



(51) International Patent Classification:

B01D 46/00 (2006.01)

B01D 46/52 (2006.01)

B01D 46/10 (2006.01)

(21) International Application Number:

PCT/GB2019/053588

(22) International Filing Date:

17 December 2019 (17.12.2019)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1900946.3

23 January 2019 (23.01.2019)

GB

(71) Applicant: **DYSON TECHNOLOGY LIMITED**

[GB/GB]; Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB).

(72) Inventors: **BARTON, Michael**; c/o Dyson Technology

Limited, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB). **AGHABABAIE, Nikian**; c/o Dyson Technology Limited, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB).

(74) Agent: **CHAPMAN, Alan** et al.; Intellectual Property

Department, Dyson Technology Limited, Tetbury Hill, Malmesbury Wiltshire SN16 0RP (GB).

(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, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, 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).

(54) Title: ANNULAR PLEATED FILTER

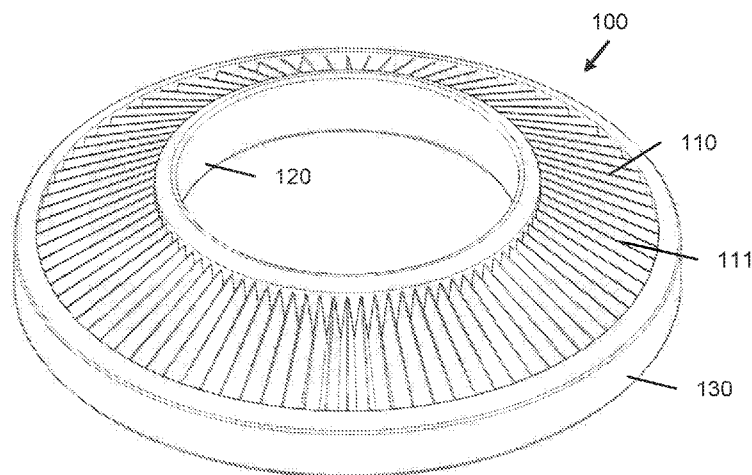


FIG. 2

(57) Abstract: There is provided a method of manufacturing a filter assembly. The method comprises obtaining a pleated filter media that is arranged into a closed shape such that a first corrugated edge of the pleated filter media defines an outer edge of the closed shape and a second corrugated edge of the pleated filter media defines an inner edge of the closed shape, spin moulding a first seamless seal of resilient material that encompasses the first corrugated edge of the pleated filter media. The method then further comprises everting the closed shape of pleated filter media, and spin moulding a second seamless seal of resilient material that encloses the second corrugated edge of the pleated filter media.

Published:

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

ANNULAR PLEATED FILTER

FIELD OF THE INVENTION

5 The present invention relates to a filter, in particular a filter assembly for an air purifier, and a method of manufacturing a filter assembly.

BACKGROUND OF THE INVENTION

10 Air pollution is an increasing problem and a variety of air pollutants have known or suspected harmful effects on human health. The adverse effects that can be caused by air pollution depend upon the pollutant type and concentration, and the length exposure to the polluted air. For example, high air pollution levels can cause immediate health problems such as aggravated cardiovascular and respiratory illness, whereas long-term exposure to polluted air can have permanent health effects such as loss of lung capacity and decreased lung function, and the
15 development of diseases such as asthma, bronchitis, emphysema, and possibly cancer.

As a consequence, the use of air purifiers is growing in an attempt to reduce exposure to airborne pollutants and thereby minimise the adverse effects. In particular, the increased recognition of the problem of air pollution has led to a rise in the use of domestic air purifiers
20 within homes etc. with the aim of combatting the effects of indoor air pollution. In addition, there is also an increasing interest in portable, and particularly wearable, air purifiers that can protect users from the effects of outdoor pollution and that can be easily travel with the user. However, to provide sufficient air filtration in a portable format it is essential to have filters that are compact and lightweight but that also maximise the available surface area for filtration.

25

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a method of manufacturing an improved filter assembly, and an improved filter assembly, that is compact, lightweight, maximises the available surface area for filtration and that also has robust/resilient edge seals
30 that can be used to prevent air from passing around the edges of the filter. The improved filter assembly is therefore particularly suitable for use in portable air purifiers.

According to a first aspect there is provided a method of manufacturing a filter assembly. The method comprises obtaining a pleated filter media that is arranged into a closed shape that has
35 an annular cross-section such that a first corrugated edge of the pleated filter media defines an outer edge of the closed shape and a second corrugated edge of the pleated filter media defines an inner edge of the closed shape, spin moulding a first seamless seal of resilient

material that is substantially parallel to a central axis of the closed shape and that encompasses/encloses the first corrugated edge of the pleated filter media. The method then further comprises everting the closed shape of pleated filter media, and spin moulding a second seamless seal of resilient material that is substantially parallel to the central axis of the closed shape and that encompasses/encloses the second corrugated edge of the pleated filter media. The inner edge of the closed shape has a greater diameter than the outer edge of the closed shape.

Folds of the pleated filter media may extend in an at least partially radial direction relative to a central axis of the closed shape. The first and second corrugated edges of the pleated filter media may be substantially parallel to a central axis of the pleated filter media. The pleated filter media may be arranged to be any of annular and frustoconical in shape. The pleated filter media may be arranged to be annular in shape such that folds of the pleated filter media extend in a radial direction relative to a central axis of the annular pleated filter media. Alternatively, the pleated filter media is arranged to be frustoconical in shape such that folds of the pleated filter media are slanted/sloped relative to a central axis of the frustoconical pleated filter media.

The step of spin moulding a first seamless seal of resilient material may comprise spinning the pleated filter media whilst a liquefied resilient material solidifies over the first corrugated edge of the pleated filter media. The step of spin moulding a first seamless seal of resilient material may further comprise spinning the pleated filter media whilst injecting the liquefied resilient material and continuing to spin the pleated filter media until the resilient material solidifies. The step of spin moulding a first seamless seal of resilient material may further comprise, prior to spinning, placing the pleated filter media within a mould that defines a space for the first seamless seal.

The step of spin moulding a second seamless seal of resilient material may comprise spinning the pleated filter media whilst a liquefied resilient material solidifies over the second corrugated edge of the pleated filter media. The step of spin moulding a second seamless seal of resilient material may further comprise spinning the pleated filter media whilst injecting the liquefied resilient material and continuing to spin the pleated filter media until the resilient material solidifies. The step of spin moulding a second seamless seal of resilient material may further comprise, prior to spinning, placing the pleated filter media within a mould that defines a space for the second seamless seal.

The step of obtaining a pleated filter media that is arranged into a closed shape that has an annular cross-section may comprise forming a sheet of the pleated filter media into a closed shape that has an annular cross-section. The step of forming a sheet of the pleated filter media

into a closed shape that has an annular cross-section may comprise forming a loop from the sheet of pleated filter media and bonding a first non-corrugated edge of the sheet of pleated filter media to a second non-corrugated edge of the sheet of pleated filter media

5 When the pleated filter media is arranged to be frustoconical in shape, the step of obtaining a pleated filter media that is arranged into a closed shape that has an annular cross-section may comprise forming a sheet of the pleated filter media into a frustocone. The step of forming a sheet of the pleated filter media into a frustocone may further comprises, prior to forming a loop from the sheet of pleated filter media, cutting/trimming a first corrugated edge of a sheet of
10 pleated filter media so that the first corrugated edge is slanted//sloped relative to the folds of the pleated filter media, and cutting/trimming a second corrugated edge of the sheet of pleated filter media so that the second corrugated edge is slanted/sloped relative to the folds of the pleated filter media. The second corrugated edge may be trimmed/cut so that it is substantially parallel to the first corrugated edge.

15 The method may further comprise, prior to spin moulding a first seamless seal of resilient material, everting the pleated filter media. The method may further comprise, prior to spin moulding the second seamless seal of resilient material, obtaining a non-pleated filter media that is arranged into a shape that substantially corresponds to that of the pleated filter media and disposing the non-pleated filter media adjacent to the underside of the pleated filter media.
20 The non-pleated filter media may be disposed with a first edge of the non-pleated filter media adjacent to the second corrugated edge of the pleated filter media and a second edge of the non-pleated filter media adjacent to the first seamless seal. The non-pleated filter media may be arranged into a closed shape that has an annular cross-section.

25 The second seamless seal may encompass/enclose both the second corrugated edge of the pleated filter media and the first edge of the non-pleated filter media. The method may further comprises, after spin moulding the second seamless seal of resilient material, bonding the second edge of the non-pleated filter media to the first seamless seal using an adhesive. The
30 step of bonding the second edge of the non-pleated filter media to the first seamless seal may comprise depositing a bead of adhesive that extends over the joint/junction between the second edge of the non-pleated filter media and the first seamless seal.

35 The step of obtaining a non-pleated filter media that is arranged into a closed shape that has an annular cross-section may comprise forming a sheet of the non-pleated filter media into a shape that substantially corresponds to that of the pleated filter media. The step of forming a sheet of the non-pleated filter media into a shape that substantially corresponds to that of the pleated

filter media may comprise forming a sheet of the non-pleated filter media into a closed shape that has an annular cross-section. The step of forming a sheet of the non-pleated filter media into a shape that substantially corresponds to that of the pleated filter media may comprise forming (e.g. cutting) an annulus from the sheet of pleated filter media. Alternatively, the step of forming a sheet of the non-pleated filter media into a closed shape that has an annular cross-section comprises forming (e.g. cutting) an arc from the sheet of pleated filter media and bonding a first end of the arc of the non-pleated filter media to a second end of the arc of the non-pleated filter media

- 10 There is also provided a filter assembly comprising a pleated filter media that is arranged to be frustoconical in shape, wherein folds of the pleated filter media are slanted/sloped relative to a central axis of the frustoconical pleated filter media and wherein both the first and second corrugated ends of the frustoconical pleated filter media are substantially parallel to a central axis of the frustoconical pleated filter media. A first seamless seal of resilient material then encompasses/encloses the first corrugated end of the frustoconical pleated filter media, and a second seamless seal of resilient material encompasses/encloses the second corrugated end of the frustoconical pleated filter media. The pleated filter media may be a particulate filter media, and is preferably a high efficiency particulate air (HEPA) particulate filter media.
- 20 There is also provided a method of manufacturing a filter assembly. The method comprises obtaining a frustocone of a pleated filter media, wherein folds of the pleated filter media are slanted/sloped relative to a central axis of the frustoconical pleated filter media and both the first and second corrugated ends of the frustoconical pleated filter media are substantially parallel to a central axis of the filter. The method then comprises spin moulding a first seamless seal of resilient material that encompasses/encloses the first corrugated end of the frustoconical pleated filter media, everting the frustoconical pleated filter media, and spin moulding a second seamless seal of resilient material that encompasses/encloses the second corrugated end of the frustoconical pleated filter media.
- 30 According to a second aspect there is provided a filter assembly comprising a pleated filter media that is arranged into a closed shape that has an annular cross-section such that a first corrugated edge of the pleated filter media defines an outer edge of the closed shape and a second corrugated edge of the pleated filter media defines an inner edge of the closed shape. A first seamless seal of resilient material then encompasses/encloses the first corrugated edge of the pleated filter media, wherein the first seamless seal is substantially parallel to a central axis of the closed shape, and a second seamless seal of resilient material that encompasses/encloses the second corrugated edge of the pleated filter media, wherein the

second seamless seal is substantially parallel to the central axis of the closed shape. The outer edge of the closed shape has a greater diameter than the inner edge of the closed shape.

5 The pleated filter media may be a particulate filter media, and is preferably a high efficiency particulate air (HEPA) particulate filter media.

10 Folds of the pleated filter media may extend in an at least partially radial direction relative to a central axis of the closed shape. The first and second corrugated edges of the pleated filter media may be substantially parallel to a central axis of the pleated filter media. The pleated filter media may be arranged to be any of annular and frustoconical in shape. The pleated filter media may be arranged to be annular in shape such that folds of the pleated filter media extend in a radial direction relative to a central axis of the annular pleated filter media. Alternatively, the pleated filter media may be arranged to be frustoconical in shape such that folds of the pleated filter media are slanted/sloped relative to a central axis of the frustoconical pleated filter media.

15 The entirety of the first corrugated end of the pleated filter media may be disposed within the first seamless seal. The entirety of the second corrugated end of the frustoconical pleated filter media may be disposed within the second seamless seal.

20 Both the first seamless seal and the second seamless seal may comprise a continuous/uninterrupted loop/ring of resilient material. The first seamless seal may have first and second axially facing surfaces that are exposed/accessible and that face in opposite axial directions. These axially facing surfaces can then be contacted and pressed upon in order to compress the first seamless seal in a direction that is substantially parallel to the central axis of the pleated filter media. These axially facing surfaces may therefore extend radially relative to the central axis. The first seamless seal may also have a radially outward facing surface that is exposed/accessible and that extends axially. The second seamless seal may have first and second axially facing surfaces that are exposed/accessible and that face in opposite axial directions. These axially facing surfaces can then be contacted and pressed upon in order to compress the second seamless seal in a direction that is substantially parallel to the central axis of the pleated filter media. These axially facing surfaces may therefore extend radially relative to the central axis. The second seamless seal may also have a radially outward facing surface that is exposed/accessible and that extends axially.

35 The filter assembly may further comprise a non-pleated filter media that is arranged into a closed shape that has an annular cross-section such that a first edge of the non-pleated filter media defines an outer edge of the closed shape and a second edge of the non-pleated filter

media defines an inner edge of the closed shape. The non-pleated filter media may be disposed on/adjacent to an under/back side of the pleated filter media. The non-pleated filter media may be a chemical filter media, such as an activated carbon paper.

- 5 The first edge of the non-pleated filter media may be disposed within the second seamless seal. The second edge of the non-pleated filter media may be attached/bonded to the first seamless seal by an adhesive. The second edge of the non-pleated filter media may be attached/bonded to the first seamless seal by a bead of adhesive extends over the entirety joint/junction between the second edge of the non-pleated filter media and the first seamless seal. The bead of
10 adhesive may comprise a loop/ring of adhesive. The second edge of the non-pleated filter media may be covered by the first seamless seal. The first seamless seal may therefore extend over/beyond the second edge of the non-pleated filter media.

- The non-pleated filter media may be arranged to be any of annular and frustoconical in shape.
15 The non-pleated filter media may be arranged to be annular in shape such that surfaces of the non-pleated filter media extend in a radial direction relative to a central axis of the annular non-pleated filter media. The non-pleated filter media may be arranged to be frustoconical in shape such that surfaces of the non-pleated filter media are slanted/sloped relative to a central axis of the frustoconical non-pleated filter media.

- 20 The first seamless seal and the second seamless seal may comprise a resilient material selected from any of an elastomeric and a rubber material. The first seamless seal and the second seamless seal may comprise an elastomer, such as natural rubber synthetic rubber, polyurethane, silicone rubber, ethylene-vinyl acetate (EVA), polyolefins (PO) etc.

25

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:

- 5 Figure 1 is a top view of an embodiment of a filter assembly as described herein;
- Figure 2 is a perspective view of the filter assembly of Figure 1;
- Figure 3 is a sectional view through the filter assembly of Figure 1;
- Figure 4 is a perspective view of a sheet of a pleated filter media;
- Figure 5 is a flow diagram illustrating a method of manufacturing a filter assembly;
- 10 Figure 6 is a sectional view through an exemplary embodiment of a mould;
- Figure 7 is a sectional view through an exemplary embodiment of a further mould;
- Figure 8 is a flow diagram illustrating a method of forming a frustocone of a pleated filter media;
- Figure 9 is a side view of a further embodiment of a filter assembly,
- Figure 10 is sectional view through the filter assembly of Figure 9,
- 15 Figure 11 is a flow diagram illustrating another method of manufacturing a filter assembly, and
- Figure 12 is a flow diagram illustrating a method of forming a frustocone of a non-pleated filter media.

DETAILED DESCRIPTION OF THE INVENTION

- 20 There will now be described a filter assembly that is suitable for use in domestic air purifiers, and particularly portable and wearable air purifiers. The term “air purifier” as used herein refers to a device or system capable of removing contaminants from air and emitting a supply of purified or filtered air. The term “portable” is used herein to define an item as being able to be carried or moved during use. Such portable items are therefore powered by a portable power
- 25 source such as a battery, photovoltaic cell etc. In particular, there is provided an improved filter assembly that is compact, maximises the available surface area for filtration and that also has robust/resilient edge seals that can be used to prevent air from passing around the edges of the filter.
- 30 The filter assembly comprises a pleated filter media that is arranged into a closed shape that has an annular cross-section such that a first corrugated edge of the pleated filter media defines an outer edge of the closed shape and a second corrugated edge of the pleated filter media defines an inner edge of the closed shape. The outer edge of the closed shape therefore has a greater diameter than the inner edge of the closed shape, and the folds of the pleated filter
- 35 media extend in an at least partially radial direction relative to a central axis of the closed shape. A first seamless seal of resilient material encompasses/encloses the first corrugated edge of the pleated filter media, wherein the first seamless seal is substantially parallel to a central axis of

the closed shape, and a second seamless seal of resilient material encompasses/encloses the second corrugated edge of the pleated filter media, wherein the second seamless seal is also substantially parallel to the central axis of the closed shape. Both the first seamless seal and the second seamless seal comprise a continuous/uninterrupted loop or ring of resilient material.

For example, the pleated filter media may be arranged to be any of annular and frustoconical in shape. In an embodiment in which the pleated filter media is arranged to be annular in shape, the folds of the pleated filter media will extend in a radial direction relative to a central axis of the annular pleated filter media. In an embodiment in which the pleated filter media is arranged to be frustoconical in shape, the folds of the pleated filter media will be slanted/sloped relative to a central axis of the frustoconical pleated filter media.

Figure 1 is a top view of an embodiment of a filter assembly 100 as described herein. Figure 2 then shows a perspective view of the filter assembly 100 of Figure 1, whilst Figure 3 shows a cross-section through the filter assembly 100 of Figure 1. In the illustrated embodiment, the filter assembly 100 comprises a pleated filter media 110 that is arranged to be generally frustoconical in shape, wherein folds 111, 112 of the pleated filter media 110 are slanted/sloped relative to a central axis (X) of the frustacone and both first and second corrugated edges 113, 114 of the pleated filter media are substantially parallel to a central axis of the frustacone. A first seamless seal 120 of resilient material then encompasses/encloses the first corrugated edge 113 of the frustoconical pleated filter media and a second seamless seal of resilient material 130 encompasses/encloses the second corrugated edge 114 of the frustoconical pleated filter media 110. In the illustrated embodiment, the folds 111, 112 of the pleated filter media 110 are slanted/sloped at an acute angle (θ) relative to the central axis of the frustacone.

The term “frustoconical” as used herein refers to an object having the shape of a frustacone. The term “frustacone” as used herein refers to the portion of a cone that remains when a region including its apex is cut off by a truncation plane that is parallel to the base of the cone. The term “frustacone” is synonymous with the terms “conical frustum” and is typically used to refer to a right circular conical frustum that has a circular base end and a circular top end, the diameter of the circular base end being greater than that of the circular top end, and a truncated conical surface extending between the base end and the top end. A frustacone can therefore be considered to have an open large diameter base end and an open small diameter top end.

Figure 4 shows a perspective view of a pleated filter media 110. As shown in Figure 4, a pleated filter media 110 typically comprises a sheet of filter media that has multiple folds 111, 112 that form a series of parallel ridges and valleys such that the filter media becomes corrugated, with

5 folds in a first direction 111 forming the ridges and folds in a second, opposite direction 112 forming grooves. A typical sheet of pleated filter media 110 is therefore generally rectangular in shape, with two corrugated edges (i.e. formed by the ends of pleats/folds) 113, 114 and two non-corrugated (i.e. straight) edges 115, 116. In the filter assembly described herein, and as illustrated in Figures 1 to 3, the pleated filter media 110 is arranged such that the first direction folds 111 of the pleated filter media 110 define a frustaconical outer surface and the second direction folds 112 (i.e. that are folded in an opposite direction to the first direction folds 111) define a frustaconical inner surface, with these first and second direction folds 111, 112 extending in a generally radial direction relative to the central axis (X) of the frustacone. Both a first corrugated edge 113 and a second corrugated edge 114 of the pleated filter media 110 can therefore be considered to extend between the frustaconical outer surface and the frustaconical inner surface, with the first corrugated edge 113 of the pleated filter media 110 defining the top end of the frustacone and the second corrugated edge 114 of the pleated filter media 110 defining the base end of the frustacone.

15 In the embodiment illustrated in Figures 1 to 3, the first corrugated edge 113 and the second corrugated edge 114 of the pleated filter media 110 are substantially parallel to the central axis (X) of the frustacone. The first corrugated edge 113 that defines the top end of the frustacone therefore generally faces radially inward relative to the central axis (X) of the frustacone, whilst the second corrugated edge 114 that defines the base end of the frustacone generally faces radially outward relative to the central axis (X) of the frustacone.

20 In Figures 1 to 3, the entirety of the first corrugated edge 113 is disposed within the first seamless seal 120, such that the first corrugated edge 113 is surrounded by/embedded within the first seamless seal 120, and the entirety of the second corrugated edge 114 is disposed within the second seamless seal 130, such that the second corrugated edge 114 is surrounded by/embedded within the second seamless seal 130. The term “seamless” is used herein to define an item as being without seams or joins. Consequently, both the first seamless seal 120 and the second seamless seal 130 comprise a continuous/uninterrupted loop/ring of resilient material.

30 The first seamless seal 120 therefore has first and second end surfaces 121, 122 that face in opposite, generally axial directions, and that extend in a generally radial direction relative to the central axis (X), and a radially inward facing side surface 123 that extends axially. The second seamless seal then also has first and second end surfaces 131, 132 that face in opposite, generally axial directions, and that extend radially relative to the central axis (X), and a radially inward facing side surface 133 that extends axially. The end surfaces of the first seamless seal

and the second seamless seal 120, 130 therefore provide surfaces that can be contacted and pressed upon in use in order to compress these edge seals 120,130 in the axial direction in order to prevent air from bypassing the filter assembly 100. In the embodiment illustrated in Figures 1 to 3, the first and second seamless seals 120, 130 are generally circular in shape extending around the circumference of the open top and base ends of the frustoconical pleated filter media 110 respectively. Consequently, the end and side surfaces of both the first and second seamless seals 120, 130 are also generally circular in shape.

In the filter assembly described herein the first seamless seal 120 and the second seamless seal 130 each comprise a resilient material so that the filter assembly 100 can be sealed without the need for a filter frame or for any end caps. For example, the first seamless seal 120 and the second seamless seal 130 can each comprise a resilient material such as an elastomeric or rubber material. In particular, the first seamless seal 120 and the second seamless seal 130 can each comprise an elastomer, such as natural rubber synthetic rubber, polyurethane, silicone rubber, ethylene-vinyl acetate (EVA), polyolefins (PO) etc.

Figure 5 is flow diagram illustrating a method of manufacturing a filter assembly such as that illustrated in Figures 1 to 3. This method involves obtaining a frustocone of a pleated filter media (S1.1), wherein folds of the pleated filter media are slanted/sloped relative to a central axis (X) of the frustoconical pleated filter media and both the first and second corrugated edges of the pleated filter media are substantially parallel to the central axis of the frustoconical pleated filter media, spin moulding a first seamless seal of resilient material that encompasses/encloses the first corrugated edge of the frustoconical pleated filter media (S1.2), everting (i.e. turning inside out) the frustoconical pleated filter media (S1.3), and spin moulding a second seamless seal of resilient material that encompasses/encloses the second corrugated edge of the frustoconical pleated filter media (S1.4).

The step of everting the frustoconical pleated filter media (S1.3) involves transposing the first corrugated edge and the second corrugated edge. In particular, the step of spin moulding the first seamless seal (S1.2) is performed with the frustoconical pleated filter media arranged such that the first corrugated edge defines the base end of the frustoconical pleated filter media and the second corrugated edge defines the top end of the frustoconical pleated filter media. The step of everting the frustoconical pleated filter media (S1.3) therefore involves rearranging the frustoconical pleated filter media so that the first corrugated edge defines the top end of the frustoconical pleated filter media and the second corrugated edge defines the base end of the frustoconical pleated filter media.

The step of spin moulding the first seamless seal of resilient material (S1.2) involves spinning the frustoconical pleated filter media around the central axis whilst a liquefied resilient material solidifies over the first corrugated end of the frustoconical pleated filter media. The spin moulding uses centrifugal force to push the liquefied resilient material to the outer edge of the frustoconical pleated filter media in order to form a seal that encompasses/encloses the outer edge that is substantially parallel to the central axis of the frustoconical pleated filter media. In a preferred embodiment, the step of spin moulding the first seamless seal (S1.2) comprises spinning the frustoconical pleated filter media whilst injecting the liquefied resilient material and continuing to spin the frustoconical pleated filter media until the resilient material solidifies.

This spin moulding of the first seamless seal makes use of a mould that defines a space for the first seamless seal. Specifically, the mould defines a space around the first corrugated edge of the frustoconical pleated filter media so that the spinning of the frustoconical pleated filter media causes the liquefied resilient material to move into and occupy this space. The resilient material then solidifies within this space so that the first corrugated edge is embedded within the first seamless seal. The filter assembly can then be removed from the mould before being everted.

Figure 6 illustrates a side section through an exemplary embodiment of a mould 200 suitable for use when spin moulding the first seamless seal 120. In the illustrated embodiment, the mould 200 comprises one or more outer sections 201, 202, 203 that surround at least the base end of the frustoconical pleated filter media 110 and that define a space 204 for the first seamless seal 120, and an inner section 205 that supports the frustoconical pleated filter media 110 and assists in maintaining the frustoconical shape during the spin moulding. In particular, it is preferable that the inner section 205 provides a generally frustoconical seat upon which the underside of the frustoconical pleated filter media 110 (i.e. the frustaconical inner surface) is supported. It is then also preferable that the mould 200, and in particular the inner section 205 of the mould 200, is provided with a central aperture 206 through which the liquefied resilient material can be injected during spinning. In addition, it is also preferable that the inner section 205 of the mould 200 defines a slot 207 through which the liquefied resilient material can pass during spinning in order to reach the space 204 defined for the first seamless seal 120.

The step of spin moulding the second seamless seal of resilient material (S1.4) then involves spinning the frustoconical pleated filter media around the central axis whilst a liquefied resilient material solidifies over the second corrugated end of the frustoconical pleated filter media. In a preferred embodiment, the step of spin moulding the second seamless seal (S1.4) comprises spinning the frustoconical pleated filter media whilst injecting the liquefied resilient material and continuing to spin the frustoconical pleated filter media until the resilient material solidifies.

This spin moulding of the second seamless seal makes use of a mould that defines a space for the second seamless seal. Specifically, the mould defines a space around the second corrugated edge of the frustoconical pleated filter media so that the spinning of the frustoconical pleated filter media causes the liquefied resilient material to move into and occupy this space. The resilient material then solidifies within this space so that the second corrugated edge is embedded within the second seamless seal. The filter assembly can then be removed from the mould.

The mould used when spin moulding the second seamless seal 130 can be the same as the mould used when spin moulding the first seamless seal 120. However, it is preferable that the mould used when spin moulding the second seamless seal 130 is different to the mould used when spin moulding the first seamless seal 120. In particular, the shape of the frustoconical pleated filter media 110 after the step of everting the frustoconical pleated filter media 110 (S1.3) does differ from the shape of the frustoconical pleated filter media 110 prior to the step of everting the frustoconical pleated filter media 110 (S1.3), and it is preferable that the mould used during spinning substantially conforms to the current shape of the frustoconical pleated filter media 110.

Figure 7 therefore illustrates a side section through an exemplary embodiment of a mould 300 suitable for use when spin moulding the second seamless seal 130. In the illustrated embodiment, the mould 300 comprises one or more outer sections 301, 302 that surround at least the base end of the frustoconical pleated filter media 110 and that define a space 303 for the second seamless seal 130, and an inner section 304 that supports the frustoconical pleated filter media 110 and assists in maintaining the frustoconical shape during the spin moulding. In particular, it is preferable that the inner section 304 provides a generally frustoconical seat upon which the underside of the frustoconical pleated filter media 110 (i.e. the frustoconical inner surface) is supported. It is then also preferable that the mould 300, and in particular the inner section 304 of the mould 300, is provided with a central aperture 305 through which the liquefied resilient material can be injected during spinning. In addition, it is also preferable that the inner section 305 of the mould 300 defines a slot 306 through which the liquefied resilient material can pass during spinning in order to reach the space 303 defined for the second seamless seal 130.

Optionally, the step of obtaining a frustocone of a pleated filter media may comprise forming a frustocone of a pleated filter media. Figure 8 therefore shows a flow diagram illustrating a method of forming a frustocone of a pleated filter media. This method involves cutting/trimming

a first corrugated edge of a sheet of pleated filter media so that the first corrugated edge is slanted/sloped relative to the folds of the pleated filter media (S2.1), cutting/trimming a second corrugated edge of the sheet of pleated filter media so that the second corrugated edge is slanted/sloped relative to the folds of the pleated filter media (S2.2), forming a loop from the trimmed sheet of pleated filter media (S2.3) and bonding a first non-corrugated edge of the sheet pleated filter media to a second non-corrugated edge of the sheet pleated filter media to form a frustacone (S2.4). When forming the frustacone of pleated filter media it is preferable that, after being trimmed, the first corrugated edge and the second corrugated edge are substantially parallel to one another.

When forming the frustacone of pleated filter media it is typically most straightforward to form the frustacone so that it has the desired final geometry required for the filter assembly. Specifically, it is preferable that the steps of forming a loop from the trimmed sheet of pleated filter media and bonding the first non-corrugated edge to the second non-corrugated edge result in a frustacone of pleated filter media in which first corrugated edge defines the top end of the frustacone and the second corrugated edge defines the base end of the frustacone. Doing so helps to ensure that these steps result in a frustacone of pleated filter media in which the first and second corrugated edges of the pleated filter media are substantially parallel to a central axis of the frustacone. It will then be necessary to evert the frustoconical pleated filter media as formed, prior to spin moulding the first seamless seal, so that the first corrugated edge then defines the base end of the frustoconical pleated filter media.

In the embodiment illustrated in Figures 1, 2 and 3, the filter assembly 100 comprises a single filter media in the form of a pleated filter media 110. In a preferred embodiment, this pleated filter media 110 is a particulate filter media, and preferably comprises a high-efficiency particulate air (HEPA) filter media. Figures 9 and 10 then illustrate a further embodiment in which the filter assembly 100 comprises two separate filter media. Figure 9 is a side view of this further embodiment of a filter assembly, and Figure 10 then shows a cross-section through the filter assembly of Figure 9. In this further embodiment, the filter assembly 100 again comprises a pleated filter media 110 that is arranged to be generally frustoconical in shape, with a first seamless seal of resilient material 120 that encompasses/encloses the first corrugated edge 113 of the frustoconical pleated filter media 110 and a second seamless seal of resilient material 130 encompasses/encloses the second corrugated edge 114 of the frustoconical pleated filter media 110. In the embodiment illustrated in Figures 9 and 10 the filter assembly 100 then further comprises a non-pleated filter media 140 that is arranged to be frustoconical in shape and that is disposed adjacent to the underside of the frustoconical pleated filter media 110 (i.e. the frustaconical inner surface defined by the second direction folds 112). In particular,

the frustoconical non-pleated filter media 140 is disposed concentrically beneath the underside of the frustoconical pleated filter media 110. One of the edges 141, 142 of the frustoconical non-pleated filter media 140 is then at least partially disposed within one of the first seamless seal 120 and the second seamless seal 130.

5

In the embodiment illustrated in Figures 9 and 10, a first edge 141 (i.e. the outer, base end) of the frustoconical non-pleated filter media 140 is disposed within the second seamless seal 130 (i.e. that encompasses/encloses the second corrugated edge 113 of the frustoconical pleated filter media 110). A second edge 142 (i.e. the inner, top end) of the frustoconical non-pleated filter media 140 is then attached/bonded to the first seamless seal 120 by an adhesive (not shown). In a preferred embodiment, the second edge 142 of the frustoconical non-pleated filter media 140 is attached/bonded to the first seamless seal 120 by a bead of adhesive extends over the entirety joint/junction between the second edge 142 of the frustoconical non-pleated filter media 140 and the first seamless seal 120. In the embodiment illustrated in Figures 7 and 8, the first and second seamless seals 120, 130 are generally circular in shape extending around the circumference of the open top and base ends of the frustoconical pleated filter media 110 respectively. The bead of adhesive that attaches the second edge 142 of the frustoconical non-pleated filter media 140 to the first seamless seal 120 therefore preferably comprises a loop/circle/ring of adhesive.

20 In the embodiment illustrated in Figures 9 and 10, the pleated filter media 110 preferably comprise a particulate filter media, whilst the non-pleated filter media preferably comprises a chemical filter media, such as an activated carbon paper.

Figure 11 is flow diagram illustrating a method of manufacturing a filter assembly such as that illustrated in Figures 9 and 10. This method involves obtaining a frustocone of a pleated filter media (S3.1), wherein folds of the pleated filter media are slanted/sloped relative to a central axis (X) of the frustoconical pleated filter media and both the first and second corrugated edges of the pleated filter media are substantially parallel to the central axis of the frustoconical pleated filter media, and spin moulding a first seamless seal of resilient material that encompasses/encloses the first corrugated edge of the frustoconical pleated filter media (S3.2), everting (i.e. turning inside out) the frustoconical pleated filter media (S3.3). Prior to spin moulding the second seamless seal of resilient material, this method then also involves obtaining a frustocone of a non-pleated filter media (S3.4), and disposing the frustoconical non-pleated filter media adjacent to the underside of the frustoconical pleated filter media (S3.5). The method then involves spin moulding a second seamless seal of resilient material that encompasses/encloses both the second corrugated edge of the frustoconical pleated filter media and a first edge of the non-pleated filter media (S3.6)

It is preferable that the frustoconical non-pleated filter media is disposed adjacent to the underside of the frustoconical pleated filter media such that the first edge 141 (i.e. the outer, base end) of the frustoconical non-pleated filter media 140 is disposed adjacent to the second corrugated edge 113 of the frustoconical pleated filter media 110. This ensures that the first edge 141 of the frustoconical non-pleated filter media 140 is encompassed within the second seamless seal 130 during the subsequent spin moulding step.

It is also preferable that a second edge 142 of the frustoconical non-pleated filter media 140 is disposed adjacent to the first seamless seal 120. The method may then further involve a step of bonding the second edge 142 of the frustoconical non-pleated filter media 140 to the first seamless 120 seal using an adhesive (i.e. a loop/circle/ring of adhesive). The step of bonding the second edge 142 of the frustoconical non-pleated filter media 140 to the first seamless 120 preferably comprises depositing a bead of adhesive that extends over the over the entirety joint/junction between the second edge 142 of the frustoconical non-pleated filter media 140 and the first seamless seal 120.

Optionally, the step of obtaining a frustocone of non-pleated filter media may comprise forming a frustocone of a non-pleated filter media. Figure 12 therefore shows a flow diagram illustrating a method of forming a frustocone of a non-pleated filter media. This method involves forming an arc of the non-pleated filter media (S4.1) and bonding a first end of the arc of the non-pleated filter media to a second end of the arc of the non-pleated filter media (S4.2). By way of example, if the non-pleated filter media were to comprise a flat sheet of filter media, then the step of forming an arc of the non-pleated filter media would typically comprise cutting the sheet so as to form an arc shaped piece of the flat sheet of filter media. Depending on the desired opening angle of the frustocone, the arc of the non-pleated filter media could be either a major arc or a minor arc; however, the frustocone of a non-pleated filter media would typically be formed from a major arc of the non-pleated filter media.

Whilst in the filter assemblies of the above described embodiments are generally frustoconical in shape they could equally be annular in shape. In this regard, whilst an annular filter assembly would have a smaller area available for filtration, it may be advantage to make use of filter assembly that has minimal depth. In such an embodiment, the filter assembly comprises a pleated filter media that is arranged to be generally annular in shape, wherein folds of the pleated filter media are substantially perpendicular relative to a central axis (X) of the annulus and both first and second corrugated edges 113, 114 of the pleated filter media are substantially parallel to the central axis of the annulus. A first seamless seal 120 of resilient material then

encompasses/encloses the first corrugated edge 113 of the frustoconical pleated filter media and a second seamless seal of resilient material 130 encompasses/encloses the second corrugated edge 114 of the frustoconical pleated filter media 110.

- 5 The method of manufacturing an annular filter assembly with inner and outer seamless seals would be essentially the same as that described above in relation to Figures 5 and 8, with the only exceptions being that an annulus of the pleated filter media could be formed without the need to trim the first and second corrugated edges of the pleated filter media, as these would remain as being substantially perpendicular to the folds/pleats. In addition, the moulds used
10 when spin moulding the first and second seamless seals would differ from those used when forming a frustoconical filter assembly.

- Furthermore, such an annular filter assembly could also comprise a both a pleated filter media and a non-pleated filter media, in an arrangement that is essentially the same as that described
15 above for the embodiment illustrated in Figures 9 and 10. In such an embodiment, the annular filter assembly would further comprise a non-pleated filter media 140 that is arranged to be annular in shape. The method of manufacturing an annular filter assembly with inner and outer seamless seals would be essentially the same as that described above in relation to Figures 11 and 12, with the additional exceptions being that an annulus of the non-pleated filter media
20 could be formed by merely cutting this from a sheet of non-pleated filter media.

- 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
25 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.

- 30 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.

CLAIMS

1. A method of manufacturing a filter assembly, the method comprising:
 - 5 obtaining a pleated filter media that is arranged into a closed shape that has an annular cross-section such that a first corrugated edge of the pleated filter media defines an outer edge of the closed shape and a second corrugated edge of the pleated filter media defines an inner edge of the closed shape;
spin moulding a first seamless seal of resilient material that is substantially parallel to a
10 central axis of the closed shape and that encompasses the first corrugated edge of the pleated filter media;
everting the closed shape of pleated filter media; and
spin moulding a second seamless seal of resilient material that is substantially parallel
to the central axis of the closed shape and that encompasses the second corrugated edge of
15 the pleated filter media.
2. The method of claim 1, wherein folds of the pleated filter media extend in an at least partially radial direction relative to a central axis of the closed shape.
- 20 3. The method of any one of claims 1 or 2, wherein the first and second corrugated edges of the pleated filter media are substantially parallel to a central axis of the pleated filter media.
4. The method of any one of claims 1 to 3, wherein the pleated filter media is arranged to be any of annular and frustoconical in shape.
- 25 5. The method of any one of claims 1 to 4, wherein the step of spin moulding a first seamless seal of resilient material comprises spinning the pleated filter media whilst a liquefied resilient material solidifies over the first corrugated edge of the pleated filter media.
- 30 6. The method of claim 5, wherein the step of spin moulding a first seamless seal of resilient material further comprises spinning the pleated filter media whilst injecting the liquefied resilient material and continuing to spin the pleated filter media until the resilient material solidifies.
- 35 7. The method of any one of claims 5 or 6, wherein step of spin moulding a first seamless seal of resilient material further comprises, prior to spinning, placing the pleated filter media within a mould that defines a space for the first seamless seal.

8. The method of any one of claims 1 to 7, wherein the step of spin moulding a second seamless seal of resilient material comprises spinning the pleated filter media whilst a liquefied resilient material solidifies over the second corrugated edge of the pleated filter media.

9. The method of claim 8, wherein the step of spin moulding a second seamless seal of resilient material further comprises spinning the pleated filter media whilst injecting the liquefied resilient material and continuing to spin the pleated filter media until the resilient material solidifies.

10. The method of any one of claims 8 or 9, wherein step of spin moulding a second seamless seal of resilient material further comprises, prior to spinning, placing the pleated filter media within a mould that defines a space for the second seamless seal.

11. The method of any one of claims 1 to 10, and further comprising, prior to spin moulding a first seamless seal of resilient material, everting the closed shape of pleated filter media.

12. The method of any one of claims 1 to 11, and further comprising, prior to spin moulding the second seamless seal of resilient material:

obtaining a non-pleated filter media that is arranged into a shape that substantially corresponds to that of the pleated filter media; and

disposing the non-pleated filter media adjacent to an under side of the pleated filter media.

13. The method of claim 12, wherein the non-pleated filter media is disposed with a first edge of the non-pleated filter media adjacent to the second corrugated edge of the pleated filter media and a second edge of the non-pleated filter media adjacent to the first seamless seal.

14. The method of claim 13, wherein the second seamless seal then encompasses both the second corrugated edge of the pleated filter media and the first edge of the non-pleated filter media.

15. The method of any one of claims 13 or 14, and further comprising, after spin moulding the second seamless seal of resilient material:

bonding the second edge of the non-pleated filter media to the first seamless seal using an adhesive.

16. A filter assembly comprising:

5 a pleated filter media that is arranged into a closed shape that has an annular cross-section such that a first corrugated edge of the pleated filter media defines an outer edge of the closed shape and a second corrugated edge of the pleated filter media defines an inner edge of the closed shape;

10 a first seamless seal of resilient material that encompasses the first corrugated edge of the pleated filter media, wherein the first seamless seal is substantially parallel to a central axis of the closed shape; and

a second seamless seal of resilient material that encompasses the second corrugated edge of the pleated filter media, wherein the second seamless seal is substantially parallel to the central axis of the closed shape.

15 17. The filter assembly of claim 16, wherein folds of the pleated filter media extend in an at least partially radial direction relative to a central axis of the closed shape

20 18. The filter assembly of any one of claims 16 or 17, wherein the first and second corrugated edges of the pleated filter media are substantially parallel to a central axis of the pleated filter media.

19. The filter assembly of any one of claims 16 to 18, wherein the pleated filter media is arranged to be any of annular and frustoconical in shape.

25 20. The filter assembly of claim 19, wherein the pleated filter media is arranged to be annular in shape such that folds of the pleated filter media extend in a radial direction relative to a central axis of the annular pleated filter media

30 21. The filter assembly of claim 19, wherein the pleated filter media is arranged to be frustoconical in shape such that folds of the pleated filter media are slanted relative to a central axis of the frustoconical pleated filter media.

22. The filter assembly of any one of claims 16 to 21, wherein both the first seamless seal and the second seamless seal comprise a continuous loop of resilient material.

35 23. The filter assembly of any one of claims 16 to 22, and further comprising a non-pleated filter media that is arranged into a shape that substantially corresponds to that of the pleated

filter media and wherein the non-pleated filter media is disposed adjacent to an under side of the pleated filter media.

24. The filter assembly of claim 23, wherein the first edge of the non-pleated filter media is disposed within the second seamless seal.

25. The filter assembly of claim 24, wherein the second edge of the non-pleated filter media is attached to the first seamless seal by an adhesive.

26. The filter assembly of claim 25, wherein the second edge of the non-pleated filter media is attached to the first seamless seal by a bead of adhesive that extends over the entirety junction between the second edge of the non-pleated filter media and the first seamless seal.

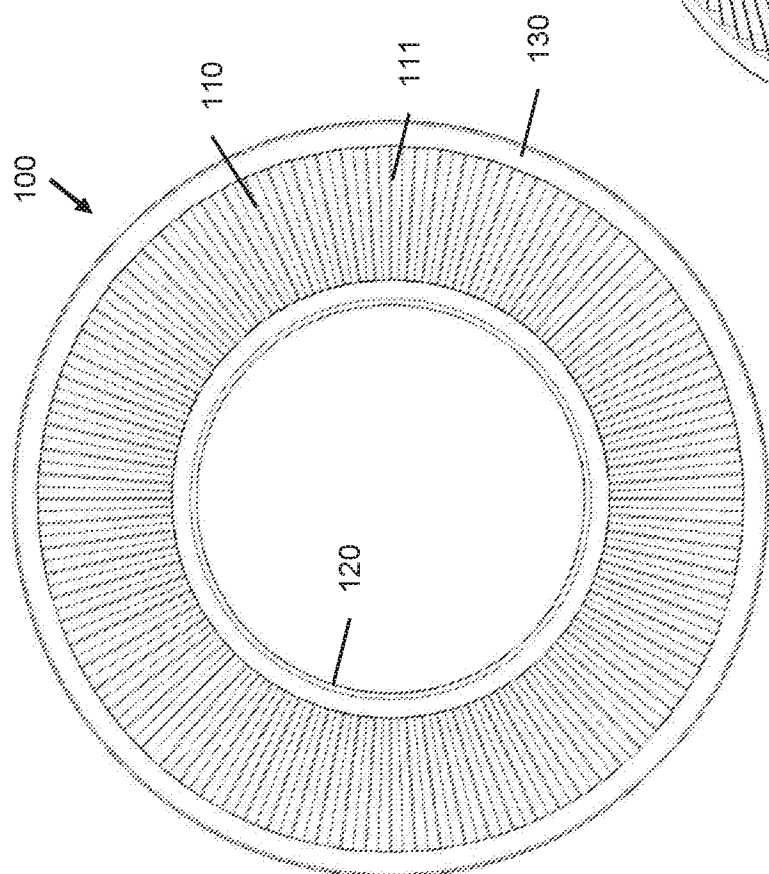


FIG. 1

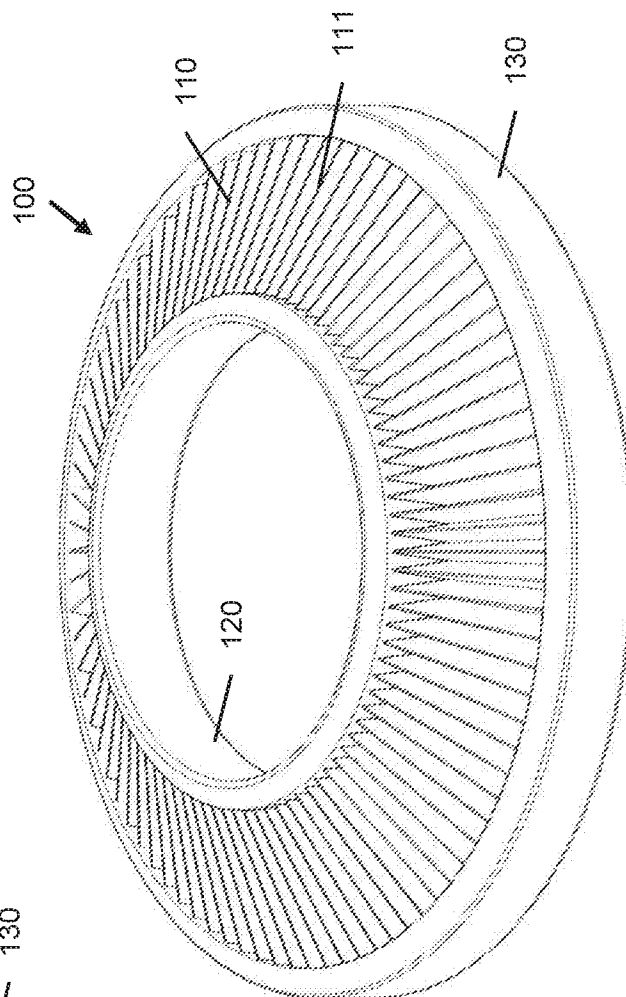


FIG. 2

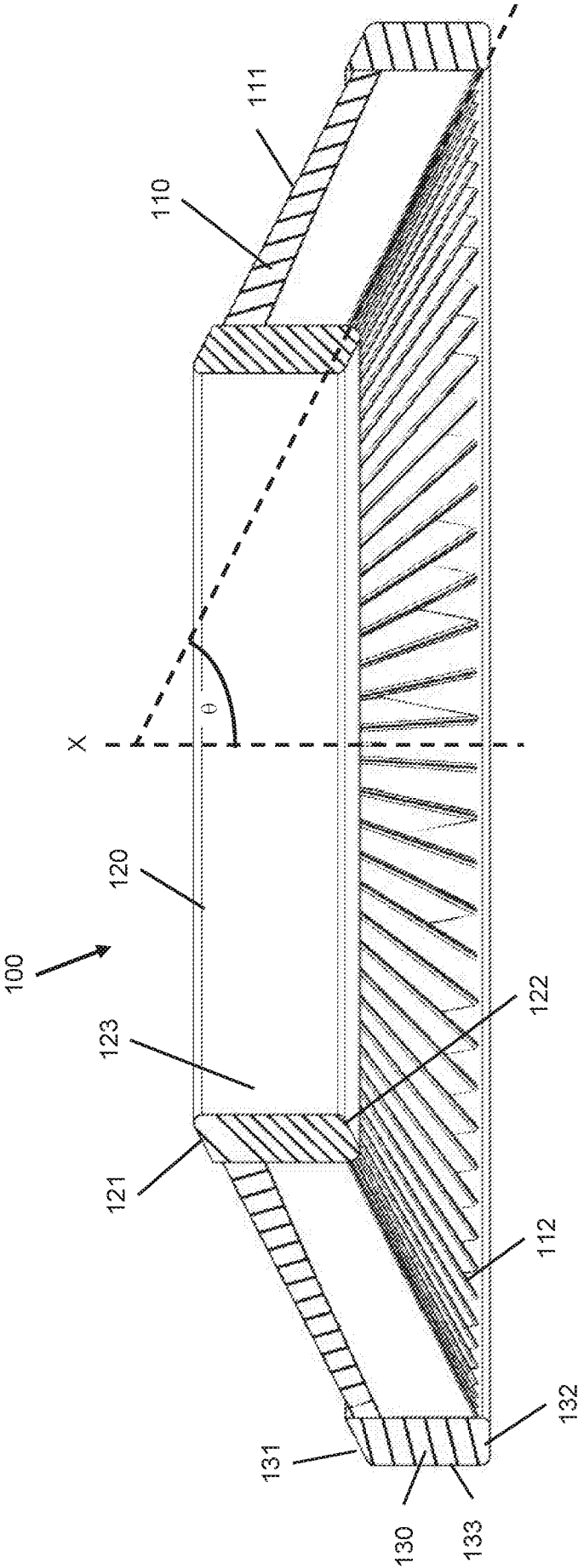


FIG. 3

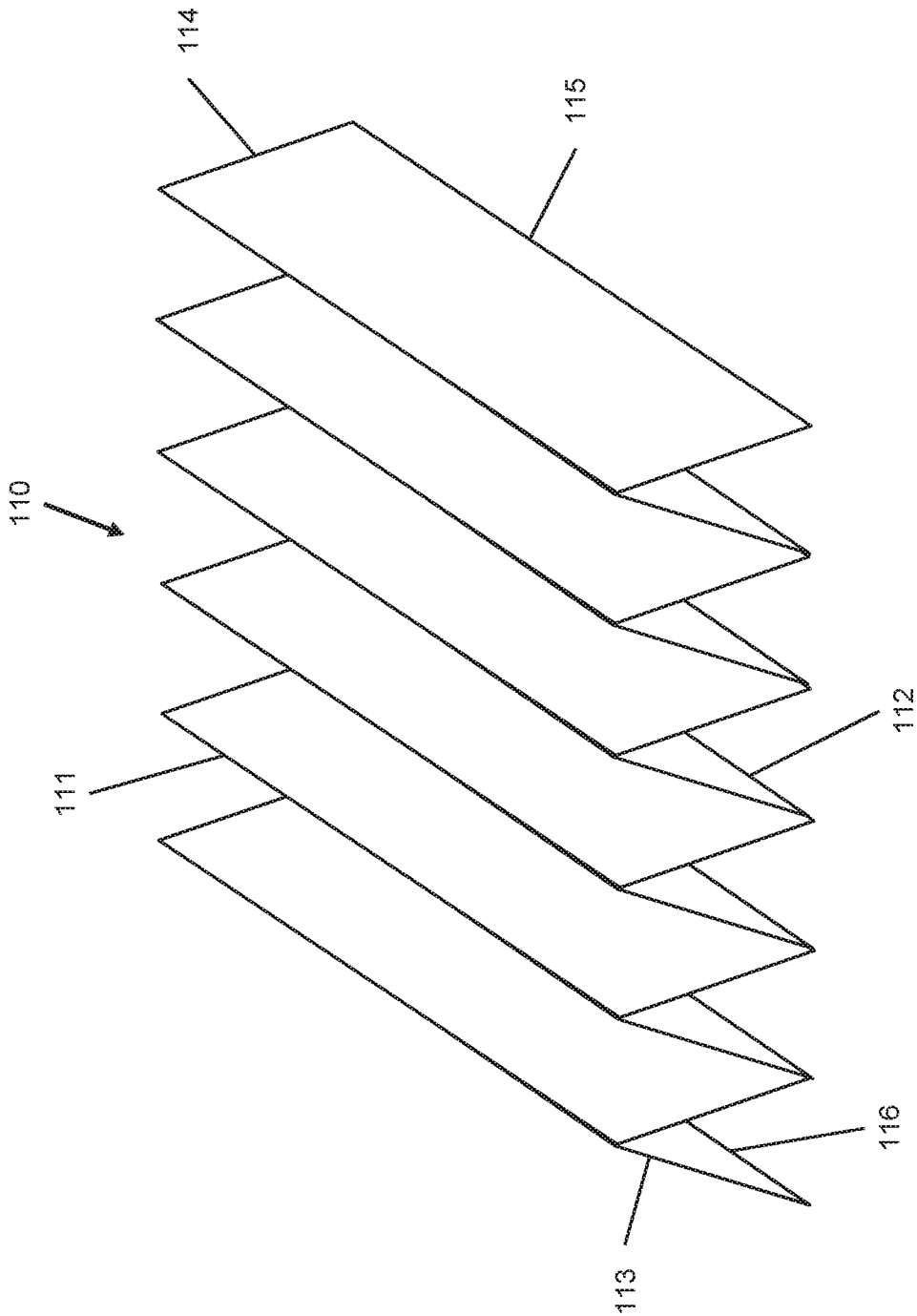
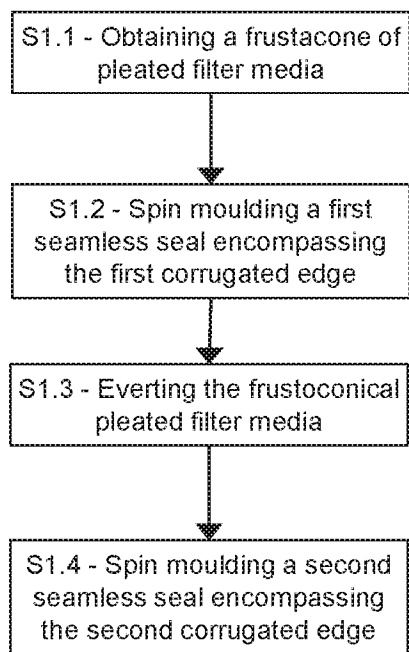
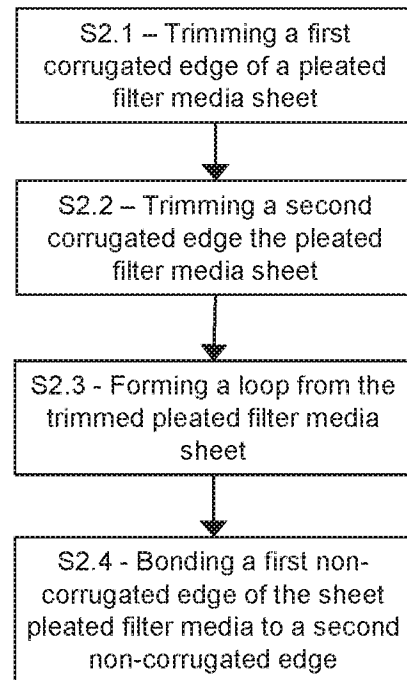
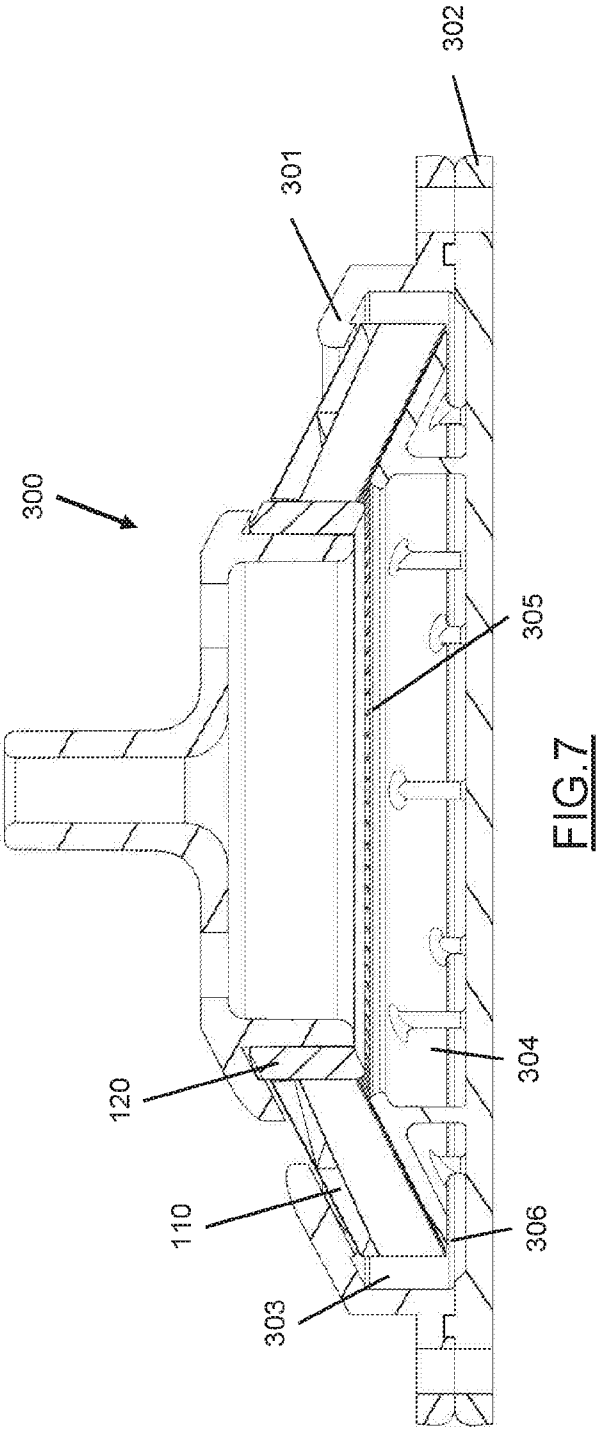
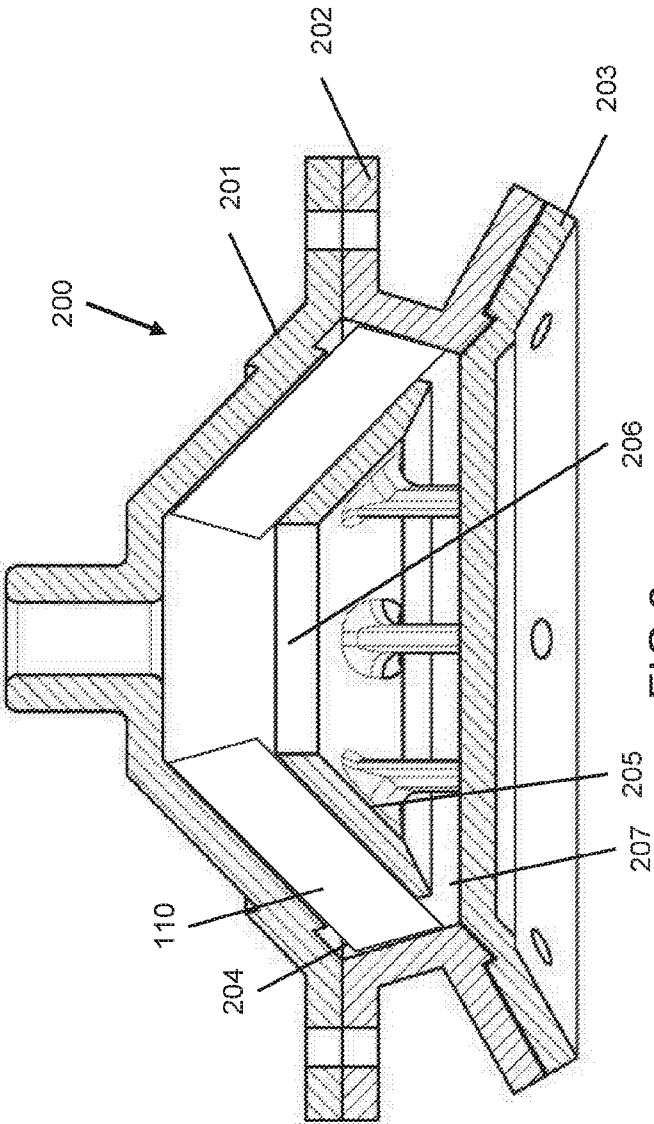


FIG. 4

FIG.5FIG.8



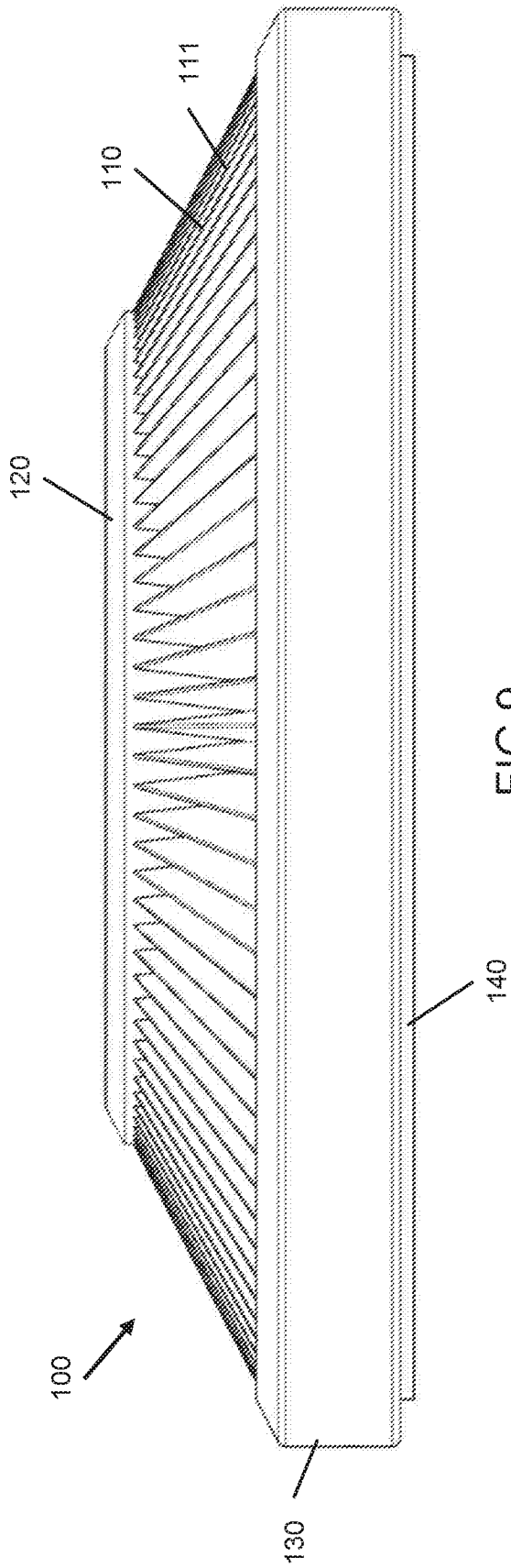


FIG. 9

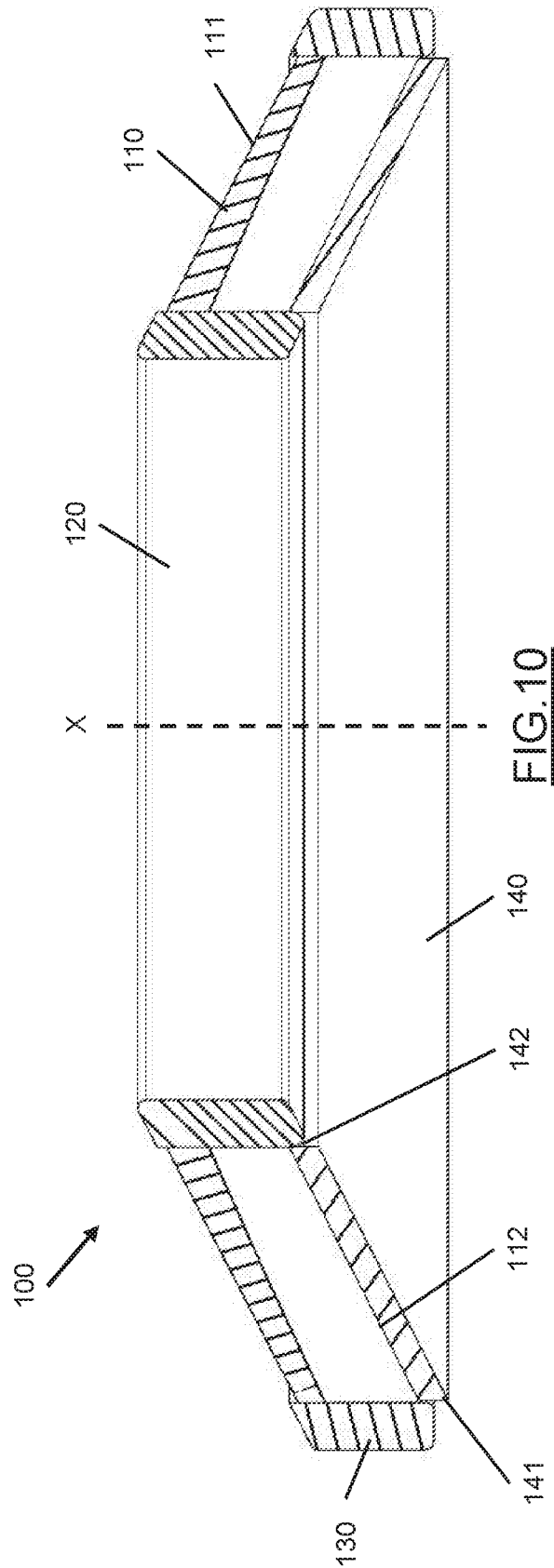
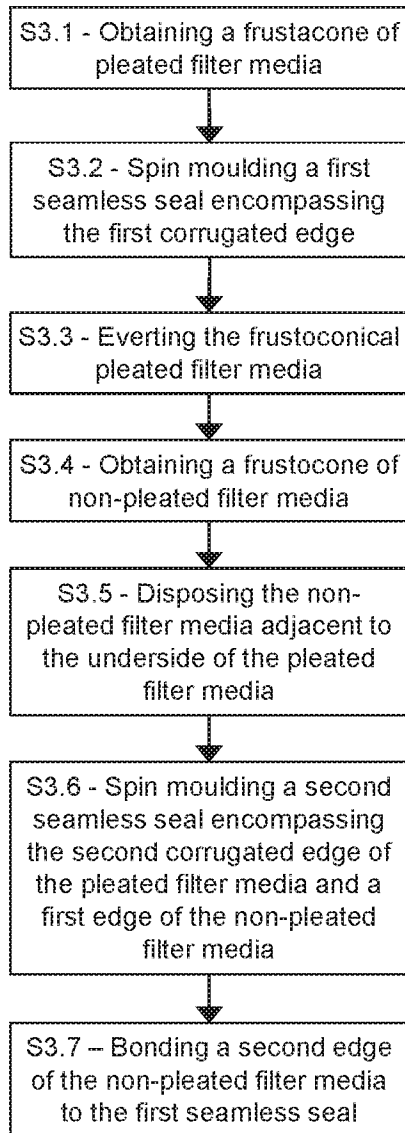
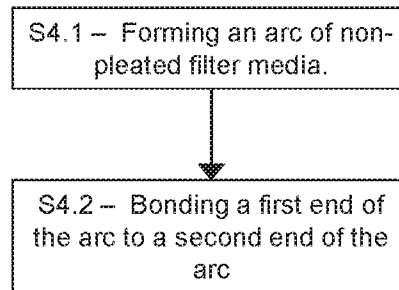


FIG. 10

FIG.11FIG.12

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2019/053588

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01D46/00 B01D46/10 B01D46/52
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

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 527 226 A (ARMAND POELMAN; ROBERT SCHNEIDER) 4 October 1940 (1940-10-04) lines 30-124 - page 2 -----	1-26
A	US 4 422 861 A (DUSZA ROBERT J [US]) 27 December 1983 (1983-12-27) figures 1-5 -----	1-26
A	JP S63 310617 A (NIPPON DENSO CO) 19 December 1988 (1988-12-19) figures 1-3 -----	1-26
A	US 4 619 675 A (WATANABE MORITSUNA [JP]) 28 October 1986 (1986-10-28) figure 3 -----	1-26



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

20 February 2020

Date of mailing of the international search report

09/03/2020

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Skowronski, Maik

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2019/053588

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 527226	A	04-10-1940	NONE
US 4422861	A	27-12-1983	NONE
JP S63310617	A	19-12-1988	NONE
US 4619675	A	28-10-1986	DE 3490313 T1 25-07-1985
		JP S605416 U	16-01-1985
		US 4619675 A	28-10-1986
		WO 8500116 A1	17-01-1985