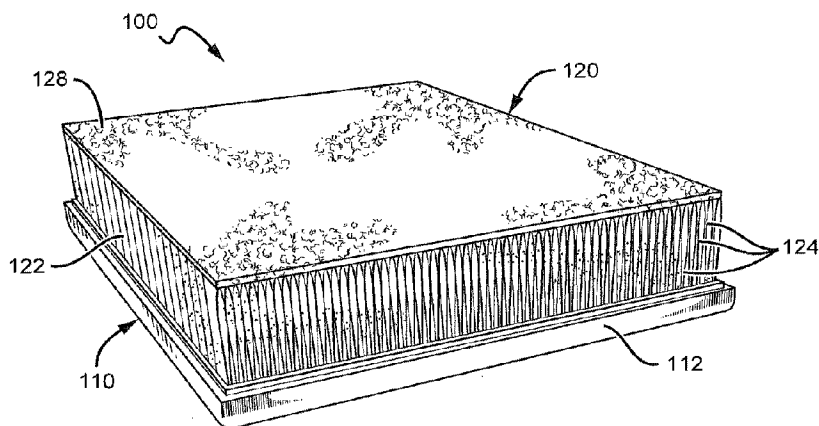




(86) Date de dépôt PCT/PCT Filing Date: 2017/06/23
(87) Date publication PCT/PCT Publication Date: 2017/12/28
(45) Date de délivrance/Issue Date: 2024/04/09
(85) Entrée phase nationale/National Entry: 2018/12/20
(86) N° demande PCT/PCT Application No.: US 2017/039124
(87) N° publication PCT/PCT Publication No.: 2017/223521
(30) Priorités/Priorities: 2016/06/24 (US62/354,549);
2017/06/23 (US15/632,139)

(51) Cl.Int./Int.Cl. *B01D 46/52* (2006.01),
B01D 46/10 (2006.01)
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(54) Titre : FILTRES A AIR CONTENANT DES COMPOSES ET PROCEDES ASSOCIES AUXDITS FILTRES
(54) Title: COMPOUND AIR FILTERS AND METHODS THEREOF



(57) **Abrégé/Abstract:**

Compound air filters and methods thereof are provided for sequestering airborne contaminants including volatile organic compounds (VOCs) from air streamed through the air filters. An air filter can include a support frame having a shape and size suitable for seating the air filter within an air-filtering system. A compound filter medium can be retained within the support frame to remove the airborne contaminants and VOCs from air flowing through the air filter and the air-filtering system containing one or more of the air filters. A first media layer of the compound filter medium can be pleated with pleats and configured to exhibit a relatively high filtration efficiency and a low air pressure drop across the filter medium. A second media layer of the filter medium can be coupled to the first media layer and configured to maintain a uniform distribution of the pleats with the first media layer.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau

(43) International Publication Date
28 December 2017 (28.12.2017)



(10) International Publication Number
WO 2017/223521 A1

(51) International Patent Classification:

B01D 27/06 (2006.01) *B01D 46/10* (2006.01)
B01D 29/07 (2006.01) *B01D 46/12* (2006.01)
B01D 29/56 (2006.01) *B01D 46/52* (2006.01)
B01D 39/14 (2006.01)

(21) International Application Number:

PCT/US2017/039124

(22) International Filing Date:

23 June 2017 (23.06.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/354,549	24 June 2016 (24.06.2016)	US
15/632,139	23 June 2017 (23.06.2017)	US

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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, 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,

(54) Title: COMPOUND AIR FILTERS AND METHODS THEREOF

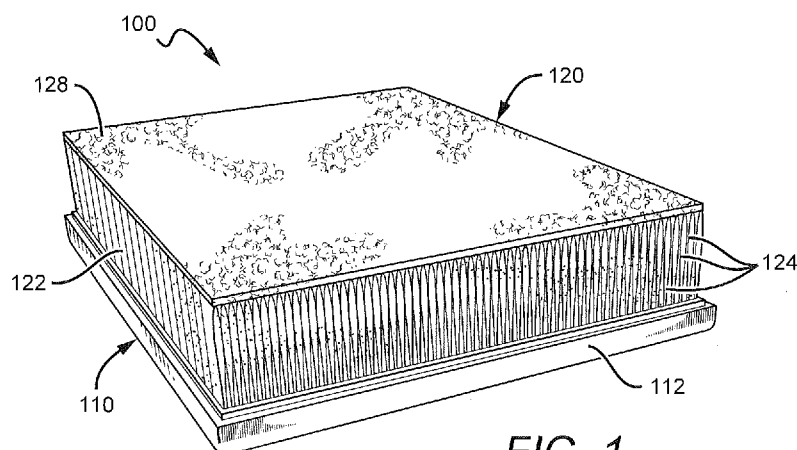


FIG. 1

(57) Abstract: Compound air filters and methods thereof are provided for sequestering airborne contaminants including volatile organic compounds (VOCs) from air streamed through the air filters. An air filter can include a support frame having a shape and size suitable for seating the air filter within an air-filtering system. A compound filter medium can be retained within the support frame to remove the airborne contaminants and VOCs from air flowing through the air filter and the air-filtering system containing one or more of the air filters. A first media layer of the compound filter medium can be pleated with pleats and configured to exhibit a relatively high filtration efficiency and a low air pressure drop across the filter medium. A second media layer of the filter medium can be coupled to the first media layer and configured to maintain a uniform distribution of the pleats with the first media layer.

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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))

COMPOUND AIR FILTERS AND METHODS THEREOF

[0001] This application claims priority to U.S. Patent Application No. 15/632,139 filed on June 23, 2017 and U.S. Provisional Patent Application No. 62/354,549, filed June 24, 2016.

BACKGROUND

[0002] An air filter designed to remove particulate matter from an airstream generally is a device including fibrous materials. These fibrous materials can remove solid particulates such as dust, pollen, mold, and bacteria from an airstream. Air filters are used in applications where air quality is important, notably in air-filtering systems such as heating, ventilation, and air conditioning (HVAC) systems of vehicles. Such air-filtering systems generally operate to provide optimal interior air quality to occupants within interior spaces of vehicles by removing particle contaminants by way of filtration of air. As will be appreciated, the effectiveness of an air-filtering system to provide an optimal interior air quality depends largely on an ability of an air filter within the air-filtering system to remove particle contaminants from the air within the vehicle.

[0003] A drawback to conventional air filters, particularly air filters including pleats, is that as the number or density of pleats increases, the ability to maintain a uniform distribution of the pleats within the air filter generally decreases. Even light forces applied to a densely pleated air filter, either from handling during installation of the air filter or from air flow pressure during use, can dent or bend the pleats out of position. When pleats are compressed together the surface area of the air filter is effectively decreased, along with the efficiency of the filter. This decrease in efficiency can reduce the effective life of an air filter prompting the air filter to be discarded prematurely in an effort to increase air-system system airflow and decrease operation costs. Considering the innumerable number of vehicles with air-filtering systems throughout the world, the volume of discarded air filters that could be eliminated from landfills is staggering.

[0004] What is needed, therefore, is a compound air filter that is configured to maintain a uniform distribution of pleats, during installation and use, in order to maximize surface area and overall efficiency of the filter.

SUMMARY

[0005] Provided herein, in some embodiments, is an air filter including a compound filter medium configured to sequester airborne contaminants from air streamed through the filter medium and a support frame configured to support the filter medium. The compound filter medium can include a first media layer and a second media layer. The first media layer can be formed into a pleated configuration including a plurality of pleats. The first media layer can be disposed between the second media layer and the support frame, wherein inner-pleat folds of the plurality of pleats can be coupled to the support frame, and wherein outer-pleat folds of the plurality of pleats can be coupled to the second media layer.

[0006] In such embodiments, each outer-pleat fold of the outer-pleat folds can be coupled to the second media layer along an entire length of the outer-pleat fold.

[0007] In such embodiments, each inner-pleat fold of the inner-pleat folds can be coupled to the support frame at both ends of the inner-pleat fold.

[0008] In such embodiments, the support frame includes a molded rim along a perimeter of the filter medium. The rim can be configured for seating the air filter in an air-filtering system.

[0009] In such embodiments, the support frame can further include a wire mesh fixed in the rim. The wire mesh can be configured to provide structural integrity to the support frame without obstructing air streamed through the air filter.

[0010] In such embodiments, the air filter can be configured to stream air through the air filter in a direction from the support frame to the second media layer.

[0011] In such embodiments, the first media layer can include a plurality of bosses embossed in the first media layer between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds.

[0012] In such embodiments, the plurality of bosses can be configured with a shape and orientation to provide structural integrity to the first media layer in the pleated configuration without obstructing air streamed through the air filter.

[0013] In such embodiments, the compound filter medium can be configured to sequester airborne contaminants selected from particulate matter, volatile organic compounds, and combinations thereof from air streamed through the filter medium.

[0014] Also provided herein, in some embodiments, is an air filter configured for a HVAC system of a vehicle including a compound filter medium and a support frame configured to support the compound filter medium. The compound filter medium can include a first media layer and a second media layer. The first media layer can be formed into a pleated configuration including a plurality of accordion pleats and a plurality of bosses embossed in the plurality of pleats. The first media layer can be disposed between the second media layer and the support frame, wherein inner-pleat folds of the plurality of pleats can be coupled to the support frame at both ends of each of the inner-pleat folds, and wherein outer-pleat folds of the plurality of pleats can be coupled to the second media layer along an entire length of each of the outer-pleat folds. The plurality of bosses can be set-wise embossed in the first media layer between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds. The plurality of bosses can also be configured with a common shape and orientation to provide structural integrity to the first media layer in the pleated configuration. The air filter can be configured to stream air through the air filter in a direction from the support frame to the second media layer to sequester airborne contaminants from the air.

[0015] In such embodiments, at least one layer of the first media layer and the second media layer can be configured to sequester volatile organic compounds from the air.

[0016] In such embodiments, at least one layer of the first media layer and the second media layer can include an electrostatic component configured to sequester particulate matter from the air.

[0017] In such embodiments, the first media layer can be a textile, paper, cotton, spun fiberglass, foam, or a combination thereof.

[0018] In such embodiments, the second media layer can be a textile, a woven synthetic material, a woven natural material, woven cotton, or a combination thereof.

[0019] In such embodiments, the support frame includes a molded rim along a perimeter of the compound filter medium and a wire mesh. The molded rim can be configured for seating the air filter in an air-filtering system. The wire mesh can be fixed in the rim to provide structural integrity to the support frame without obstructing air streamed through the air filter.

[0020] In such embodiments, the rim can be silicone rubber, foam rubber, or integral skin polyurethane foam.

[0021] Also provided herein, in some embodiments, is a method including forming a compound air filter configured to sequester airborne contaminants from air streamed through the air filter. Forming the compound air filter can include coupling a second media layer to a first media layer to form a compound filter medium, molding a rim over a wire mesh to form a support frame for the compound filter medium, and coupling the compound filter medium to the support frame to form the compound air filter. Coupling the second media layer to the first media layer can include coupling the second media layer to the first media layer having a pleated configuration including a plurality of pleats to form the compound filter medium. Coupling the compound filter medium to the support frame can include disposing the compound filter medium such that the first media layer is between the second media layer and the support frame. Inner-pleat folds of the plurality of pleats can be coupled to the support frame at both ends of each of the inner-pleat folds. Outer-pleat folds of the plurality of pleats can be coupled to the second media layer along an entire length of each of the outer-pleat folds.

[0022] In such embodiments, coupling the second media layer to the first media layer can include adhering the outer-pleat folds of the plurality of pleats to the second media layer either continuously or at discrete points along an entire length of each of the outer-pleat folds. Coupling the compound filter medium to the support frame can include adhering the inner-pleat folds of the plurality of pleats to the support frame at both ends of each of the inner-pleat folds.

[0023] In such embodiments, the method can further include embossing the first media layer with a plurality of bosses configured with a shape and orientation to provide structural integrity to the first media layer in the pleated configuration without obstructing air streamed through the air filter.

[0024] In such embodiments, the method can further include pleating the first media layer into the pleated configuration such that the plurality of bosses are set-wise embossed in the first media layer between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds.

[0025] These and other features of the concepts provided herein might be better understood with reference to the drawings, description, and appended claims.

DRAWINGS

[0026] FIG. 1 illustrates a downstream perspective view of an air filter configured for use in an air-filtering system of a vehicle in accordance with some embodiments.

[0027] FIG. 2 illustrates an upstream perspective view of an air filter configured for use in an air-filtering system of a vehicle in accordance with some embodiments.

[0028] FIG. 3 is a side view of the air filter shown in FIGS. 1 and 2, illustrating a direction of airflow through the air filter in accordance with some embodiments.

[0029] FIG. 4 is a side view of the air filter shown in FIGS. 1 and 2, illustrating a direction of airflow through the air filter in accordance with some embodiments.

[0030] FIG. 5 illustrates a close-up view of a plurality of pleats of the air filter of FIGS. 1 and 2 in accordance with some embodiments.

[0031] FIG. 6 illustrates an air filter in an air-filtering system of a vehicle in accordance with some embodiments.

[0032] While the concepts provided herein are subject to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and will be described herein in detail. It should be understood the concepts provided herein are not limited to the particular embodiments disclosed, but, on the contrary, the intention is to cover all modifications, equivalents, and alternatives of such with the particular embodiments provided as examples thereof.

DESCRIPTION

[0033] In the following description, numerous specific details are set forth in order to provide a thorough understanding of the concepts provided herein. It will be apparent, however, to one of ordinary skill in the art that the concepts provided herein can be practiced without these specific details. In other instances, specific numeric references such as “a first media layer,” can be made. However, the specific numeric reference should not be interpreted as a literal sequential order but rather interpreted that the “first media layer” is different than a “second media layer.” Thus, the specific details set forth are merely examples. The specific details can be varied from and still be within the spirit and scope of the concepts presented herein. The term “coupled” is defined as meaning connected either directly to the component or indirectly to the component through another component. Further, as used herein, the terms “about,” “approximately,” or “substantially” for any numerical values or ranges indicate a suitable dimensional tolerance that allows the part or collection of components to function for its intended purpose as described herein.

[0034] In accordance with that set forth above, a compound air filter is needed that is configured to maintain a uniform distribution of pleats, during installation and use, in order to maximize surface area and overall efficiency of the filter. As such, a compound air filter is provided herein including, in some embodiments, a compound filter medium configured to sequester airborne contaminants from air streamed through the filter medium and a support frame configured to support the filter medium. The compound filter medium can include a first media layer and a second media layer. The first media layer can be formed into a pleated configuration including a plurality of pleats. The first media layer can be disposed between the second media layer and the support frame, wherein inner-pleat folds of the plurality of pleats can be coupled to the support frame, and wherein outer-pleat folds of the plurality of pleats can be coupled to the second media layer.

[0035] Such a compound air filter is described for sequestering airborne contaminants from air within, for example, residential or commercial spaces, as well as within any of various types of vehicle. The air filter can include a support frame having a shape and size suitable to orient the air filter within an air-filtering system. A filter medium can be retained within the support frame and configured to remove the airborne contaminants from air flowing through the air filtering. The support frame can include a single molded rim disposed along a perimeter of the filter medium

and can be configured to orient the filter medium within an air-filtering system, such that air flowing through the air-filtering system is passed through the filter medium. The air filter can include a wire support incorporated into the air filter and configured to provide strength and durability to the air filter. The filter medium can include a combination of one or more media layers configured to exhibit a relatively high filtration efficiency and a relatively low air pressure drop across the filter medium. The filter medium can include a plurality of pleats so as to increase the surface area of the filter medium. The air filter can also include a support layer configured to maintain a uniform distribution of the pleats.

[0036] Although embodiments of the compound air filters can be described and illustrated herein in terms of a rectangular air filter, it should be understood that the compound air filters are not limited to the exact embodiments or shapes illustrated, but rather the compound air filters can include a wide variety of generally rectangular shapes, generally square, circular, oval, round, curved, conical, or other closed perimeter shape that will become apparent.

[0037] FIGS. 1 and 2 illustrate an embodiment of an air filter 100 that is configured for use in embodiments of the air-filtering system incorporated into a vehicle. The air filter 100 includes a support frame 110 having a shape and size suitable to support a filter medium 120 and seat the air filter within an air-filtering system. A filter medium 120 is retained within the support frame 110 and configured to remove airborne contaminants from air flowing through the air filter. The support frame 110 can include a single molded rim 112 that is disposed along a perimeter of the filter medium 120, wherein the rim is configured for seating the air filter in an air-filtering system. It is understood that the molded rim 112 can be formed from molded foam rubber, silicone rubber, integral skin polyurethane foam rubber; or any of various similar materials that are known in the art.

[0038] In some embodiments, the support frame 110 include a plurality of elongate sections and corner sections suitably assembled along a perimeter of the filter medium to orient the air filter 100 within an air-filtering system.

[0039] As best shown in FIG. 2, the air filter 100 can include a wire mesh 214 that is incorporated (e.g., molded such as by overmolding) into the air filter 100 and configured to provide strength, structural integrity, durability, or a combination thereof to the support frame 110 and the

air filter 100 itself without obstructing air streamed through the air filter 10. Although the wire mesh 214 shown in FIG. 2 is molded into the support frame 110, it should be understood that the wire mesh 214 can be fixed or coupled with the support frame 110 by way of any of various techniques that are known in the art. Further, it should be recognized that the size of mesh of the wire mesh 214 can be varied from that shown in FIG. 2, based on design choice.

[0040] In some embodiments two or more layers of wire mesh can be used to provide relatively greater support to the air filter 100. For example, one or more layers of wire mesh can be disposed in front of, behind, or within the filter medium 120 with respect to the direction of airflow. It is contemplated that situating one or more layers of wire mesh 214 in front of the filter medium 120; with respect to the direction of airflow, can operate to catch larger particulate matter, thereby removing this particulate matter from the airstream prior to passing into filter medium 120.

[0041] It is contemplated that any of a variety of fasteners or structures can be implemented so as to retain the filter medium 120 within the support frame 110. In some embodiments, for example, the support frame 110 can include a grate, or a similar structure, which encloses the filter medium 120 within the support frame 110 without restricting airflow through the filter medium 120. In some embodiments, the filter medium 120 can be coupled with a wire support, for example the wire mesh 214, that is configured to resist bowing of the filter medium due to the airstream passing therethrough. For example, the filter medium 120 can be disposed between a first wire support and a second wire support. The first and second wire supports can include a rigid material, such as, by way of non-limiting example, any of various suitable plastics or metals.

[0042] In some embodiments, the molded rim 112 can be molded directly onto the edges of the filter medium 120 so as to retain the filter medium within the support frame 110. In some embodiments, the molded rim 112 can be molded onto a first support layer, such as the wire mesh 214, a second support layer, the filter medium 120, or any combination thereof. For example, in those certain embodiments wherein the filter medium 120 is disposed between a first support layer and a second support layer, the molded rim 112 can be molded onto the first and second support layers to retain the filter medium 120 within the support frame 110. Further, in some embodiments, the support frame 110 can include a crimped portion that folds onto and retains the first and second support layers and this retains the filter medium 120 within the support frame 110.

[0043] As discussed above, a first support layer, such as the wire mesh 214, can be coupled with the filter medium 120 so as to provide additional strength and durability to the air filter 100. It is envisioned that in some embodiments, the wire mesh 214 can be positioned on an outer surface and an inner surface of the filter medium 120. In some embodiments, the wire mesh 214 can include of powder-coated aluminum screen wire that is co-pleated along with the filter medium 120 so as to reinforce the air filter 100. In some embodiments, the inner surface of the filter medium 120 can also include a wire mesh reinforcement. It is contemplated that the wire mesh supports can vary in rigidity. In some embodiments, additional or alternative reinforcements can be provided, as will be apparent to those skilled in the art.

[0044] FIGS. 3 and 4 illustrate side views of the air filter 100, indicating a direction of airflow 301 passing through the air filter 100 from the support frame 110 (e.g., inlet side of the air filter 100) through the filter medium 120 (e.g., outlet side of the air filter 100). The air filter 100 generally includes a combination of two or more filter media layers forming a compound filter medium 120 configured to exhibit a relatively high filtration efficiency and a relatively low air pressure drop across the filter medium 120. In the embodiments illustrated in FIGS. 1-5, the air filter 100 includes a first media layer 122 and a second media layer 128 forming the compound filter medium 120, in which at least one of the foregoing media layers (or both) is configured to sequester airborne contaminants selected from at least particulate matter, volatile organic compounds (VOCs), and combinations thereof from air streamed through the compound filter medium 120. As such, the direction of airflow 301 passing through the air filter 100 of FIGS. 3 and 4 is from the support frame 110, through the first media layer 122, and, ultimately, through the second media layer 128.

[0045] The first media layer 122 can be formed into a pleated configuration including a multiplicity of pleats 124 (e.g., accordion pleats) so as to increase the surface area of the filter medium 120. It will be appreciated that an increase in the number or density of the pleats 124 increases the surface area of the filter medium 120. As best shown in FIGS. 1 and 3, the first media layer 122 can be disposed between the second media layer 128 and the support frame 110 such that inner-pleat folds (e.g., pleat fold lines or creases on the inlet side of the air filter 100) of the plurality of pleats 124 are coupled (e.g., adhered) to the support frame 110 and outer-pleat folds (e.g., pleat fold lines or creases on the outlet side of the air filter 100) of the plurality of pleats

124 are coupled (e.g., adhered) to the second media layer 128. Each outer-pleat fold of the outer-pleat folds can be coupled to the second media layer 128 along an entire length of the outer-pleat fold. For example, each outer-pleat fold of the outer-pleat folds can be adhered to the second media layer 128 along an entire length of the outer-pleat fold either continuously (e.g., line of adhesive along the length of the outer-pleat fold) or at discrete points (e.g., points of adhesive along the length of the outer-pleat fold) along an entire length of each of the outer-pleat folds. Each inner-pleat fold of the inner-pleat folds can be coupled to the support frame 110 at both ends of the inner-pleat fold. For example, each inner-pleat fold of the inner-pleat folds can be adhered to the support frame 110 at both ends of the inner-pleat fold while leaving the center free.

[0046] It is contemplated that the first media layer 122 can be constructed of a natural material (i.e., a material sourced from nature), a synthetic material, or a combination thereof. The natural material can include, but is not limited to, cotton, wool, flax, hemp, or the like, optionally formed into fibers, a paper product thereof, or a woven or felted textile thereof. The synthetic material can include, but is not limited to, polyester, aramid, acrylic, nylon, polyurethane, olefin, polylactide, carbon, or the like, optionally formed into fibers or a woven or felted textile thereof. Combinations of the natural material and the synthetic material can include woven or felted textiles of at least one of the foregoing natural-material fibers and at least one of the foregoing synthetic-material fibers. Other filter materials known in the art can also be used. As such, the first media layer 122 can be constructed of paper, foam, cotton, spun fiberglass, or other filter materials known in the art, woven or non-woven material, synthetic or natural, or any combination thereof. In some embodiments the first media layer 122 can be configured to remove VOCs from the airstream. For example, in some embodiments, the first media layer 122 can include a portion capable of removing VOCs from the airstream. It is envisioned that embodiments of the first media layer 122 can include components capable of removing VOCs from the airstream such as activated charcoal or similar materials known in the art.

[0047] In some embodiments, the first media layer 122, the second media layer 128, or both media layers can include an electrostatic portion that is configured to electrostatically attract and agglomerate particle contaminants within the air flowing through the air filter. It is contemplated that the electrostatic portion can include at least some fibers that are treated with a coating of antimicrobial molecules configured to destroy microbes. In some embodiments, the antimicrobial

molecules can include positively charged molecules distributed around a circumference some fibers of the first media layer 122 and configured to cooperate with polarized fibers disposed within the filter medium 120.

[0048] In some embodiments, the first media layer 122 can include a combination of one or more media layers, each having a unique appearance. The combination of one or more media layers can be configured to exhibit a relatively high filtration efficiency and a relatively low air pressure drop across the filter medium 120, and the unique appearance can be configured to indicate a preferred direction of airflow 301 through the filter medium 120. In one embodiment, the combination of one or more media layers includes a first media layer and a second media. The first media layer includes a first color (e.g., cream color) and the second media layer includes a second color (e.g., grey color). As will be appreciated, the first color indicates an air entry side of the filter medium 120, and the second color indicates an air exit side of the filter medium. It will be recognized that a variety of colors, shapes, symbols, logos, written instructions or the like can be used, without limitation, to indicate a preferred air entry side of the filter medium 120.

[0049] As best shown in FIGS. 4 and 5, the first media layer 122 can include a plurality of bosses or embossed shapes 426. The embossed shapes 426 can be positioned between the fold lines or creases of the pleats 124 such that they are disposed substantially on the sides of the pleats when the first media layer 122 is in the pleated configuration. In other words, the first media layer 122 can include the plurality of bosses 426 embossed (in sets) in the first media layer 122 between each inner-pleat fold of the inner-pleat folds (e.g., pleat fold lines or creases on the inlet side of the air filter 100) and an adjacent outer-pleat fold of the outer-pleat folds (e.g., pleat fold lines or creases on the outlet side of the air filter 100). The plurality of bosses 426 can be configured with a common or shared shape (e.g., line, triangle, etc.) and orientation (e.g., in direction of air flow through the air filter 100) to provide structural integrity to the first media layer 426 in the pleated configuration without obstructing air streamed through the air filter 100. The embossed shapes 426 of adjacent pleats 124 are longitudinally aligned such that apices of opposing embossed shapes 426 sharing a pleat fold line are in contact when the first media layer 122 is in the folded configuration. These embossed shapes 426 aide in maintaining a fold-to-fold pitch of the pleats in the spaced configuration while maintaining a minimal loss in surface area as well as operating to impart structural integrity to the first media layer 122, thereby mitigating deformation of the

plurality of pleats and preserving filtration efficiency of the air filter. In some embodiments, the embossed shapes 426 include adhesive beads or strips configured to advantageously maintain a majority of their original shape while adhering adjacent pleats 124. The adhesive beads or strips can advantageously direct air through the first media layer 122 as shown in FIGS. 3 and 4 instead of allowing the air to escape through sides of the air filter 100. While the embossed shapes 426 in the present embodiment are disclosed as longitudinal and orientated substantially parallel with the direction of airflow 301, it should be understood that any orientation, shape and number of the embossed shapes 426 can be used that provide structural integrity with suitable air flow.

[0050] As described above, the filter medium 120 includes a second media layer 128 which can be incorporated into or coupled (e.g., adhered) to the first media layer 122. The second media layer 128 is configured to maintain a uniform distribution of the pleats 124 as best shown in FIG. 3. Preferably, the second media layer 128 includes a woven, fibrous material adhered to a downstream side of the first media layer 122, with respect to the direction of airflow 301.

[0051] It should be understood that the second media layer 128 can include materials other than the above mentioned woven, fibrous material, such as any of the natural materials, synthetic materials, or the combinations thereof described for the first media layer 122. The material including the second media layer 128 can be any material that is suitable for maintaining a uniform distribution of the pleats 124 while providing little or no resistance to airflow. For example, the second media layer 128 can include synthetic or natural materials, organic or inorganic materials, rigid or flexible materials, woven cotton or cotton fabric, a woven synthetic material such as nylon fabric, wire mesh, perforated plastic sheet, and the like.

[0052] It is contemplated that the second media layer 128 can be adhered to the first media layer 122 by way of any suitable fixation means known in the art, such as by way of non-limiting examples any of adhesive (e.g., glue), clips, staples, sewing, pins and the like. It is contemplated that the second media layer 128 can be affixed to the first media layer 122 by way of any one, or a combination of, the suitable fixation configurations. In one embodiment, the second media layer 128 is adhered to the first media layer 122 by way of one or more lines of a suitable adhesive disposed perpendicular to the pleats 124 and extends along a width of the first media layer 122. It is contemplated that any suitable adhesive can be used to adhere the first and second media layers

122, 128, without limitation. In some embodiments, the first and second media layers can be mechanically fastened together by way of , for example, a multiplicity of staples, one or more lines of thread, or a combination thereof.

[0053] In some embodiments, at least some of the fibers including the second media layer 128 can be treated with a coating of antimicrobial molecules configured to destroy microbes on contact. Preferably, the coating of antimicrobial molecules surrounds substantially the entire circumference of each fiber strand that is treated. In some embodiments, substances configured to release a fragrance can be incorporated into the second media layer 128 including the antimicrobial molecules. It is contemplated that the fragrance can be any natural substance, synthetic material, (incorporating aldehydes, ketones, esters, and other chemical constituents), or combinations thereof, which is known in the art and suitable for use in candles for imparting an odor, aroma, or fragrance. In some embodiments, suitable natural and synthetic fragrance/flavor substances can include those compiled by the U.S. Food and Drug Administration in Title 21 of the Code of Federal Regulations, Sections 172.510 and 172.515 respectively. In some embodiments, suitable fragrances include spice oil, flower oil, fruit oil, and the like. In some embodiments, suitable fragrances include fragrance components, such as for example benzaldehydes, phenols, cinnamic aldehydes and esters, octadienes, dienes, cyclohexadienes, terpenes, and the like. Further details regarding dispersion of aromas by way of air filters and fragrance compositions are disclosed in U.S. Patent Application Serial No. 10/544,157, entitled “Vehicle cabin air filter freshener,” filed on August 13, 2003.

[0054] It should be understood that the air filter 100 described herein is not to be construed as limited solely to HVAC systems for treating air within vehicle cabins where passengers and drivers reside. Rather the air filter 100 can be used for internal combustion engine intakes or the like requiring filtered air. Vehicles, by way of non-limiting example, include automobiles, trucks, recreational vehicles, buses, earthmoving equipment and tractors with enclosed cabins, crane operator cabins, various cargo moving vehicles, locomotives, rail passenger cars, airplanes, helicopters, ship cabins, airship cabins, military vehicles, and the like. Moreover, the air filter 100 can be incorporated into other HVAC systems such as portable HVAC systems for treating air volumes commensurate with, for example, those of vehicle cabins.

[0055] FIG. 6 illustrates an air filter in an air-filtering system of a vehicle in accordance with some embodiments. As shown, the compound air filter 100 is incorporated into a ventilation system 602 of a vehicle 600 so as to clean outside air drawn through the air filter 100 for a passenger compartment 604. The ventilation system 602 includes a fan configured to draw a stream of outside air through the compound air filter 100, wherein particulate matter, volatile organic compounds (VOCs), and other airborne contaminants are removed from the air. The fan then pushes a stream of clean air into a heater core or an air conditioning system before the passenger compartment 604.

Methods

[0056] Methods for forming the compound air filter 100 configured to sequester airborne contaminants from air streamed through the air filter 100 can include coupling the second media layer 128 to the first media layer 122 to form the compound filter medium 120, molding the rim over the wire mesh 214 to form the support frame 110 for the compound filter medium 120, and coupling the compound filter medium 120 to the support frame 110 to form the compound air filter 100.

[0057] Coupling the second media layer 128 to the first media layer 122 can include coupling the second media layer 128 to the first media layer 122 having the pleated configuration including a plurality of pleats 124 to form the compound filter medium 120. Such coupling can include adhering the outer-pleat folds of the plurality of pleats 124 to the second media layer 128 either continuously or at discrete points along an entire length of each of the outer-pleat folds. As such, outer-pleat folds of the plurality of pleats 124 can be coupled or adhered to the second media layer 128 along an entire length of each of the outer-pleat folds.

[0058] Coupling the compound filter medium 120 to the support frame 110 can include disposing the compound filter medium 120 such that the first media layer 122 is between the second media layer 128 and the support frame 110. Such coupling can include adhering the inner-pleat folds of the plurality of pleats 124 to the support frame 110 at both ends of each of the inner-pleat folds. As such, inner-pleat folds of the plurality of pleats 124 can be coupled or adhered to the support frame 110 at both ends of each of the inner-pleat folds.

[0059] Methods for forming the compound air filter 100 can further include embossing the first media layer 122 with a plurality of bosses 426 configured with a shape and orientation to provide structural integrity to the first media layer 122 in the pleated configuration without obstructing air streamed through the air filter 100.

[0060] Methods for forming the compound air filter 100 can further include pleating the first media layer 122 into the pleated configuration such that the plurality of bosses 426 are set-wise embossed in the first media layer 122 between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds.

[0061] While the concepts provided herein have been described in terms of particular variations and illustrative figures, those of ordinary skill in the art will recognize that the concepts are not limited to the variations or figures described. In addition, where methods and steps described above indicate certain events occurring in certain order, those of ordinary skill in the art will recognize that the ordering of certain steps can be modified and that such modifications are in accordance with the concepts provided herein. Additionally, certain of the steps can be performed concurrently in a parallel process when possible, as well as performed sequentially as described above. To the extent there are variations, it is the intent that this patent will cover those variations as well. Therefore, it should be understood the concepts presented herein are not limited by the specific embodiments described herein, but only by scope of the appended claims.

CLAIMS

What is claimed is:

1. An air filter, comprising:

a compound filter medium configured to sequester airborne contaminants from air streamed through the filter medium;

a first media layer of the compound filter medium formed into a pleated configuration including a plurality of pleats;

a second media layer of the compound filter medium; and

a support frame configured to support the compound filter medium wherein the support frame is constructed of a single molded rim disposed along a perimeter of the filter medium and configured to orient the filter medium within an air filtering system,

wherein the first media layer is disposed between the second media layer and the support frame such that inner-pleat folds of the plurality of pleats are coupled to the support frame and outer-pleat folds of the plurality of pleats are coupled to the second media layer,

wherein at least one of said first and second media layers have an electrostatic portion treated with a coating of antimicrobial molecules configured to destroy microbes,

wherein the first media layer includes a plurality of bosses embossed in the first media layer between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds, and

wherein the plurality of bosses are configured with a shape and orientation to (i) provide structural integrity to the first media layer in the pleated configuration without obstructing air streamed through the air filter and (ii) inhibit lateral air flow perpendicular to the plurality of bosses.

2. The air filter of claim 1, wherein each outer-pleat fold of the outer-pleat folds is coupled to the second media layer along an entire length of the outer-pleat fold.

3. The air filter of claim 1, wherein each inner-pleat fold of the inner-pleat folds is coupled to the support frame at both ends of the inner-pleat fold.

4. The air filter of claim 1, wherein the support frame comprises a molded rim along a perimeter of the filter medium, the rim configured for seating the air filter in an air-filtering system.
5. The air filter of claim 4, wherein the support frame further comprises a wire mesh fixed in the rim, the wire mesh configured to provide structural integrity to the support frame without obstructing air streamed through the air filter.
6. The air filter of claim 4, wherein the air filter is configured to stream air through the air filter in a direction from the support frame to the second media layer.
7. The air filter of claim 1, wherein each inner-pleat boss of the inner-pleat folds and the adjacent outer-pleat boss of the outer-pleat folds are directly opposite each other in the first media layer.
8. The air filter of claim 1, wherein the compound filter medium is configured to sequester airborne contaminants selected from particulate matter, volatile organic compounds (VOCs), and combinations thereof from air streamed through the filter medium.
9. An air filter configured for a heating, ventilation, and air conditioning (“HVAC”) system of a vehicle, comprising:
 - a first media layer of a compound filter medium formed into a pleated configuration including a plurality of accordion pleats and a plurality of bosses embossed in the plurality of pleats and a support layer configured to maintain a uniform distribution of the plurality of pleats;
 - a second media layer treated with an antimicrobial and a substance configured to release a fragrance; and
 - a support frame configured to support the compound filter medium, wherein:
 - the first media layer is disposed between the second media layer and the support frame such that inner-pleat folds of the plurality of pleats are coupled to the support frame at both ends of each of the inner-pleat folds and outer-pleat folds of the plurality of pleats are coupled to the second media layer along an entire length of each of the outer-pleat folds,

the plurality of bosses are set-wise embossed in the first media layer between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds,

the plurality of bosses are configured with a common shape and orientation to (i) provide structural integrity to the first media layer in the pleated configuration and (ii) inhibit lateral air flow perpendicular to the plurality of bosses,

wherein each inner-pleat boss of the inner-pleat folds and the adjacent outer-pleat boss of the outer-pleat folds are directly opposite each other in the first media layer. and

the air filter is configured to stream air through the compound air filter in a direction from the support frame to the second media layer to sequester airborne contaminants from the air.

10. The air filter of claim 9, wherein at least one layer of the first media layer and the second media layer is configured to sequester volatile organic compounds (VOCs) from the air.

11. The air filter of claim 9, wherein at least one layer of the first media layer and the second media layer includes an electrostatic component configured to sequester particulate matter from the air.

12. The air filter of claim 9, wherein the first media layer is a textile, paper, cotton, spun fiberglass, foam, or a combination thereof.

13. The air filter of claim 9, wherein the second media layer is a textile, a woven synthetic material, a woven natural material, woven cotton, or a combination thereof.

14. The air filter of claim 9, wherein the support frame comprises:

a molded rim along a perimeter of the compound filter medium configured for seating the air filter in an air-filtering system, and

a wire mesh fixed in the rim configured to provide structural integrity to the support frame without obstructing air streamed through the air filter.

15. The air filter of claim 14, wherein the rim is silicone rubber, foam rubber, or integral skin polyurethane foam.

16. A method, comprising:

coupling a second media layer to a first media layer to form a compound filter medium, the first media layer having a pleated configuration including a plurality of pleats, the coupled second media layer having at least an electrostatic portion treated with a coating of antimicrobial molecules configured to destroy microbes;

molding a rim over a wire mesh to form a support frame for the compound filter medium; and

coupling the compound filter medium to the support frame to form an air filter configured to sequester airborne contaminants from air streamed through the air filter wherein the support frame is constructed of a single molded rim disposed along a perimeter of the filter medium and configured to orient the filter medium within an air filtering system, and further wherein:

the first media layer is disposed between the second media layer and the support frame such that inner-pleat folds of the plurality of pleats are coupled to the support frame at both ends of each of the inner-pleat folds and outer-pleat folds of the plurality of pleats are coupled to the second media layer along an entire length of each of the outer-pleat folds,

wherein the first media layer includes a plurality of bosses embossed in the first media layer between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds, and

wherein the plurality of bosses are configured with a shape and orientation to (i) provide structural integrity to the first media layer in the pleated configuration without obstructing air streamed through the air filter, and (ii) inhibit lateral air flow perpendicular to the plurality of bosses.

17. The method of claim 16, wherein:

coupling the second media layer to the first media layer includes adhering the outer-pleat folds of the plurality of pleats to the second media layer either continuously or at discrete points along an entire length of each of the outer-pleat folds, and

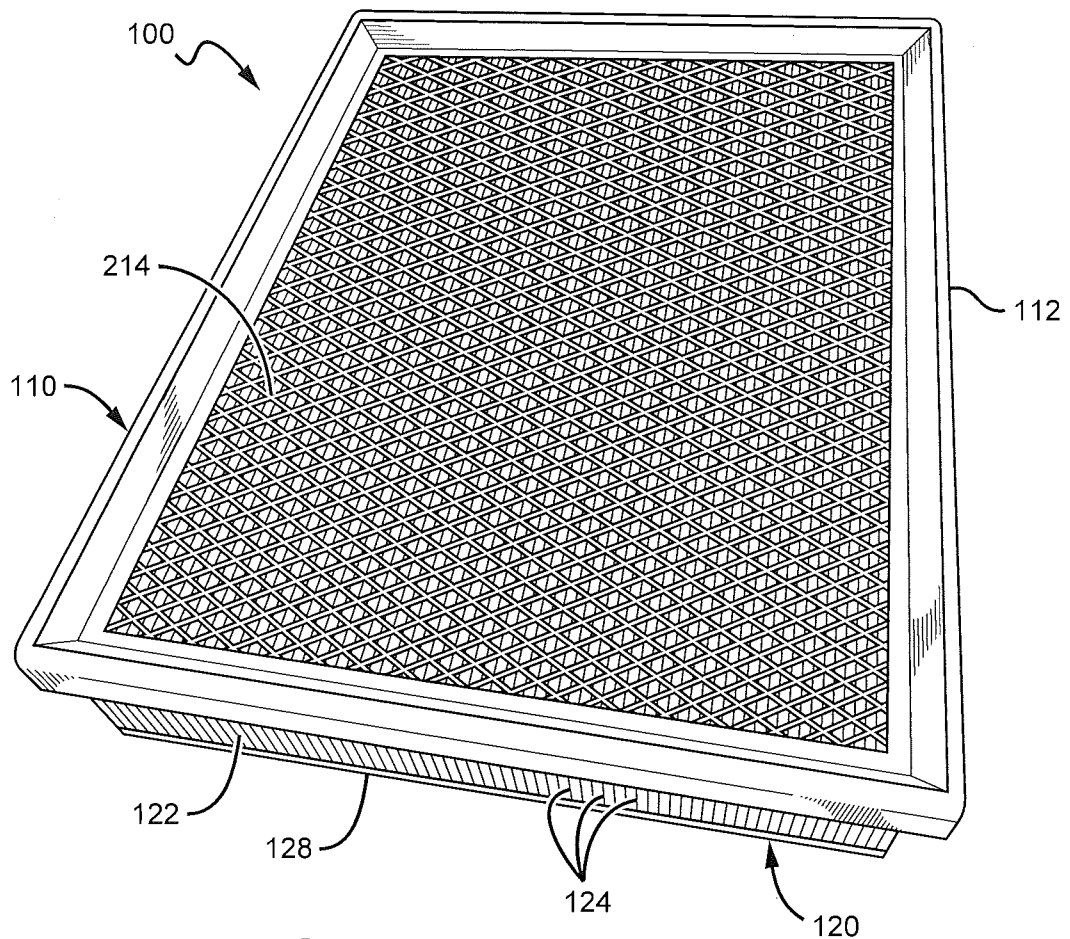
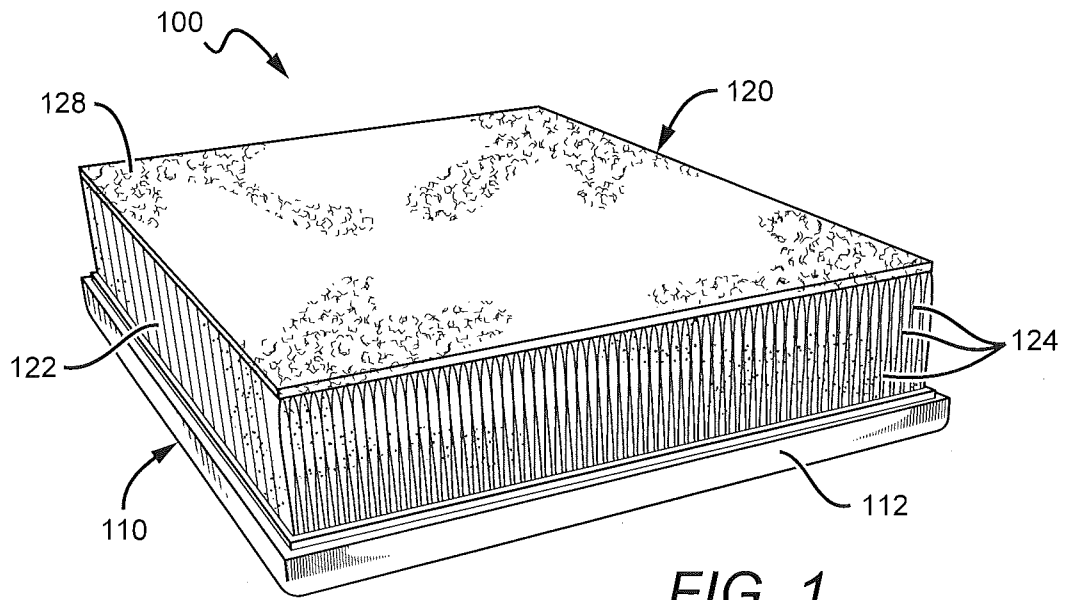
coupling the compound filter medium to the support frame includes adhering the inner-pleat folds of the plurality of pleats to the support frame at both ends of each of the inner-pleat folds.

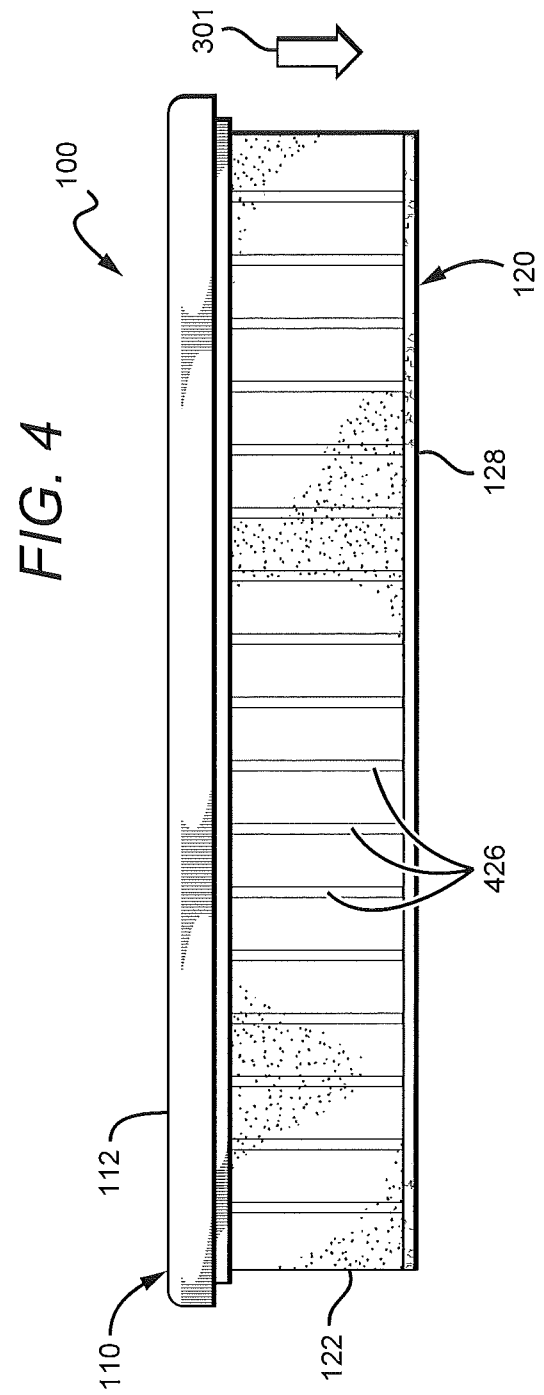
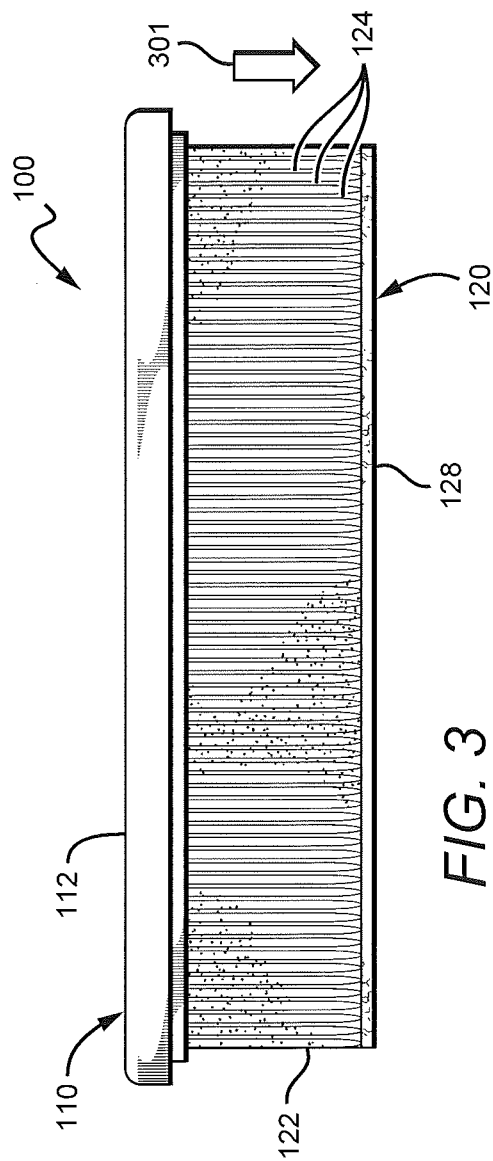
18. The method of claim 16, wherein:

each inner-pleat boss of the inner-pleat folds and the adjacent outer-pleat boss of the outer-pleat folds are directly opposite each other in the first media layer.

19. The method of claim 18, further comprising:

pleating the first media layer into the pleated configuration such that the plurality of bosses are set-wise embossed in the first media layer between each inner-pleat fold of the inner-pleat folds and an adjacent outer-pleat fold of the outer-pleat folds.





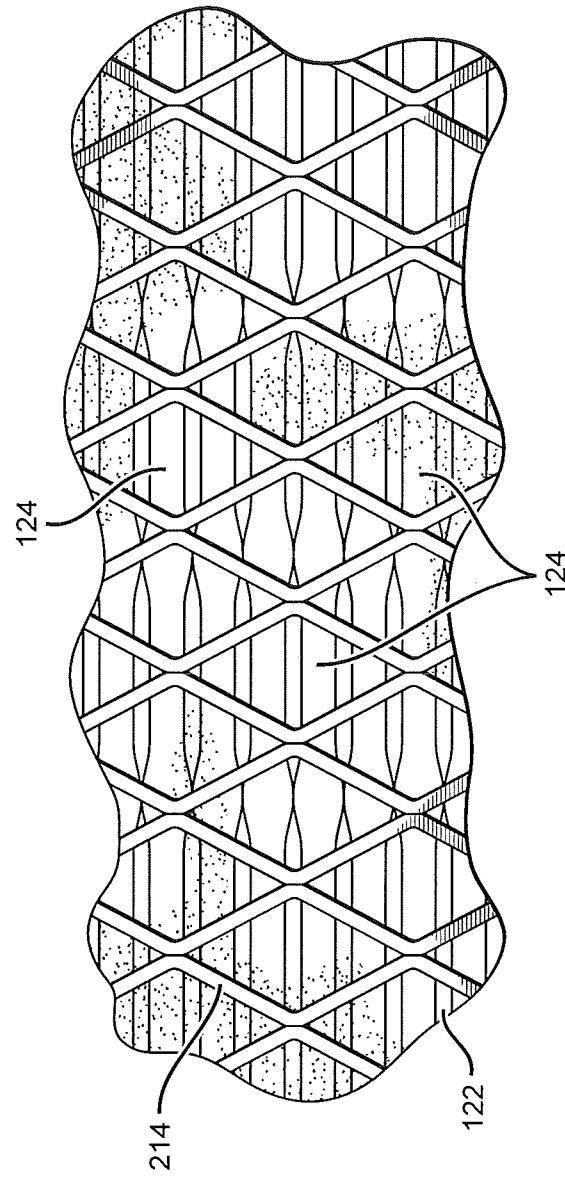


FIG. 5

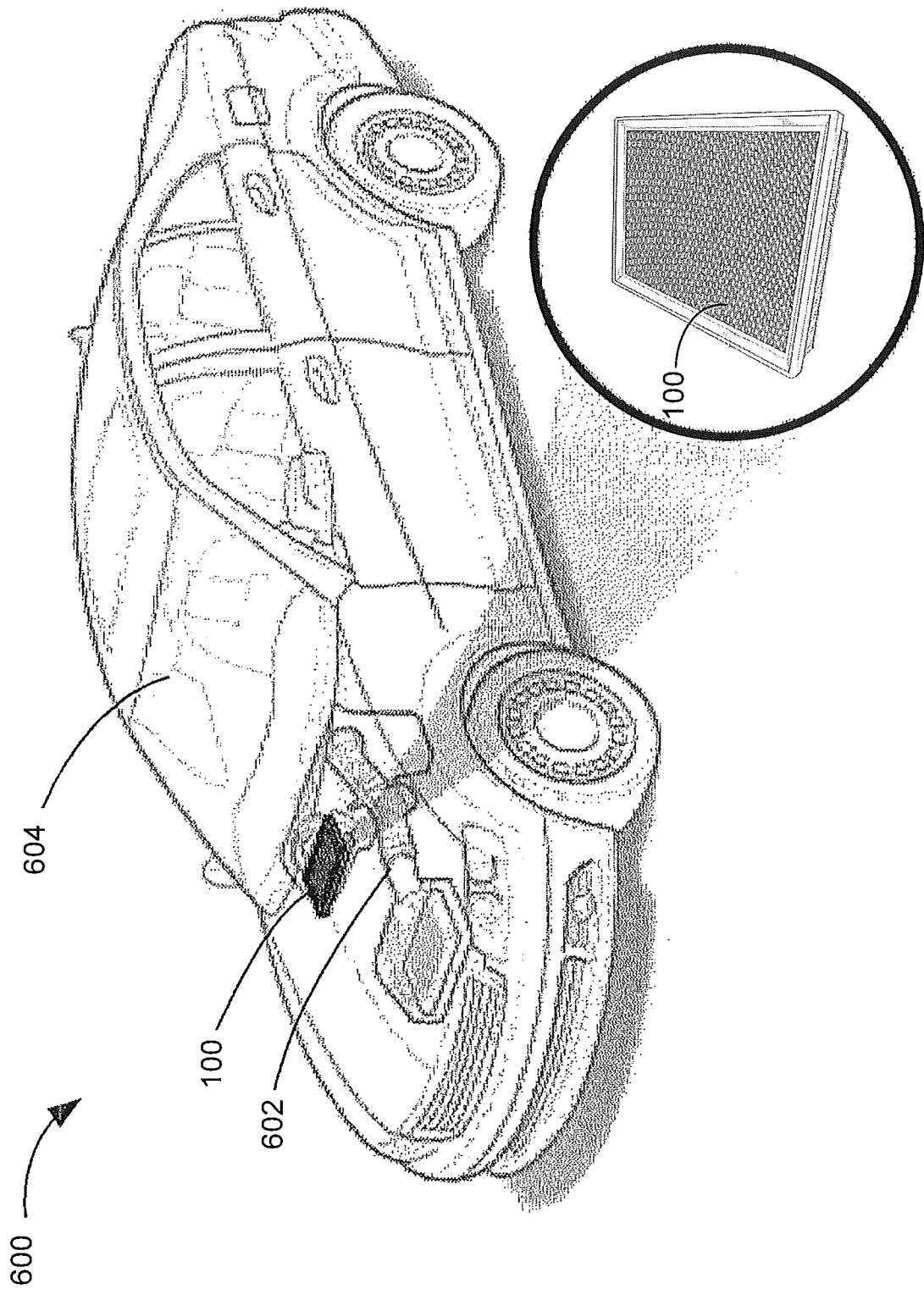


FIG. 6

