferably of from 3.5 mm to 4 mm.

The filter assembly may be arranged such that, when mounted to an air treatment apparatus, a first surface of each of the plurality of separate sheets of solid foam filter media is outward facing and a second surface of each of the plurality of separate sheets of solid foam filter media is inward facing. The first surface may then be upstream relative to an airflow generated by the air treatment apparatus that passes through the filter assembly, whilst the second surface would be

downstream relative to the air flow generated by the air treatment apparatus that passes through the filter assembly.

The plurality of separate sheets of solid foam filter media may comprise a stochastic open-cell polymer foam material, such as a polyurethane foam. The plurality of separate sheets of solid foam filter media may further comprise a plurality of catalytic particles that are dispersed throughout the solid foam filter media. In particular, the catalytic particles may be dispersed within the pores of the solid foam filter media. The catalytic particles may comprise a thermal catalyst that is capable of oxidative decomposition of volatile organic compounds at ambient/room temperature.

The filter frame may further comprise an interior portion or part comprising a plurality of bars that divide the area bounded by the exterior portion into the array of openings. Preferably, the bars of the interior portion are arranged as a grid, grille or lattice that spans/extends across the area bounded by the exterior portion of the filter frame.

The filter frame may encompass edges of both the first layer of air permeable mesh and the second layer of air permeable mesh, and is preferably spaced apart from edges of each of the plurality of separate sheets of solid foam filter media. Preferably, the air permeability of the first layer of air permeable mesh is greater than that of the plurality of separate sheets of solid foam filter media, and the air permeability of the second layer of air permeable mesh is also greater than that of the plurality of separate sheets of solid foam filter media.

The first layer of air permeable mesh may be formed with an array of indentations or depressions, and each of the plurality of separate sheets of the solid foam filter media may then be disposed within a corresponding indentation of the first layer of air permeable mesh. The first layer of air permeable mesh may comprise a sheet of an air permeable mesh that is formed with the array of indentations that are each arranged to receive one of the plurality of pieces of solid foam filter media. The indentations of the first layer of air permeable mesh may be aligned with the openings defined by the filter frame.

The filter assembly may further comprise a border material disposed between the first layer of air permeable mesh and the second layer of air permeable mesh, the border material extending across an area between edges of each of the plurality of separate sheets of solid foam filter media and adjacent edges of the filter frame. Preferably, the air permeability of the border material is lower than the air permeability of the plurality of separate sheets of solid foam filter media.

The border material may define an array of openings or gaps, and wherein each of the plurality of separate sheets of solid foam filter media are exposed within a corresponding opening in the border material. The openings in the border material may be distributed across an area bounded by outer edges of the border material. The border material may extend across an area between
5 edges of each of the plurality of separate sheets of solid foam filter media and adjacent edges of the filter frame. Preferably, the openings in the border material are aligned with the openings defined by the filter frame.

The filter frame may comprises a plastic material, and preferably comprises a thermoplastic
10 polymer. The filter frame may be moulded over edges of both the first layer of air permeable mesh and the second layer of air permeable mesh, and is preferably spaced apart from edges of the solid foam filter media. The filter frame may also be moulded over edge portions of the border material.

The filter frame may have two-fold rotational symmetry such that the filter frame can be retained
15 on an air treatment apparatus in either of two opposing orientations. The filter frame may be provided with at least one first engagement member on a first side edge of the filter frame and at least one second engagement member on a second side edge of the filter frame, the first edge being opposite to the second edge. Each engagement member may comprise a projection or tab
20 that is arranged to engage a corresponding opening provided on the air treatment apparatus and thereby retain the filter assembly.

The filter assembly may be substantially semi-cylindrical in shape. The filter frame may have a first side edge and a second side edge, the first side edge and the second side edge being parallel
25 to a longitudinal axis of the filter frame, and the first side edge being opposite to the second side edge. The filter frame may have a first end edge and a second end edge, the first end edge and the second end edge being perpendicular to the longitudinal axis of the of the filter frame, the first end edge and the second end edge each having an arc-shaped cross section in a plane perpendicular to longitudinal axis.

The filter assembly may be arranged such that, when mounted to an air treatment apparatus, the first layer of air permeable mesh is outward facing and the second layer of air permeable mesh is inward facing. The first layer of air permeable mesh may then be upstream relative to an air flow generated by the air treatment apparatus that passes through the filter assembly, whilst the
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35 second layer of air permeable mesh would be downstream relative to the air flow generated by the air treatment apparatus that passes through the filter assembly.

The air permeable mesh of the first layer may be the same as or different to the air permeable mesh of the second layer. The first layer of air permeable mesh may comprise an arrangement of fibres defining an array of holes or apertures. The first layer of air permeable mesh may comprise a woven mesh of fibres. The first layer of air permeable mesh may comprise metal
5 fibres, and preferably comprises stainless steel fibres. The second layer of air permeable mesh may comprise an arrangement of fibres defining an array of holes or apertures. The second layer of air permeable mesh may comprise a woven mesh of fibres. The second layer of air permeable mesh may comprise metal fibres, and preferably comprises stainless steel fibres.

10 An aperture size of air permeable mesh of the first layer may be smaller than an aperture size of the air permeable mesh of the second layer. A diameter of the fibres of the first layer of air permeable mesh may be smaller than a diameter of the fibres of the second layer of air permeable mesh.

15 The first layer of air permeable mesh may comprise fibres that are are angled at 45 degrees relative to edges of the first layer of air permeable mesh. The first layer of air permeable mesh may comprise fibres having a diameter of from 0.1 to 0.15 mm. The first layer of air permeable mesh may have an aperture size of from 0.15 to 0.3 mm, and preferably of from 0.2 to 0.28 mm. The second layer of air permeable mesh may comprise fibres that are are angled at 45 degrees
20 relative to edges of the second layer of air permeable mesh. The second layer of air permeable mesh may comprise fibres having a diameter of from 0.1 to 0.2 mm. The second layer of air permeable mesh may have an aperture size of from 0.35 to 0.5 mm, and preferably of from 0.4 to 0.48 mm.

25 According to a second aspect there is provided an air treatment apparatus comprising a filter assembly according to the first aspect, and an air flow generator that is arranged to generate an air flow through the filter assembly.

The air treatment apparatus may further comprise an air inlet through which the air flow enters
30 the apparatus and an air outlet through which the air flow enters the apparatus, and the air flow generator is then arranged to generate an air flow between the air inlet and the air outlet. The filter assembly may be supported on the fan assembly upstream of the air flow generator.

The air treatment apparatus may further comprise a body housing the air flow generator. The filter
35 assembly may be mounted on or within the body. The body may comprise the air inlet of the apparatus and the air flow generator may then be arranged to generate an air flow through the air inlet. The filter assembly may be mounted on the body over the air inlet, on either the upstream

of downstream side of the air inlet. The filter assembly may be arranged to cover or extend over an entirety of the air inlet.

The air treatment apparatus may further comprise a nozzle mounted on and supported by the body, the nozzle being arranged to receive the airflow from the body and to emit the airflow from the fan assembly. The air outlet of the apparatus may then be provided on the nozzle. The body may comprise an air vent through which the air flow through is emitted from the body, and the nozzle may then be mounted over the air vent of the body.

The air treatment apparatus may further comprise a particulate filter media supported on the treatment apparatus upstream of the filter assembly. The particulate filter media may be mounted on or within the body. The particulate filter media may be mounted on the body over the air inlet. The particulate filter media may be provided by a further filter assembly, the further filter assembly comprising a further filter frame supporting the particulate filter media. The further filter assembly may comprise a filter seal that is arranged to engage the body to prevent air from passing around the edges of the further filter assembly. The filter seal may extend around the entire periphery of the further filter frame. The particulate filter media may be arranged so as to cover an entirety of an area defined within the periphery the further filter frame. The further filter assembly may be releasably attached to the body. The particulate filter media may comprise a high-efficiency particulate air (HEPA) particulate filter media. The further filter assembly may be arranged to cover/extend over an entirety of the air inlet.

The air treatment apparatus may further comprise an activated carbon filter media mounted on the body downstream of the particulate filter media and upstream of the filter assembly. The activated carbon filter media may be provided by the further filter assembly. The activated carbon filter media may be supported by the further filter frame of the further filter assembly. The air treatment apparatus may further comprise an intermediate filter assembly disposed between the filter assembly and the further filter assembly, wherein the intermediate filter assembly comprises the activated carbon filter media. The intermediate filter assembly may be mounted on the body over the air inlet. The intermediate filter assembly may be releasably attached to any of the body and the further filter assembly.

BRIEF DESCRIPTION OF THE INVENTION

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1a is a front perspective view of an example of a filter assembly as described herein;

5 Figure 1b is a rear perspective view of the filter assembly of Figure 1a;

Figure 1c is a front view of the filter assembly of Figure 1a;

Figure 1d is a rear view of the of the filter assembly of Figure 1a;

Figure 2a is a cross-sectional view of the filter assembly taken along line A-A in Figure 1c;

Figure 2b is a cross-sectional view of the filter assembly taken along line B-B in Figure 1c;

10 Figure 3 is an enlarged view of the region C indicated in Figure 2b;

Figure 4 is an exploded view of an example of an air permeable structure of a filter assembly as described herein;

Figure 5a is a front perspective view of an example of an air treatment apparatus with which the filter assembly described herein is suitable for use; and

15 Figure 5b is a front perspective view of the air treatment apparatus of Figure 5a with the filter assembly separated from the air treatment apparatus.

DETAILED DESCRIPTION OF THE INVENTION

There will now be described a filter assembly that is suitable for use in domestic air treatment apparatus. The term “air treatment apparatus” as used herein refers to an apparatus configured to supply air that has been treated so as to change one or more characteristics of that air. For example, such an air treatment apparatus may be capable of generating one or more of a dehumidified airflow, a humidified airflow, a purified airflow, a filtered airflow, a cooled airflow, and a heated airflow for the purposes of thermal comfort and/or environmental or climate control.

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The filter assembly comprises a filter frame that is arranged to be mounted to the air treatment apparatus and a solid foam filter media that is retained within the filter frame, wherein the solid foam filter media is at least partially compressed within the filter frame. The solid foam filter media therefore has thickness/depth when uncompressed (i.e. when not retained within the filter frame) that is greater than the thickness/depth of the compressed solid foam filter media. The term “solid foam” as used herein refers to a material comprising a framework of solid material surrounding gas-filled voids (i.e. a cellular solid). Preferably, the solid foam is a stochastic open-cell material.

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At least a portion (i.e. one or more regions/areas) of the solid foam filter media may be compressed such that the compressed thickness/depth of the compressed portion is less than the uncompressed thickness of the solid foam filter media. However, it is preferable that the entirety of the solid foam filter material is compressed such that the thickness/depth across the

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entire area of the solid foam filter material is less than the uncompressed thickness of the solid foam filter media.

In addition, whilst the solid foam filter media can be provided as a single panel or sheet of solid foam filter media, it is preferable that the solid foam filter media comprises a plurality of separate/discrete panels or sheets that are arranged as an array. The plurality of separate sheets of the solid foam filter media are then distributed across an area bounded by exterior/boundary portions of the filter frame. The filter frame may then define an array of openings or gaps that are distributed across an area bounded by the exterior portions of the filter frame, with each of the plurality of separate sheets of the solid foam filter media then being disposed within a corresponding opening in the filter frame. To do so, the filter frame may comprise an interior portion comprising a plurality of bars that divide the area bounded by the exterior portions into the array of openings. Preferably, the bars of the interior portion are arranged as a grid, grille or lattice that spans/extends across the area bounded by the exterior portions of the filter frame.

Furthermore, it also preferable that the filter assembly further comprises a first layer of air permeable mesh and a second layer of air permeable mesh. The filter frame may then be arranged to support both the first layer of air permeable mesh and the second layer of air permeable mesh, with the solid foam filter media being disposed between the first layer of air permeable mesh and the second layer of air permeable mesh. The solid foam filter media may then be at least partially compressed by/between the first layer of air permeable mesh and the second layer of air permeable mesh.

Figures 1a to 1d illustrate an embodiment of such a filter assembly 100 that is suitable for use in domestic air treatment apparatus. Figure 1a is a front perspective view of the filter assembly 100 and Figure 1b is a rear perspective view of the filter assembly 100, whilst Figure 1c is a front view of the filter assembly 100 and Figure 1d is a rear view of the filter assembly 100. The filter assembly 100 comprises a filter frame 101 that is arranged to be mounted to the air treatment apparatus and an air permeable structure 102 supported by and therefore retained within the filter frame 101, wherein this air permeable structure 102 comprises a solid foam filter media 103. The air permeable structure 102 is arranged so as to cover an open area defined by the filter frame 101.

In the illustrated embodiment the filter frame 101 comprises an exterior/boundary portion 104 and an interior portion 105. The exterior/boundary portion 104 defines the outermost edges of the filter frame 101. The interior portion 105 then comprises a plurality of bars that divide the area bounded by the exterior portion 104 into an array of openings or gaps 106. In particular, the bars of the

interior portion 105 are arranged as a grid or grille that spans/extends across the area bounded by the exterior portion 104 of the filter frame 101 such that the openings 106 defined by the interior portion 105 of the filter frame 101 are distributed across the area bounded by the exterior portions 104 of the filter frame 101.

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In the illustrated embodiment the bars of the interior portion 105 are arranged as a square grid. However, in alternative embodiments the bars of the interior portion 105 could be arranged in any other form of grid. For example, the bars could be arranged as a diamond, triangular or hexagonal grid. In addition, in the illustrated embodiment the bars of the interior portion 105 are arranged
10 such that they either parallel with or perpendicular to the exterior portion 104 of the filter frame. However, in alternative embodiments the bars of the interior portion 105 could be arranged such that they are either sloped or slanted relative to the exterior portion 104 of the filter frame 101.

In the illustrated embodiment, the solid foam filter media 103 is provided as a plurality of
15 separate/discrete panels or sheets that are arranged as an array, with the plurality of separate sheets of the solid foam filter media 103 being distributed across the area bounded by the exterior portions 104 of the filter frame 101. In particular, each of the plurality of separate sheets of the solid foam filter media 103 is disposed within a corresponding one of the openings 106 defined by the interior portion 105 of the filter frame 101. To illustrate this, Figure 2a is a cross-sectional
20 view of the filter assembly taken along line A-A in Figure 1c, whilst Figure 2b is a cross-sectional view of the filter assembly taken along line B-B in Figure 1c.

Figure 3 is then an enlarged view of the region C indicated in Figure 2b showing the air permeable structure 102. In the illustrated embodiment, the air permeable structure 102 comprises a first
25 layer of air permeable mesh 107 and a second layer of air permeable mesh 108, with the solid foam filter media 103 disposed between the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108. In particular, the air permeable structure 102 is arranged so that the solid foam filter media 103 is compressed between the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108. Both the first layer of air permeable mesh 107
30 and the second layer of air permeable mesh 108 are then affixed to the filter frame 101 so that the solid foam filter media 103 is indirectly retained by the filter frame 101. To avoid any unnecessary drop in pressure of an airflow passing through the filter assembly 100, the air permeability of the first layer of air permeable mesh 107 is greater than that of the solid foam filter media 103, and the air permeability of the second layer of air permeable mesh 108 is also greater
35 than that of the solid foam filter media 103. In this regard, air permeability is an expression describing the properties of a material that permit the passage of air through the material's

interstices and is typically defined as the rate of airflow passing perpendicularly through a known area under a prescribed air pressure differential between the two surfaces of the material.

The term “mesh” as used herein refers to a material that comprises an arrangement of fibres that define an array of holes or pores. Consequently, a typical mesh can comprise fibres that are woven or knitted together. For the sake of clarity, the accompanying drawings do not show the separate fibres that make up each of the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108, but instead show the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108 as simple sheet materials.

The air permeable structure 102 then further comprises a border material 109 disposed between the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108, with the border material 109 extending across an area between edges of the solid foam filter media 103 and adjacent edges of the filter frame 101. This border material 109 is provided in order to encourage air impinging upon the filter assembly 100 to flow through the solid foam filter material 103 rather than through the gaps between edges of the solid foam filter material 103 and the filter frame 101. To do so, the air permeability of the border material 109 is lower than the air permeability of the solid foam filter media 103. By way of example, the border material 109 could comprise a sheet of nonwoven fabric material, such as a plastic scrim.

To illustrate this more detail, Figure 4 is an exploded view of an embodiment of the air permeable structure 102 that is supported by the filter frame 101. In the illustrated embodiment, the first layer of air permeable mesh 107 comprises a sheet of an air permeable mesh that is formed with an array of indentations or depressions 110 that are each arranged to receive one of the plurality of pieces of solid foam filter media 103. The border material 109 then comprises a sheet that has an array of openings 111 that are each arranged to align with the indentations 110 of the first layer of air permeable mesh 107. The air permeable structure 102 can therefore be constructed by locating a piece of solid foam filter media 103 within each of the indentations 110 of the first layer of air permeable mesh 107 before laying the border material 109 over the first layer of air permeable mesh 107 so that the border material 109 extends across the area between edges of each of the plurality of separate pieces of the solid foam filter media 103 and adjacent edges of the filter frame 101 (i.e. so as to provide a border around the solid foam filter media 103). The second layer of air permeable mesh 108 can then be laid over the border material 109 to complete the air permeable structure 102.

The indentations 110 in the first layer of air permeable mesh 107 serve to locate and retain the pieces of solid foam filter material 103 in the desired positions so that they align with the openings

110 in the border material 109. The border material 109 then extends across the gaps between the pieces of solid foam material 103 and the filter frame 101. In particular, in the illustrated embodiment the border material 109 is arranged such that, when the border material 109 is aligned with the first layer of air permeable mesh 107, the edges of the openings 111 overlap edge portions of the pieces of solid foam filter material 103 as doing so ensures that only the solid foam filter media 103 is exposed within the openings 111 in the border material 109.

In the illustrated embodiment, the filter frame 101 is made from a plastic material, such as a thermoplastic polymer (e.g. polycarbonate (PC), acrylonitrile butadiene styrene (ABS)), and is formed by over-moulding of the filter frame 101 directly onto the air permeable structure 102 such that a portion of the air permeable structure 102 is embedded within the filter frame 101. Specifically, the filter frame 101 is moulded over the air permeable structure 102 such that edges of both the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108 are embedded/encompassed within the filter frame 110, without the filter frame impinging upon the solid foam filter material 103. Preferably, the filter frame 101 is moulded over the air permeable structure 102 such that exterior edges of the border material 109 are also embedded/encompassed within the filter frame 110.

As described above, the air permeable structure 102 is arranged so that the solid foam filter media 103 is compressed between the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108. The solid foam filter media 103 therefore has an uncompressed thickness/depth, when not retained between the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108, which is greater than the compressed thickness/depth (D_c) of the solid foam filter media 103. In particular, in the illustrated embodiment an entirety of the solid foam filter media 103 is compressed. Consequently, when retained within the filter frame, the solid foam filter media 103 is compressed so that the distance between the two surfaces 112, 113 of the solid foam filter media is less than the distance between these surfaces 112, 113 when the solid foam filter media 103 is uncompressed.

In the illustrated embodiment, the compressed thickness (D_c) of the solid foam filter media 103 is approximately 46% of the uncompressed thickness of the solid foam filter media 103. Specifically, in the illustrated embodiment the solid foam filter media has an uncompressed thickness of approximately 8.0 mm and a compressed thickness (D_c) of approximately 3.7 mm. However, in alternative embodiments the solid foam filter media could have an uncompressed thickness of from 6 mm to 10 mm, and preferably of from 7 mm to 9 mm, and a compressed thickness (D_c) (i.e. when retained between the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108) of from 3 mm to 5 mm, and preferably of from 3.5 mm to 4 mm.

In the illustrated embodiment the solid foam filter media 103 is air permeable and comprises a stochastic open-cell polymer foam material, such as a polyurethane foam. The solid foam filter media 103 then further comprises a plurality of catalytic particles that are dispersed throughout the solid foam filter media 103. In particular, the catalytic particles are dispersed within the pores of the solid foam filter media 103. The catalytic particles comprise a thermal catalyst that is capable of oxidative decomposition of volatile organic compounds at ambient/room temperature. In this regard, whilst there are various materials that may be suitable thermal catalyst for the oxidation of volatile organic compounds at ambient/room temperature, there are two main types of materials that are particular effective heterogeneous catalysts:

1) Supported transition metals.

Suitable supported transition metal catalysts typically take the form of nanoparticles (<100nm) of the transition metal dispersed on the surface of a substrate or catalyst support, wherein the substrate can be in the form of particles or a framework that typically comprises a metal oxide, semimetal oxide or carbon. By way of example, suitable transition metals include ruthenium (Ru), rhodium (Rh), palladium (Pd), silver (Ag), osmium (Os), iridium (Ir), platinum (Pt), gold (Au), rhenium (Re), molybdenum (Mo), vanadium (V), iron (Fe), and manganese (Mn), whilst suitable metal oxide support materials can comprise a metal selected from cerium (Ce), zirconium (Zr), titanium (Ti), silicon (Si), tin (Sn), aluminium (Al), vanadium (V), iron (Fe), manganese (Mn) and lanthanum (La).

2) Non-noble metal oxides.

Suitable non-noble metal oxides catalysts typically take the form of particles of the metal oxide. By way of example, suitable -noble metal oxide can comprise a non-noble metal selected from manganese, copper, cobalt, chromium, titanium, cerium, zirconium, vanadium and iron.

The filter assembly 100 is arranged such that, when mounted to a domestic air treatment apparatus, a first of the two surfaces 112 of the solid foam filter media 103 is outward facing relative to the air treatment apparatus and a second of the two surfaces 113 of the solid foam filter media 103 is inward facing. The first surface 112 of the solid foam filter media 103 is then upstream relative to an air flow generated by the air treatment apparatus and that passes through the filter assembly 100, whilst the second surface 113 is downstream relative to this air flow. The first layer of air permeable mesh 107 is then arranged to be outward facing relative to the air treatment apparatus, such that the first layer of air permeable mesh 107 is upstream of the solid foam filter media 103, whilst the second layer of air permeable mesh 108 is arranged to be inward

facing, such that the second layer of air permeable mesh 108 is downstream of the solid foam filter media 103.

The air permeable mesh of the first layer 107 may be the same as the air permeable mesh of the second layer 108. However, it is preferable that the air permeable mesh of the first layer 107 is different to the air permeable mesh of the second layer 108. In particular, it is preferable that the aperture size of air permeable mesh of the first layer 107 is smaller than the aperture size of the air permeable mesh of the second layer 108. In this regard, using a mesh that has a relatively small aperture size for the outward facing first layer 107 reduces the risk of a user contacting the solid foam filter media 103 when the first layer 107 is exposed. However, in order to ensure that the mesh is sufficiently air permeable, a mesh having a relatively small aperture size should comprise fibres that have a relatively small diameter, which in turn reduces the stiffness of the mesh. In order to prevent any undesirable deformation of the second layer 108, and to ensure that the solid foam filter media 103 remains sufficiently compressed, the second layer 108 should make use of a relatively stiff mesh that comprises fibres having a relatively large diameter. Then, in order to ensure that the mesh is sufficiently air permeable, a mesh that comprises fibres having a relatively large diameter should have a relatively large aperture size. Consequently, it is also preferable that the diameter of the fibres of the first layer of air permeable mesh 107 is smaller than the diameter of the fibres of the second layer of air permeable mesh 108.

In the illustrated embodiment, both the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108 comprise a woven mesh of metal fibres, such as stainless steel fibres. The first layer of air permeable mesh 107 comprises fibres that are angled at 45 degrees relative to edges of the first layer of air permeable mesh 107. The first layer of air permeable mesh 107 then comprises fibres having a diameter of 0.12 mm +/- 0.02 mm and an aperture size of 0.24 mm +/- 0.04mm. The second layer of air permeable mesh 108 then also comprises fibres that are angled at 45 degrees relative to edges of the second layer of air permeable mesh 108. The second layer of air permeable mesh 108 then comprises fibres having a diameter of 0.16 mm +/- 0.04 mm and an aperture size of 0.44 mm +/- 0.04mm. However, in alternative embodiments the first layer of air permeable mesh 107 could comprise fibres having a diameter of from 0.1 to 0.15 mm and an aperture size of 0.15 to 0.3 mm, and the second layer of air permeable mesh 108 could comprise fibres having a diameter of from 0.1 to 0.2 mm and an aperture size of from 0.35 to 0.5 mm.

In the illustrated embodiment, the filter frame 101 substantially has the shape of a semi-cylinder. The exterior portions 104 of the filter frame 101 that define the shape therefore comprise two straight side edges 114, 115 that are parallel to the longitudinal axis of the filter frame 101 and

two curved end edges 116, 117 that are perpendicular to the longitudinal axis of the filter frame 101. The two straight side edges 114, 115 of the filter frame 101 are then each provided with a pair of tabs or projections 118, 119 that are arranged to engage with corresponding recesses or holes provided on an air treatment apparatus so as to retain the filter assembly 101 on the air
5 treatment apparatus. The filter assembly 100 therefore has two-fold rotational symmetry such that it can be retained on an air treatment apparatus in either of two opposing orientations.

Figures 5a and 5b then show external views of an embodiment of a free-standing air treatment apparatus 200 with which the above described filter assembly 100 is suitable for use. In particular,
10 Figure 5a show a front perspective view of the air treatment apparatus 200, whilst Figure 5b shows a front perspective view of the air treatment apparatus 200 with the filter assembly 100 separated from the near side of the air treatment apparatus 200.

In the illustrated embodiment, the air treatment apparatus 200 comprises a body or stand 201, a
15 motor-driven impeller (not shown) contained within the body 201 and arranged to generate an airflow, and a nozzle 202 mounted on and supported by the fan body 201, the nozzle 202 being arranged to receive the airflow from the body 201 and to emit the airflow from the air treatment apparatus 200. The body 201 is provided with a pair of air inlets through which air enters the body 201 (i.e. through which air is drawn into the body 201 by the motor-driven impeller). Specifically,
20 the body 201 is provided with a first air inlet 203 and a second air inlet (not shown), the first air inlet 203 and the second air inlet being on opposing halves of the body 201.

The body 201 comprises a substantially cylindrical main body section 204 mounted on a substantially cylindrical lower body section 205. The main body section 204 has a smaller external
25 diameter than the lower body section 205. The main body section 204 has a lower annular flange 206 that extends radially/perpendicularly away from the lower end of the main body section 204. The outer edge of the lower annular flange 206 is substantially flush with the external surface of the lower body section 205. The main body section 204 further comprises an upper annular flange (not shown) that extends radially/perpendicularly away from an opposite, upper end of the main
30 body section 204. The outer edge of the upper annular flange is then substantially flush with the external surface of a base/neck 207 of the nozzle 202 that connects to upper end of the main body section 204.

The main body section 204 comprises a perforated cylindrical housing that contains various
35 components of the air treatment apparatus 200. The perforated housing comprises two separate arrays of apertures which act as the air inlets of the body 201 of the air treatment apparatus 200. The first air inlet 203 of the air treatment apparatus 200 is therefore provided by a first array of

apertures provided on a first half/portion of the main body section 204 and that extends over the entire length/height of the main body section 204, with the first half/portion being visible in Figure 5b. The second inlet of the air treatment apparatus 200 is then provided by a second array of apertures provided on a second half/portion of the main body section 204 and that extends over the entire length/height of the main body section 204.

In the illustrated embodiment, the above described filter assembly 100 is arranged to be located over and cover an air inlet of the air treatment apparatus 200. The air treatment apparatus 200 is therefore provided with a pair of these filter assemblies 100, one for each of the two air inlets that are provided on the opposing halves of the main body section 204. The semi-cylindrical shape of the above described filter assembly 100 provides that the filter assembly 100 can be located concentrically over the outer surface of the generally cylindrical main body section 204 so as to cover the corresponding air inlet.

In the illustrated embodiment, the air treatment apparatus 200 is also provided with a pair of additional filter assemblies 300. These additional filter assemblies 300 are configured to be located over and cover the filter assemblies 100 that in turn cover the air inlets provided on the opposing halves of the main body section 204. Each of these additional filter assemblies 300 therefore substantially has the shape of a semi-cylinder that can therefore be located concentrically over one of the filter assemblies 100 and the outer surface of the generally cylindrical main body section 204.

In this embodiment, each additional filter assembly 300 comprises a filter frame 301 that supports both an activated carbon filter media (not shown) and a particulate filter media 302. For example, the particulate filter media 302 could comprise a pleated polytetrafluoroethylene (PTFE) or glass microfiber nonwoven fabric, whilst the activated carbon filter media could comprise either a pleated carbon cloth or activated carbon granules retained between layers of air-permeable material. Each additional filter assembly 300 is arranged so that the activated carbon filter media is downstream of the particulate filter media 302 when the additional filter assembly 300 is mounted on the air treatment apparatus 200. Each additional filter assembly 300 then further comprises a flexible seal 303 provided around the entirety of an inner periphery of the filter frame 301 for engaging with the main body section 204 to prevent air from passing around the edges of the additional filter assembly 300 to the air inlet of the main body section 204.

A perforated shroud or protective casing 400 is then releasably attached concentrically to each additional filter assembly 300 so as to cover the each additional filter assembly 300. The perforated shrouds 400 each comprise an array of apertures which provide an air inlet 401

through the shroud 400. When mounted on filter frame 301 of one of the additional filter assemblies 300, the shroud 400 protects the filter media from damage, for example during transit, and also provide a visually appealing outer surface that cover the filter assemblies 100, 300 which is in keeping with the overall appearance of the air treatment apparatus 200. Accordingly, Figure 5b shows a perspective view of the air treatment apparatus 200, with a shroud 400, additional filter assembly 300, and filter assembly 100 separated from the near side of the main body section 204, and with a shroud 400, additional filter assembly 300, and filter assembly 100 mounted on the opposing, far side of the main body section 204. The filter assembly 100 can then be mounted onto the near side of the air treatment apparatus 200 by positioning the filter assembly 100 over the air inlet 203 and pushing towards the main body section 204. Outward flexing of the resilient filter frame 101 of the filter assembly 100 would then allow the tabs 118, 119 to engage recesses/through-holes (not shown) provided on the main body section 204.

It will be appreciated that individual items described above may be used on their own or in combination with other items shown in the drawings or described in the description and that items mentioned in the same passage as each other or the same drawing as each other need not be used in combination with each other. In addition, the expression "means" may be replaced by actuator or system or device as may be desirable. In addition, any reference to "comprising" or "consisting" is not intended to be limiting in any way whatsoever and the reader should interpret the description and claims accordingly.

Furthermore, although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims. For example, those skilled in the art will appreciate that the above-described invention might be equally applicable to other types of air treatment apparatus, and not just free standing fan assembly. By way of example, such an air treatment apparatus could be any of a freestanding fan assembly, a ceiling or wall mounted fan assembly and an in-vehicle fan assembly.

By way of further example, whilst the above described embodiments all relate to fan assemblies having a circular cylindrical fan body, various features described above would be equally applicable to embodiments in which the fan body has a shape other than cylindrical. For example, the fan body could have the shape of an elliptic cylinder, a cube or any other prism.

As a yet further example, in the above described embodiments both the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108 comprise fibres that are angled at

approximately 45 degrees relative to the edges of the mesh. However, in alternative embodiments, one or both of the first layer of air permeable mesh 107 and the second layer of air permeable mesh 108 could comprise fibres that are perpendicular and parallel with the edges of the mesh. Depending upon the thickness of the fibres used in the mesh, orientating the mesh so that the fibres are slanted relative to the edges of the mesh minimises the risk of tearing during cutting or when forming any indentations. In addition, orientating the mesh so that the fibres are slanted relative to the edges of the mesh also provides that any slight misalignment between the mesh and filter frame are less visually apparent. However, when tearing and misalignment are not considered to be issues, orientating the mesh so that the fibres are perpendicular and parallel with the edges of the mesh minimises wastage when individual sheets are cut from a larger sheet.

CLAIMS

1. A filter assembly for an air treatment apparatus, the filter assembly comprising:
 - a first layer of air permeable mesh;
 - 5 a second layer of air permeable mesh;
 - a filter frame that is arranged to be mounted to the air treatment apparatus and that is arranged to support both the first layer of air permeable mesh and the second layer of air permeable mesh, wherein the frame defines an array of openings that are distributed across an area bounded by an exterior portion of the filter frame;
 - 10 a plurality of separate sheets of solid foam filter media, each of the plurality of separate sheets of solid foam filter media being disposed within a corresponding opening in the filter frame and being at least partially compressed between the first layer of air permeable mesh and the second layer of air permeable mesh.
- 15 2. The filter assembly of claim 1, wherein each of the plurality of separate sheets of solid foam filter media has an at least partially compressed thickness.
3. The filter assembly of any one of claims 1 or 2, wherein at least a portion of each of the plurality of separate sheets of solid foam filter media is compressed such that a compressed
20 thickness of a compressed portion is less than an uncompressed thickness of an uncompressed portion.
4. The filter assembly of any one of claims 1 to 3, wherein an entirety of each of the plurality of separate sheets of solid foam filter material is compressed such that a compressed thickness
25 is less than an uncompressed thickness.
5. The filter assembly of any one of claims 1 to 4, wherein the filter assembly is arranged such that, when mounted to an air treatment apparatus, a first surface of each of the plurality of separate sheets of solid foam filter media is outward facing and a second surface of each of the
30 plurality of separate sheets of solid foam filter media is inward facing.
6. The filter assembly of any one of claims 1 to 5, wherein the plurality of separate sheets of solid foam filter media comprise a stochastic open-cell polymer foam material.
- 35 7. The filter assembly of any one of claims 1 to 6, wherein the plurality of separate sheets of solid foam filter media further comprise a plurality of catalytic particles that are dispersed

throughout the solid foam filter media, and preferably wherein the catalytic particles are dispersed within pores of the solid foam filter media.

8. The filter assembly of claim 7, wherein the catalytic particles comprise a thermal catalyst that is capable of oxidative decomposition of volatile organic compounds at ambient temperature.

9. The filter assembly of any one of claims 1 to 8, wherein the first layer of air permeable mesh is formed with an array of indentations or depressions, and each of the plurality of separate sheets of the solid foam filter media are disposed within a corresponding indentation of the first layer of air permeable mesh.

10. The filter assembly of any one of claims 1 to 9, and further comprising a border material disposed between the first layer of air permeable mesh and the second layer of air permeable mesh, the border material extending across an area between edges of each of the plurality of separate sheets of solid foam filter media and adjacent edges of the filter frame.

11. The filter assembly of claim 10, wherein the border material is provided with an array of openings, and wherein each of the plurality of separate sheets of the solid foam filter media are exposed within a corresponding opening in the border material.

12. The filter assembly of any one of claims 1 to 11, wherein the air permeable mesh of the first layer is the same as or different to the air permeable mesh of the second layer.

13. The filter assembly of any one of claims 1 to 12, wherein the filter frame encompasses edges of both the first layer of air permeable mesh and the second layer of air permeable mesh, and is preferably spaced apart from edges of each of the plurality of separate sheets of solid foam filter media.

14. The filter assembly of any one of claims 1 to 13, wherein the filter frame comprises an interior portion comprising a plurality of bars that divide the area bounded by the exterior portion into the array of openings.

15. An air treatment apparatus comprising a filter assembly according to any one of claims 1 to 14, and an air flow generator that is arranged to generate an air flow through the filter assembly.

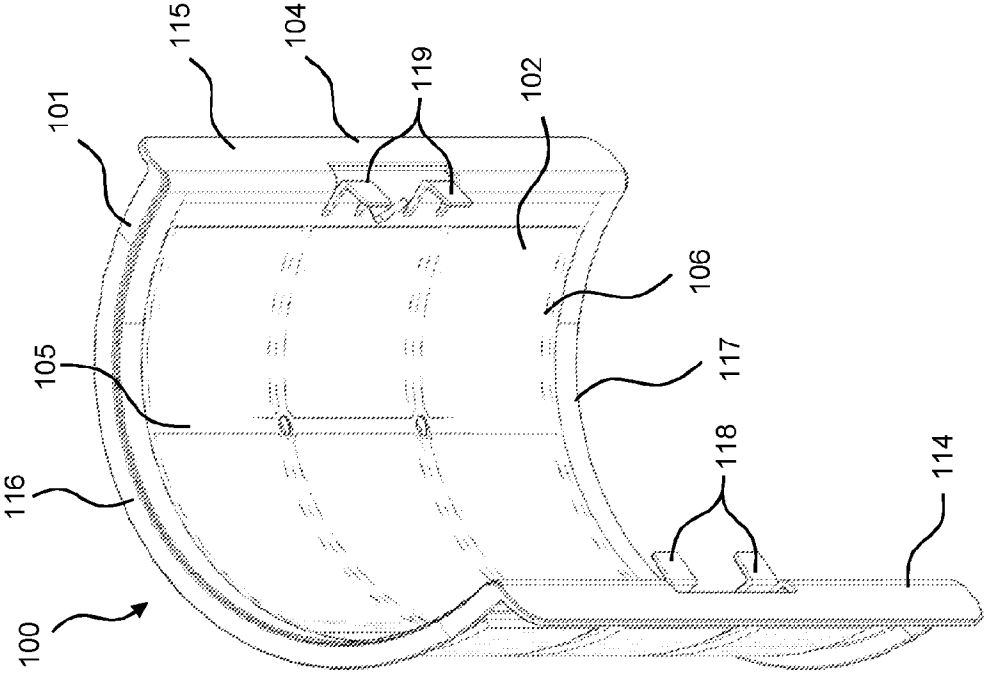


FIG. 1a

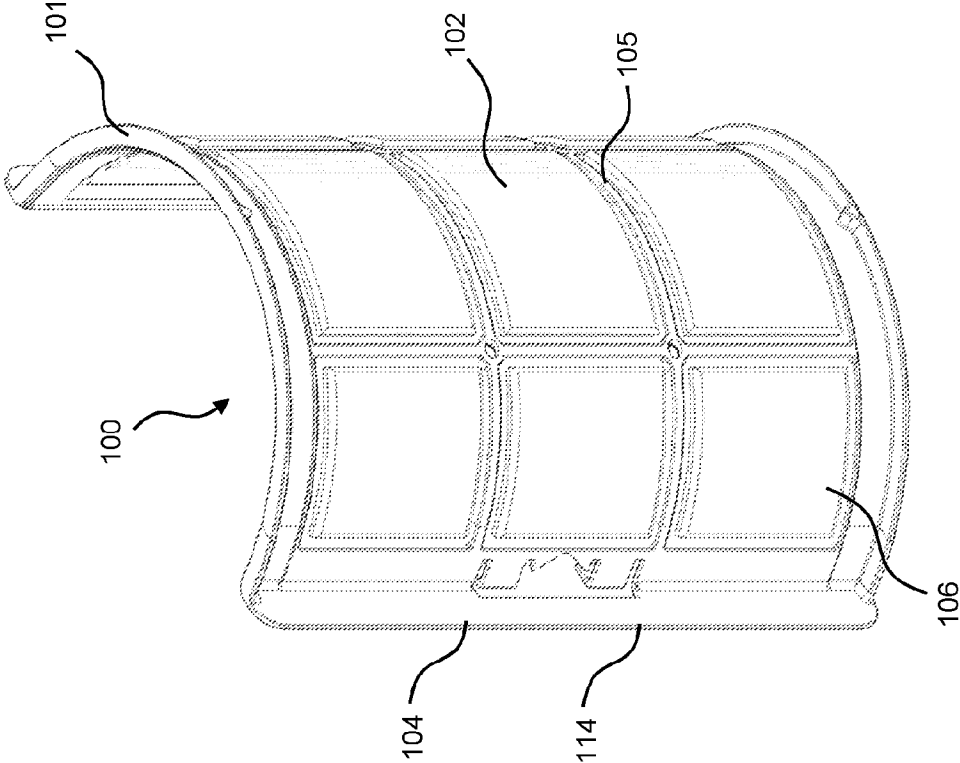


FIG. 1b

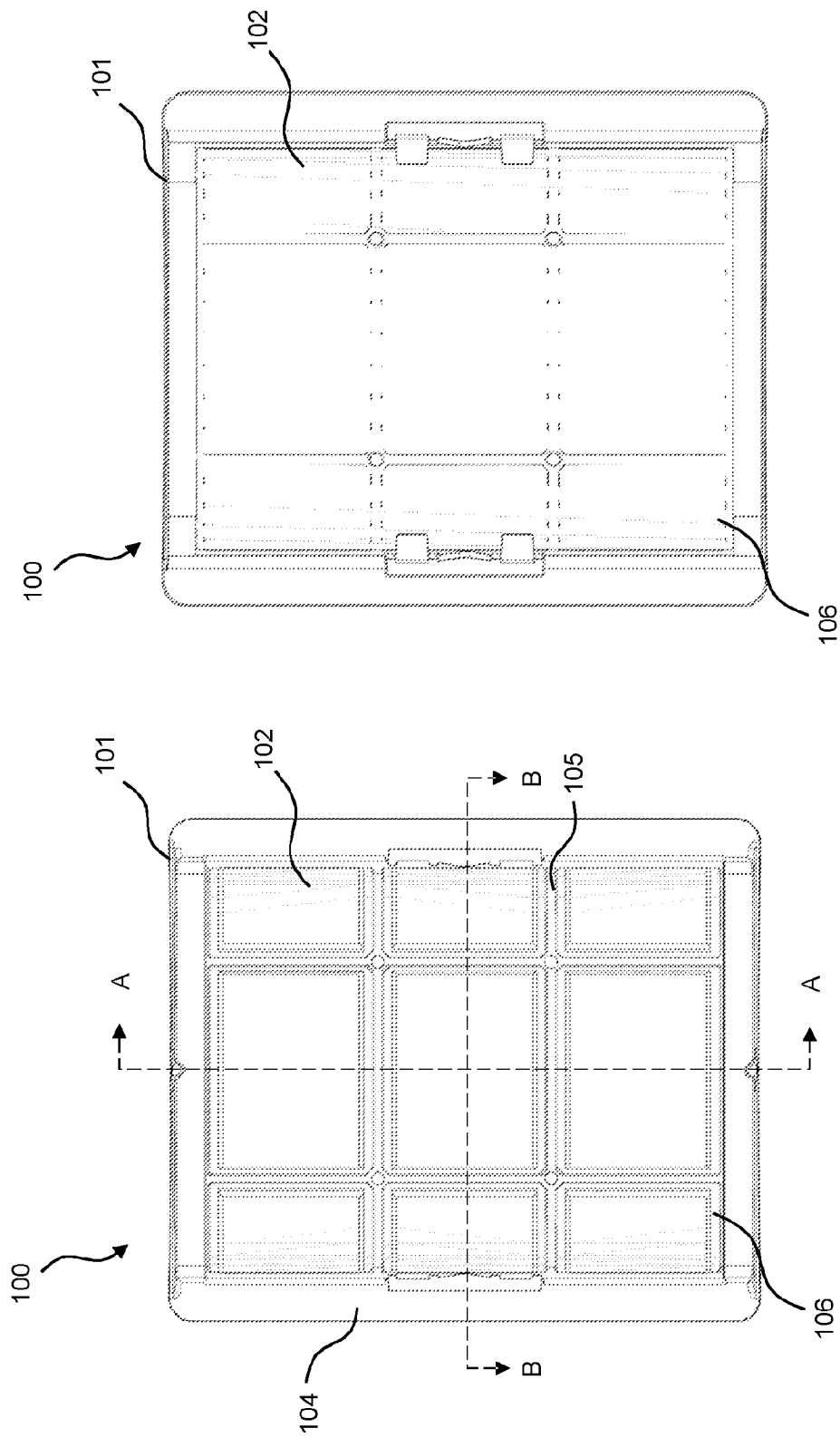


FIG. 1d

FIG. 1c

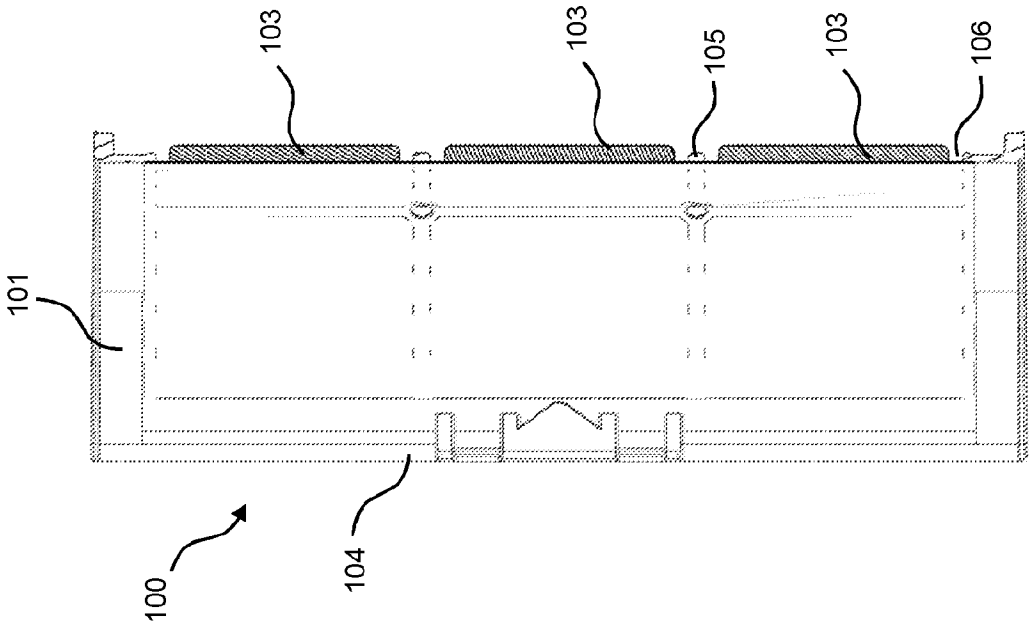


FIG. 2a

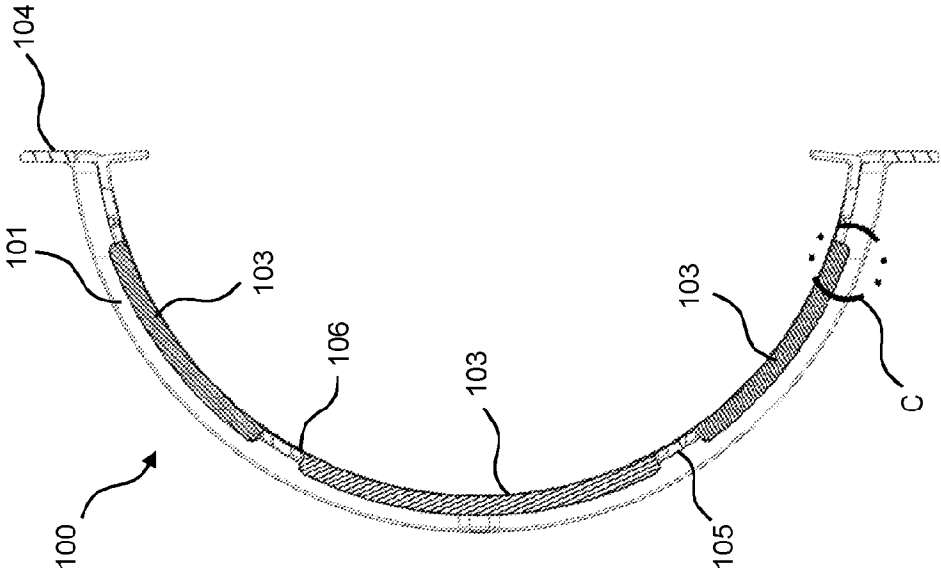


FIG. 2b

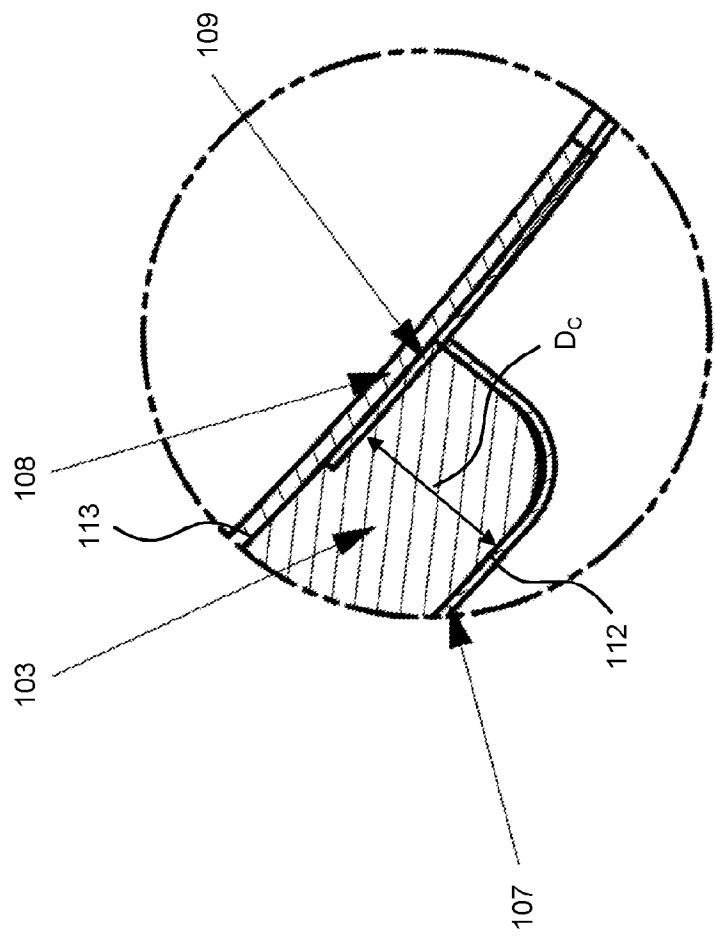


FIG. 3

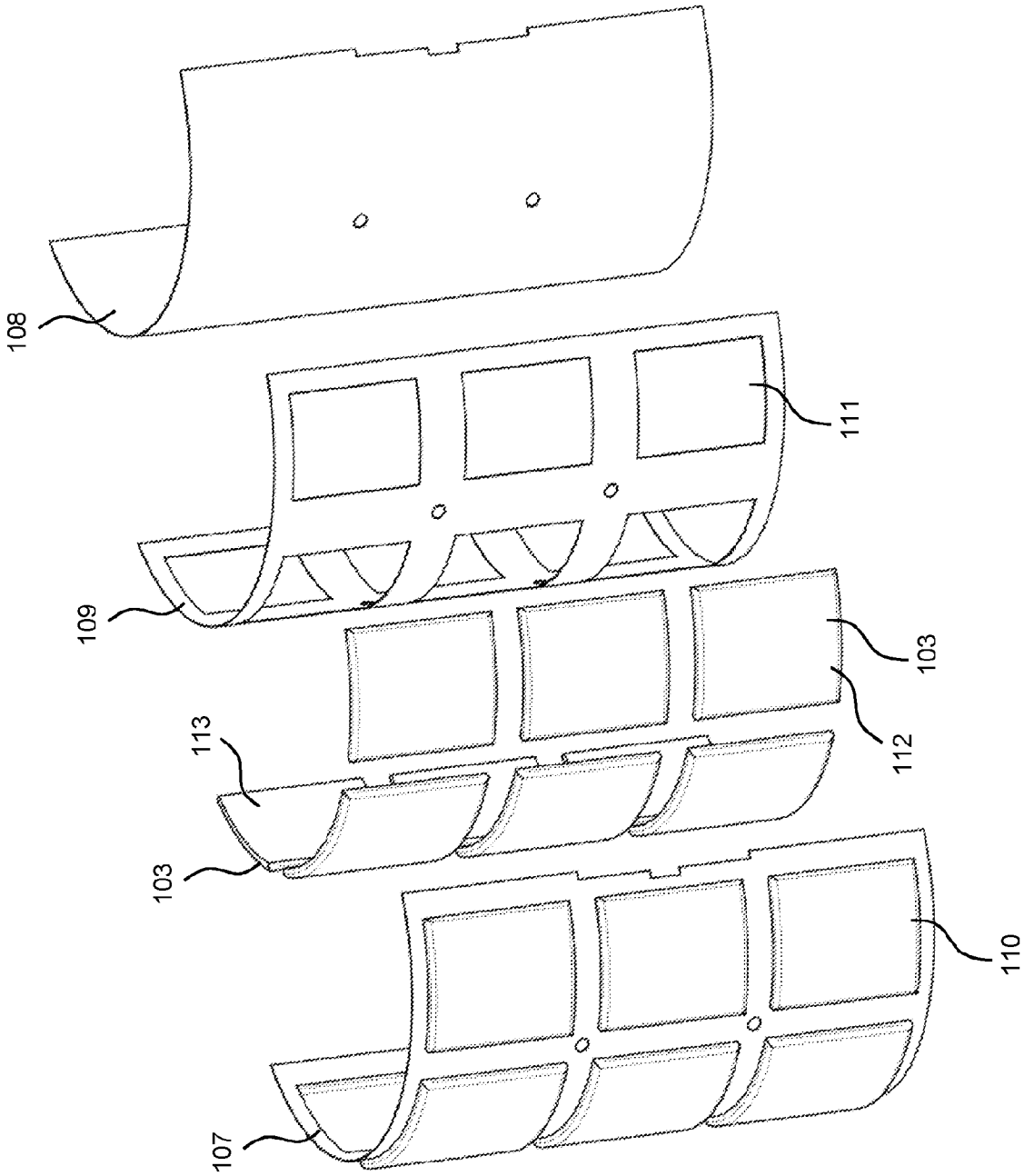
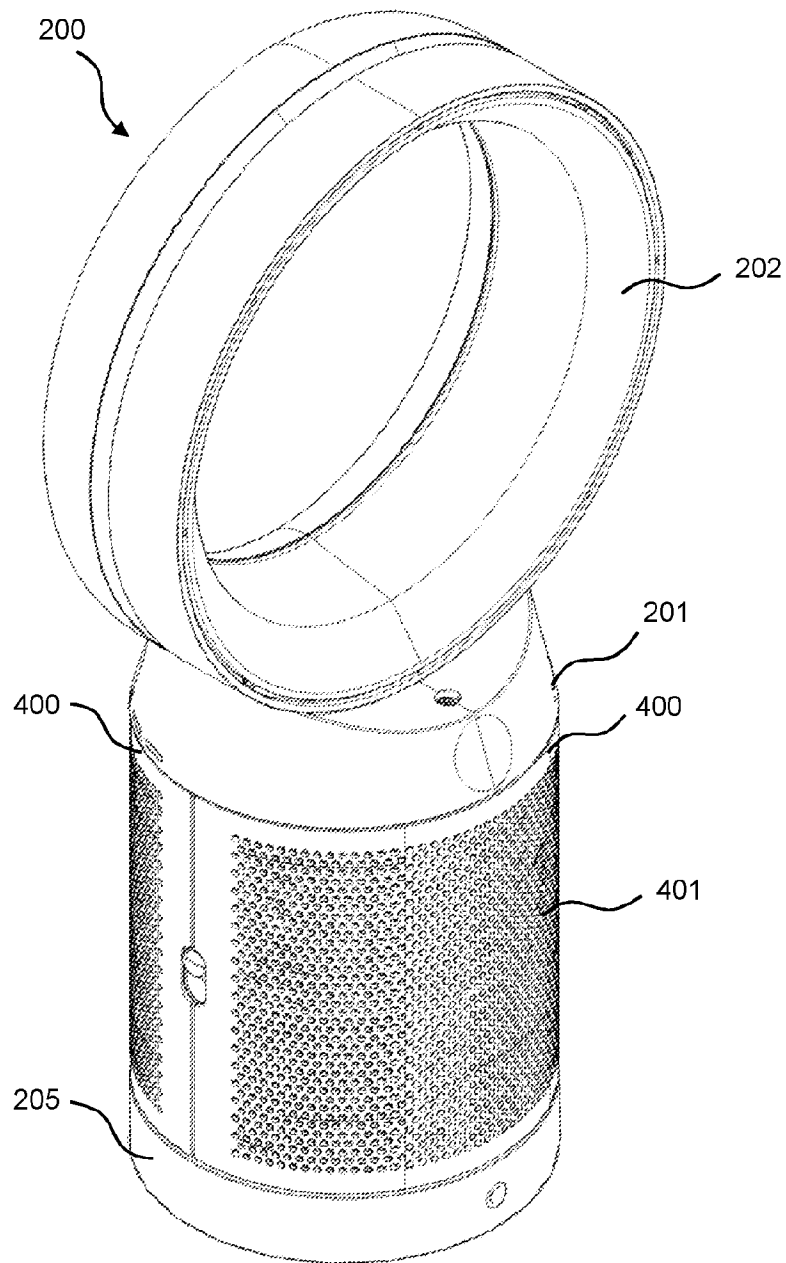


FIG. 4

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FIG. 5a

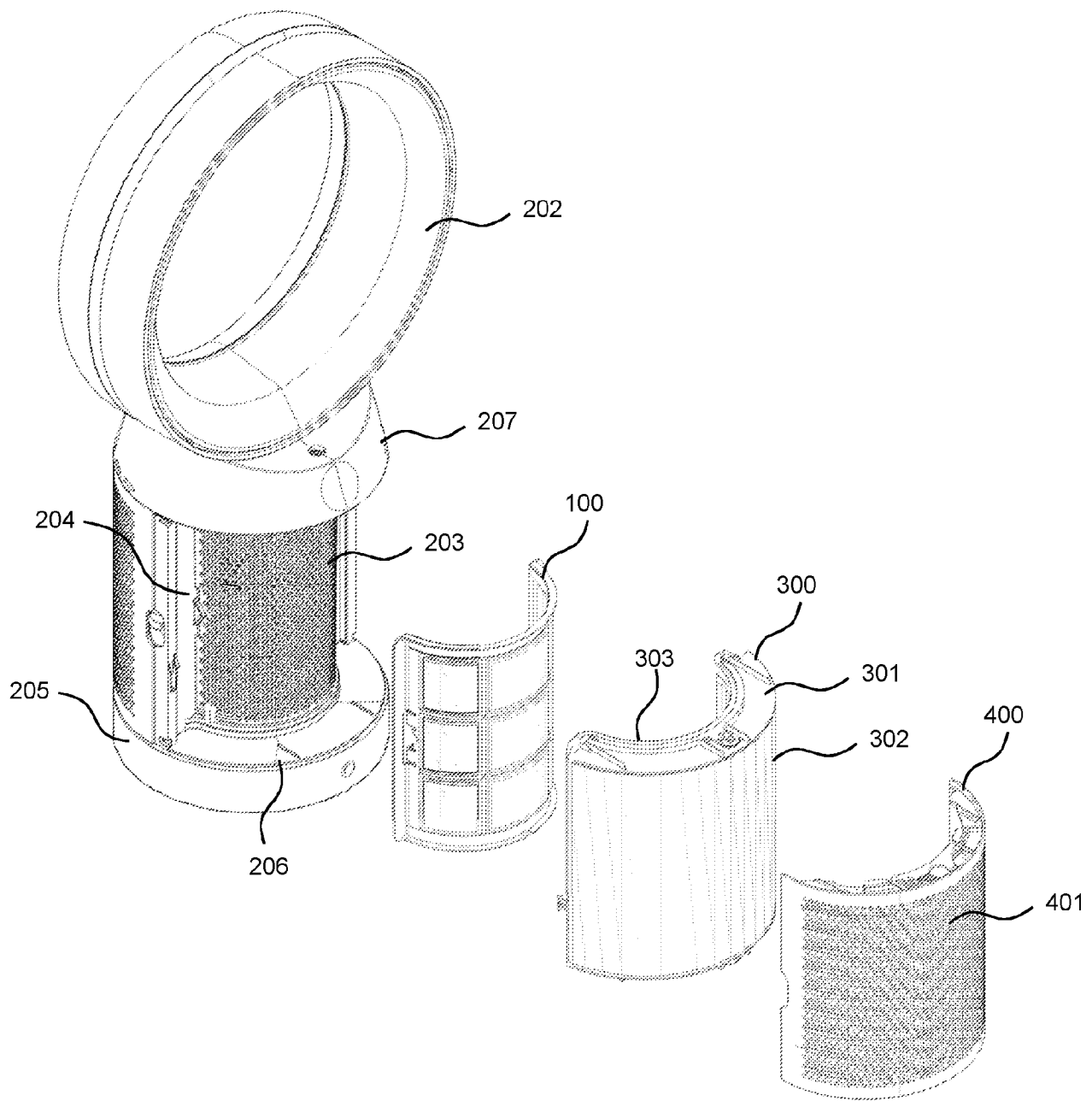


FIG.5b

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2020/050848

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01D46/10 F04D29/70
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01D F04D

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)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 2006/058370 A1 (PANACHE GLOBAL HOLDINGS PTY LT [AU]; RUBIN RICHARD [AU]) 8 June 2006 (2006-06-08)	1-5,9-15
Y	figures 1-11 page 17, line 33 - page 49, line 9 -----	6-8
X	US 2007/095037 A1 (MCLAMB SAMUEL B III [US]) 3 May 2007 (2007-05-03)	1-5,9-15
Y	figures 1-10 paragraphs [0019] - [0062] -----	6-8
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	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

2 June 2020

Date of mailing of the international search report

12/06/2020

Name and mailing address of the ISA/

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Authorized officer

Galiana López, Paula

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2020/050848

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 2016/128734 A1 (DYSON TECHNOLOGY LTD [GB]) 18 August 2016 (2016-08-18) cited in the application figures 1-14 page 15, line 20 - page 30, line 24 -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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