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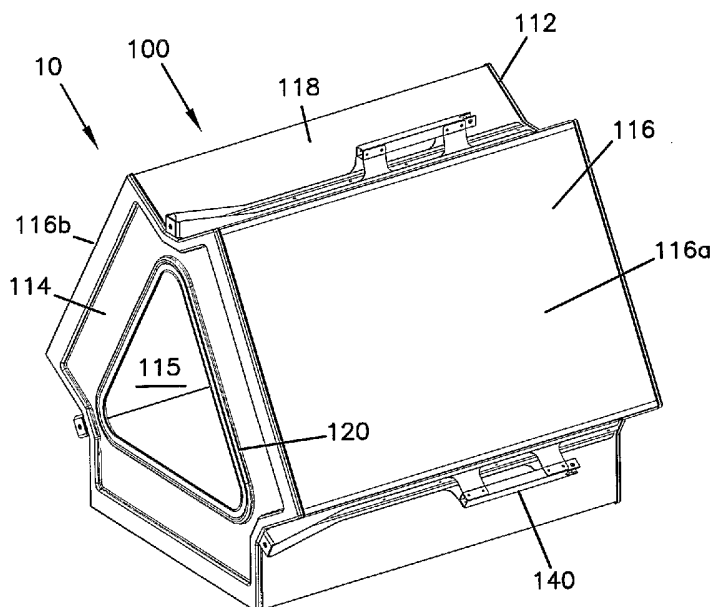
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(54) Title: NON-CYLINDRICAL FILTER ELEMENTS, AND METHODS



(57) Abstract: A filter element that has at least two, planar, non-curved filtration panels. In a preferred embodiment, the filter element has three panels, providing a generally triangular filter element. The outlet aperture, from the filter element, generally follows the configuration of the filter. That is, a filter element having three filtration panels will have a generally three-sided outlet aperture. The outlet aperture preferably is not a true polygon, but rather, includes rounded or curved sides and/or corners. The filter element includes an outlet sealing configuration that may provide both axial and radial sealing to outlet ductwork.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

NON-CYLINDRICAL FILTER ELEMENTS, AND METHODS

This application is being filed on 3 February 2006, as a PCT International Patent application in the name of Donaldson Company, Inc., a U.S. national
5 corporation, applicant for the designation of all countries except the US, and Jarren B. Mills, Daniel E. Adamek, and Richard P. DeJong, all citizens of the U.S., and claims priority to U.S. Provisional Application Serial Number 60/650,019 filed February 4, 2005, U.S. Provisional Application Serial Number 60/733,978 filed November 3, 2005, and U.S. Utility Application Serial Number unknown, filed
10 February 2, 2006.

Field

The present invention relates to a fluid filter for removing contaminants from a gaseous stream, such as an air stream.
15

Background

Filter elements are used in many industries to remove airborne contaminants to protect people, the environment, and often, a critical manufacturing process or the products that are manufactured by the process.
20 There is always a need to design different filter elements.

Summary of the Invention

Non-cylindrical filter elements are provided. Preferably, the filter elements have at least two flat or planar filtration panels. Fluid, such as air, to be filtered
25 enters the filter element through the panels, preferably through each of the panels. An outlet aperture is provided, which has generally the same shape as the cross-sectional shape of the filter. A filter element having three filter elements will be generally triangular in shape and have a generally triangular outlet aperture.

The design of the present filter element can be such that both axial and radial
30 seals are formed between the outlet aperture and any outlet duct or piping. The filter element can include an integrally molded outlet flange or collar for connecting to an outlet duct.

Various problems are solved by the design of the present disclosure. The filter element of the present disclosure, by having a non-circular outlet aperture, increases the outlet area to thus decrease outlet velocity and decrease pressure drop. The non-circular cross-section limits the possible orientations for adjoining ductwork, which is desired for some installations; a circular outlet has infinite orientations, which may be a non-preferred configuration for some installations.

Brief Description of the Drawings

Referring now to the drawings, wherein like reference numerals and letters indicate corresponding structure throughout the several views:

FIG. 1 is a perspective view of a filter element according to the present invention;

FIG. 2 a perspective view of the filter element of FIG. 1 operably connected to an outlet duct;

FIG. 3A is an end view of the filter element of FIG. 1;

FIG. 3B is similar to FIG. 3A;

FIG. 4A is a cross-sectional view of the filter element taken along line 4-4 of FIG. 3A, the filter element including the outlet duct thereon;

FIG. 4B is an enlarged section of a portion of FIG. 4A detailing the outlet seal;

FIG. 5 is a perspective view of a second embodiment of a filter element according to the present invention;

FIG. 6A is an end view of the filter element of FIG. 5;

FIG. 6B is similar to FIG. 6A; and

FIG. 6C is a cross-sectional view of a portion of the filter element of FIG. 6A taken along line 6-6.

Detailed Description

Referring now to the Figures, a filter element according to the present invention is shown at 10 in FIGS. 1 through 4B. Filter element 10 is a fluid filter; that is, filter element 10 filters out or removes contaminants from a fluid stream. In many embodiments, filter element 10 is a gas filter, configured for removal of contaminants from a gas stream. In most embodiments, the gas being filtered is air.

Filter element 10 is particularly suitable for use in an aircraft or other lightweight vehicle, for filtering cabin air. In a passenger aircraft, filter element 10 would generally be located in a cargo hold, below the passenger cabin.

In use, filter element 10, in many embodiments, is removably positioned in a housing, duct, or other structure. The housing, duct or other structure may or may not complete enclose or envelope filter element 10.

Filter element 10 has a first end 12 and an opposite second end 14. Filter element includes filtration panels 16 and support structure 18, which will be described below. Together, panels 16 and support structure 18, between first end 12 and second end 14, define a filter interior 15. Panels 16 provide fluid access into and out from interior 15. Second end 14 includes an aperture 20, which provides fluid access to and from interior 15. In FIGS. 2, 4A and 4B, a duct 44 is attached to aperture 20. In the preferred configuration, panels 16 provide fluid access into interior 15, and are thus the inlet into interior 15 of filter 10. Thus, fluid to be filtered passes through panels 16 and panels 16 provide filtration. In line with panels 16 being the inlet into filter 10, aperture 20 provides access out from interior 15, and thus is the outlet from interior 15 of filter 10. Panels 16 are radially positioned in relation to interior 15, and aperture 20 is axially positioned in relation to interior 15. With such a configuration, the fluid being filtered changes direction, e.g., turns, when moving from panels 16 (e.g., the inlet) to aperture 20 (e.g., the outlet). Generally, no air or other fluid passes out from interior 15 through panels 16.

Filter element 10 is generally a non-cylindrical element. In the particular embodiment illustrated, filter element 10 is a three-sided filter element 11, composed of three panels 16, which are generally flat or planar. By the terms "generally flat" or "generally planar", what is intended is that the panel may not be completely flat or planar (i.e., having a surface angle of 0 degrees), but may include a slight dip, indentation variation, bend, or the like on its surface or structure; overall, the overall surface angle of a "generally planar" or "generally flat" panel, from end-to-end, is no more than 10 degrees, preferably no more than 5 degrees. In some embodiments, filter element 10 has no rounded or curved surfaces, e.g., panels 16, that provide filtration.

Filter element 10 includes at least two filtration portions or panels 16; preferably filter element 10 includes at least three filtration panels 16. For three-

sided filter element 11, panels 16 are indicated as first panel 16a, second panel 16b, and third panel 16b. It is understood that filter element 10 could have any number of panels 16, however, as the number of panels 16 increases the cost of designing and assembling such a filter 10 generally increases, thus, less panels 16 are preferred.

5 Preferred numbers of panels 16 include three, four, six, and eight.

The at least two panels 16 are positioned angled to other or they may be opposite each other. The at least two panels 16 may be evenly spaced. For example, a filter element having two panels 16 may have the panels 16 opposite to and parallel to each other. As another example, filter element 10 has three panels 16a, 16b, 16c
10 spaced apart approximately 120 degrees. Alternately, a filter element having two panels 16 may have panels 16 angled with respect to each other, for example, at an angle of 90 degrees. It is understood that other degrees, other than 0 degrees (i.e., having the panels 16 planar to or co-planar with each other), are suitable.

Preferably, each of panels 16a, 16b, 16c is the same size, shape and filtration
15 material, although it is not necessary that all panels have the same size, shape and/or filtration material. Panels 16 are planar or flat; that is, they are not rounded or curved. The planar or flat characteristic is due to the rigid material used for panels 16. In future embodiments, it may be possible to provide non-planar or curved panels, however, the present application is directed to using planar, non-curved
20 filtration panels 16.

Panels 16 are held together by a support structure 18, which can be any combination of suitable frames, pieces, and materials to provide support to panels 16 and define interior 15 and aperture 20. Examples of suitable materials for any portion of support structure 18 include metals (e.g., aluminum, titanium), polymeric
25 or plastic materials (e.g., polyethylene, polyethylene terephthalate, polypropylene, polycarbonate, urethane or polyurethane), composite materials, or any combinations thereof.

In one embodiment, support structure 18 includes aluminum metal bent as a frame to support panels 16 and a hard polymer material molded to engulf the metal
30 frame and seal interior 15 from the exterior of element 10. In another embodiment, support structure 18 includes hard plastic molded as a frame to support panels 16 and a soft polymer material molded to engulf the hard plastic frame and seal interior

15 from the exterior of element 10. Support structure 18 may include details and features to attach filter 10 to mounting brackets or other supporting structures.

Panels 16 of filter element 10 (or, for the specific embodiment illustrated, panels 16a, 16b, 16c of filter element 11) filter particulate and chemical
5 contaminants from the fluid passing therethrough. Panels 16 may include a single feature or layer that accomplishes both chemical and particulate removal from the fluid passing therethrough. However, as in a preferred embodiment, panels 16 include multiple features or layers. Referring to FIG. 4A, panel 16c is illustrated having four layers, first media layer 22, second media layer 24, third medial layer 26
10 and fourth media layer 28.

A first example of a suitable layer, for any of media layers 22, 24, 26, 28 is a low pressure drop, rigid article having a plurality of passages therethrough, the passages having surfaces with adsorptive material. Fluid passes through the passages following the direction of the passage, which is generally in a straight line.
15 Contaminants present in the fluid are adsorbed, absorbed, trapped, retained, reacted, or otherwise removed from the fluid by the adsorptive material. The rigid article can be configured for removal of specific contaminants. For example, the article can be designed for the removal of acidic materials, of basic materials, organic materials, or any combination thereof.

20 Examples of such rigid articles are taught in U.S. Patent No. 6,645,271 (Sequin et al.), the entire disclosure of which is incorporated herein by reference. Pending U.S. patent application having serial number 10/947,732 (Ding et al.), filed Sept. 23, 2004 entitled "Adsorptive Filter Element and Methods" provides rigid elements specifically designed for the removal of carbonyl-containing compounds;
25 this application is incorporated herein by reference. It is understood that the rigid elements, or any of the filtration elements described herein, can be modified from their original design to obtain the desired properties for this application. For example, at anytime during the manufacturing process of rigid articles, the substrate of the articles may be treated to obtain the desired final characteristics for the
30 articles. For example, an aluminum substrate may be etched or otherwise treated to increase the adhesion of a binder to the surface, or for other reasons.

Another example of a suitable layer for any of media layers 22, 24, 26, 28 is a low pressure drop fibrous article having a plurality of passages therethrough, the

fibrous material having been impregnated with various materials to adsorb, absorb, or react with contaminants. Pending U.S. patent application having serial number 10/928,776 (Dallas et al.), filed Aug. 27, 2004 entitled "Acidic Impregnated Filter Element, and Methods" provides impregnated porous elements specifically designed
5 for the removal of basic or alkaline compounds; this application is incorporated herein by reference. Pending U.S. patent application having serial number 10/927,708 (Dallas et al.), filed Aug. 27, 2004 entitled "Alkaline Impregnated Filter Element, and Methods" provides impregnated porous elements specifically designed for the removal of acidic compounds; this application is incorporated herein by
10 reference. Pending U.S. patent application having serial number 11/016,013 (Ding et al.), filed Dec. 17, 2004 entitled " Impregnated Filter Element, and Methods" provides impregnated porous elements specifically designed for the removal of carbonyl-containing compounds; this application is incorporated herein by reference. Additional details regarding removal of alkaline materials, acidic materials,
15 carbonyl-containing compounds, and organics, are provided in pending PCT application having serial number US05/30577, filed August 25, 2005.

A third example for a suitable layer for any of media layers 22, 24, 26, 28 is a fibrous or particulate filtration layer. Suitable examples of a particulate layer include mats of randomly placed non-woven fibers, thin layers of conventional filtration
20 media, and pleated conventional filtration media. A preferred filtration media to use is HEPA media.

HEPA filters are known in the art of filters as "high-efficiency particulate air" filters. HEPA media is the media of the filter that provides the filtration efficiency. HEPA media has a minimum efficiency of 99.97% removal when tested with
25 essentially monodispersed 0.3 micron particles. The media may be any suitable HEPA media and may be made from cellulose, polymeric materials (e.g., viscose, polypropylene, polycarbonate, etc.), glass or fiberglass, or natural materials (e.g., cotton). Other HEPA media materials are known. Microfibrous glass is a preferred material for HEPA media. A suitable HEPA media for aircraft applications is that
30 commercially available as H&V "HB-7633".

Any of the fibrous or media materials may be electrostatically treated and/or include one or more layers of material. One or more layers of fine fiber, such as taught by U.S. Patent No. 6,673,136 (Gillingham et al.), may be included.

Any or all of these various media layers may be provided in any order to provide panel 16.

Referring again to FIG. 4A, panel 16 is illustrated as having first media layer 22, second media layer 24, third media layer 26 and fourth media layer 28. In a preferred construction, first media layer 22 is a pleated HEPA filter element configured for particulate removal, second media layer 24 is a rigid media having impregnated absorbent materials (such as taught by U.S. Patent No. 6,645,271), third media layer 26 is a rigid media having impregnated absorbent material (such as taught by U.S. Patent No. 6,645,271), and fourth media layer 28 is a rigid media configured for carbonyl-containing compound removal, particularly for aldehyde removal (such as taught by U.S. patent application no. 10/947,732). Thus, in use, fluid to be filtered would first pass through the HEPA filter, then through two rigid layers to remove acids and bases, and then through a layer to remove aldehydes. It is understood that this is an exemplary configuration for the media layers, and that other arrangements are suitable. For example, none, one, two, or any number of the media layers may be rigid and/or impregnated, or the various layers may be impregnated with different materials and/or arranged to provide a different path through the layers.

The filtered fluid, such as air, arrives in interior 15 of filter element 10. From interior 15, the fluid exits filter element 10 via aperture 20.

Aperture 20 is present at second end 14 of element 10. Aperture 20 includes an outlet aperture 30 that provides access into and out from interior 15. In the particular embodiment, outlet aperture 30 is a three-sided outlet aperture 31, as will be further described below. Surrounding aperture 30 is an outlet collar or flange 32. Collar 32 preferably has a circular outer perimeter, for reasons which will be described later.

Outlet aperture 30 preferably has the same number of sides as there are number of panels 16. For three-sided filter element 11, the aperture is a three-sided outlet aperture 31. Aperture 31, and any non-round aperture 30, need not be a true polygon, but can include rounded or curved sides and/or corners. See for example, FIG. 3A. Aperture 31 has a general triangular shaped, but with rounded angles or corners and curved sides; aperture 31 could be referred to as having a tri-oval or a tri-lobal shape.

The shape of outlet aperture 30 is selected to correspond to the overall shape of filter element 10, which is dependent on the number of panels 16. Outlet aperture 30 preferably follows the same general shape as interior 15, formed by panels 16 and support structure 18. Having outlet aperture 30 generally correspond to the shape of interior 15 allows a larger outlet aperture area than if a circular outlet were used. For example, for aperture 31, the three corners extend farther out than would a circular outlet, thus obtaining more outlet area. Increased outlet area is desired as it decreases the velocity of the exiting fluid, thus decreasing pressure losses.

Collar 32 is configured to receive duct 44 (see FIGS. 2 and 4A) and provide a leak-free seal therebetween. The particular configuration of collar 32 provides both axial and radial sealing to duct 44. As best seen in FIGS. 3A and 4B, collar 32 includes an inner perimeter surface 34, a stop or longitudinal surface 36, a chamfered edge 38 on the inner surface 34, and outer perimeter surface 40 opposite inner surface 34, and a retaining lip 42 at outer surface 40. Inner surface 34, stop 36 and chamfered edge 38 have the same general shape as aperture 30, which in the illustrated embodiment, is aperture 31. Outer perimeter surface 40 and retaining lip 42 have a generally circular shape.

Collar 32 can be formed, typically molded, together with support structure 18; collar 32 may be integral with support structure 18. Such a configuration eliminates the need for a separate flange to be attached to filter element 10.

Referring to FIGS. 2 and 4A, duct 44 is configured to fit within collar 32 and specifically, within inner perimeter surface 34. Duct 44 is specifically configured to fit with the tri-oval or tri-lobal shape of aperture 31. By having duct 44 formed to the same shape as aperture 31, only three proper orientations of duct 44 are available, which in some configurations is more preferable than an infinite number of orientations, which would be the case if the duct was circular and formed to a circular outlet aperture. Duct 44 includes a transition region 46, which changes from tri-oval or tri-lobal to circular, thus allowing filter element 11 to be connected to circular ductwork.

To connect duct 44 to filter element 10 via aperture 20, as illustrated in FIGS. 4A and 4B, duct 44 is slid into collar 30, facilitated by chamfered surface 38. Duct 44 is pushed in to seal against both inner surface 34 and stop 36. A radial seal is formed between duct 44 and inner surface 34 and an axial seal is formed between

duct 44 and stop 36. A band clamp 50 (seen in FIG. 4B) is used to tighten against collar 30 and duct 44. Band clamp 50 is positioned on collar 32 against outer surface 40, between retaining lip 42 of collar 32 and bead 48 on duct 44. Positioning between lip 42 and bead 48 improves the stability of clamp 50 and reduces the chance of it pulling off.

As stated above, collar 32 has a circular outer perimeter. When band clamp 50 is positioned on collar 32 behind retaining lip 42, band clamp 50 contacts collar 32 continuously around the perimeter and, thus, the pressure exerted by band clamp 50 is a uniformly distributed load around collar 32 and duct 44.

Referring to FIGS. 5 and 6A, 6B, 6C, a second embodiment of a filter element 10 according to the present invention is illustrated. The particular embodiment of filter element 10 of these figures is filter element 100. It is to be understood that any of the features from filter element 10 could be used for filter element 100, in any combination, and vice versa.

Filter element 100 has a first end 112 and an opposite second end 114. Filter element includes filtration panels 116 and support structure 118. Together, panels 116 and support structure 118, between first end 112 and second end 114, define a filter interior 115. Panels 116 provide fluid access into and out from interior 115, thus providing an inlet into interior 115. Second end 114 includes an aperture 120, which provides fluid access to and from interior 115, and thus providing an outlet from interior 115. In this embodiment, first end 112 includes indicia thereon; it is understood that any filter element embodiment may include indicia, or, no indicia may be present. Such indicia can be used to identify the manufacturer of filter element 100, or to convey, for example, installation instructions.

Filter element 100 is a non-cylindrical element, particularly, a three-sided filter element composed of three planar or flat panels 116. Filter element 100 has no rounded or curved surfaces that provide filtration.

Filter element 100 includes at least two filtration portions or panels 116; in this embodiment, filter element 100 has three panels 116, which are indicated as first panel 116a, second panel 116b, and third panel 116c. Preferably, each of panels 116a, 116b, 116c is the same size, shape and filtration material, although it is not necessary that all panels have the same size, shape and/or filtration material. Panels 116 are preferably planar or flat; that is, they are not rounded or curved.

Panels 116 filter particulate and chemical contaminants from the fluid passing therethrough. Panels 116 may include a single feature or layer that accomplishes both chemical and particulate removal from the fluid passing therethrough. Although not specifically illustrated, each panel 116 of this
5 embodiment is composed of multiple layers, similar to filter element 11. The same materials suitable for panels 16 are suitable for panels 116.

Aperture 120 of filter element 100 provides access into and out from interior 115. In the particular embodiment, aperture 120 is a three-sided outlet aperture, as will be further described below, defined by structure 122, which is similar to collar
10 32 of filter element 11 in many aspects. Structure 122 includes an outer surface 124 and an inner perimeter surface 134. In this embodiment, outer surface 124 and inner surface 134 of structure 122 have generally the same shape, i.e., they are both generally triangular, unlike for filter element 11 wherein outer surface 40 is generally circular and inner surface 34 is generally triangular.

15 Aperture 120 and structure 122 have the same number of sides as there are number of panels 116, i.e., three for this embodiment. Aperture 120 and structure 122 have a generally triangular shape, but with rounded angles or corners. The shape of aperture 120, and in this embodiment, of structure 122, is selected to correspond to the overall shape of filter element 100.

20 Referring to FIG. 6C, an enlarged of a portion of structure 122 is illustrated, in close proximity to a mounting bracket 150, onto which filter element 100 will be seated. As provided above, structure 122 is similar to collar 32 of filter element 11, except that, for example, structure 122 does not extend away from structure 118 in the same manner that collar 32 extends away from structure 18. Structure 122
25 includes a channel, trough, or other recessed area which retains a seal 136.

Structure 122, in particular seal 136, has a low or no-clearance; that is, structure 122 extends no more than about 1 cm, preferably no more than about 0.5 cm, past support structure 118 of filter element 100. In preferred embodiments, structure 122 is flush with or recessed in toward end 114.

30 In use, filter element 100 will be operably sealed against bracket 150 at structure 122, in particular at seal 136, to provide a leak-free seal. Bracket 150 includes a protrusion 155 extending toward filter element 100. Protrusion 155 can

be a radiused or sloped bead, and have a height of at least about 0.1 cm (1 mm), or at least about 0.25 cm.

Prior to use, filter element 100 is slid into placed against bracket 150. Having structure 122 with a low or no-clearance facilitates sliding filter element 100 into its position, with minimal clearance needed between bracket 150 and filter element 100.

When properly seated, filter element 100, via seal 136, forms an axial seal with bracket 150. Depending on the configuration of protrusion 155, a radial seal may also be formed. Seal 136 is sufficiently deformable, flexible and/or resilient to allow protrusion 155 to embed into seal 136; seal 136 is generally a low-durometer material. Examples of suitable material for seal 136 include urethanes, polyethylenes, silicone, rubbers, and other similar materials. Seal 136 may be, for example, a rolled seal, may be formed-in-place, such as by a one-component or multiple-component foam or gel that is poured into place. The engagement of seal 136 with protrusion 155 and bracket 150 should be a continuous seal, with no breaks.

Filter element 100 may be seated in a generally horizontal position, as illustrated in the figures, with the outlet being generally horizontal out from interior 115, or, filter element 100 may be seated in a generally vertical position, with the outlet being generally vertical above or below interior 115.

Filter element 100 includes three mounting elements 140 and three mounting elements 145. In this embodiment, mounting elements 140 function both as handles, to facilitate moving and lifting of filter element 100, and as mounting mechanisms, to mount and lock filter element in a desired position, for example, for use. Mounting elements 145 also mount and lock filter element 100 in the desired position. It is not necessary that all three mounting elements 140 and three mounting elements 145 are used; this will depend on the housing, duct, or other structure to which filter element 100 is mounted. For example, only two mounting elements 140 together with all three mounting elements 145 may be used. Other configurations of mounting elements can also be used.

It is understood that mounting elements 140 may be used for mounting of element 100 and a separate structure can be used to facilitate moving and lifting of the filter element, or, mounting elements 140 may be used solely as handles.

Referring to the reference numerals in FIGS. 3B, 4A, 6A and 6B, the following properties and dimensions are suitable examples for filter elements 10, 100.

5

	Filter element 10	filter element 100
Panel size	17.5 x 25 inches	
# of panels 16	3	3
panel thickness	4.6 inches	
# layers in panel 16	4	
layer 1	pleated HEPA filter (having a thickness of about 1.5 inches) with hot melt adhesive spacer beads between the pleats	pleated HEPA filter (having a thickness of about 1.5 inches)
layer 2	rigid absorption filtration media layer (having a thickness of about 1.04 inches)	
layer 3	rigid absorption filtration media layer (having a thickness of about 1.04 inches)	
layer 4	rigid absorption filtration media layer (having a thickness of about 1.04 inches)	
A	25.31 inches	25.96 inch
B	22.75 inches	22.53 inches
C	17.00 inches	17.14 inches
D	3.80 inch radius	
E	2.75 inch radius	
F	16.00 inch radius	
G	15.25 inch radius	
H	15.00 inch diameter	
I	25.00 inches	25.00 inches
J		11.56 inches

Additionally, for an embodiment of filter element 10, the widest dimension, in one direction, is about 26.3 inches, and, in another direction, is about 22.8 inches.

Additionally, in this embodiment, collar 32 extend pasts panels 16 by about 2 inches. The approximate diameter of aperture 31 is 15.25 inches, with the corners of aperture 31 being radiused to 2.75 inches. Such an outlet aperture has an area of about 94.7 square inches; a comparable circular outlet would have an area of about 38.5 square inches. Circumscribing aperture 31 is an outer surface 40, which follows the shape of aperture 31. Outer surface 40 has an approximate diameter of 10 inches with the corners being radiused to 3.5 inches.

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

15

What is claimed:

1. A filter element comprising:
 - (a) at least two generally planar filtration panels;
 - (b) a support structure supporting the at least two planar filtration panels, and together with the at least two planar filtration panels, defining an interior; and
 - (c) a non-circular aperture axially positioned in relation to the at least two generally planar filtration panels.
2. The filter element of claim 1, comprising:
 - (a) an inlet being the at least two filtration panels; and
 - (b) an outlet defined by the non-circular aperture.
3. The filter element of claim 2, wherein:
 - (a) the support structure defines the non-circular aperture.
4. The filter element of claim 3, wherein:
 - (a) the non-circular aperture has an inner perimeter surface and an outer perimeter surface.
5. The filter element of claim 4 further comprising:
 - (a) a stop on the inner perimeter surface.
6. The filter element of claim 4, the inner perimeter surface comprising:
 - (a) a chamfered surface.
7. The filter element of claim 3, wherein the non-circular aperture comprises a seal.
8. The filter element of claim 7, wherein the seal is within a channel.
9. The filter element of claim 1, wherein:

- (a) the at least two generally planar filtration panels consist of three generally planar filtration panels; and
 - (b) the non-circular aperture is a tri-oval or tri-lobal aperture.
- 10. The filter element of any of claims 1-9, wherein:
 - (a) the at least two generally planar filtration panels comprises a multiple layers of filtration material.
- 11. The filter element of claim 10, wherein:
 - (a) the multiple layers of filtration material includes at least one layer of HEPA media.
- 12. The filter element of claim 10 or 11, wherein:
 - (a) the multiple layers of filtration materials includes at least one layer of rigid filtration material configured for absorption of a chemical contaminant.
- 13. The filter element of claim 12, wherein:
 - (a) the multiple layers of filtration materials includes at least two layers of rigid filtration material configured for absorption, the at least two layers being different.
- 14. A filter element comprising:
 - (a) three generally planar filtration panels;
 - (b) a support structure supporting the three generally planar filtration panels, the support structure:
 - (i) together with the three generally planar filtration panels, defining an interior; and
 - (ii) comprising a non-circular aperture axially positioned in relation to the three generally planar filtration panels;
 - (c) the filter element further comprising a seal around the non-circular aperture.

15. The filter element of claim 14, wherein the non-circular aperture is a tri-oval or tri-lobal aperture.
16. The filter element of claim 14, wherein the seal comprises a seal recessed in a channel.

FIG. 2

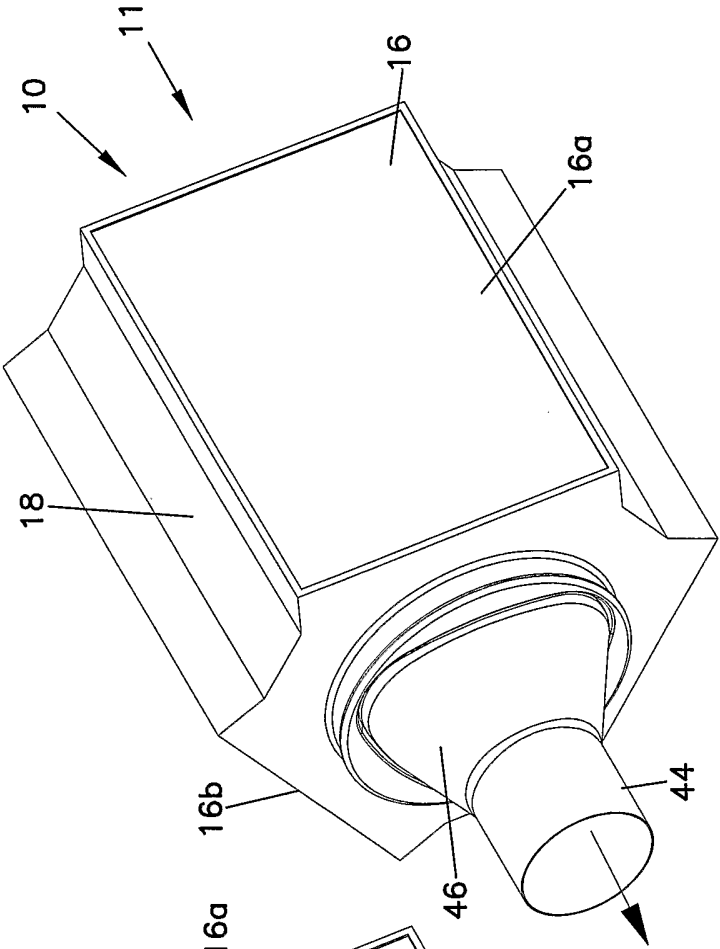


FIG. 1

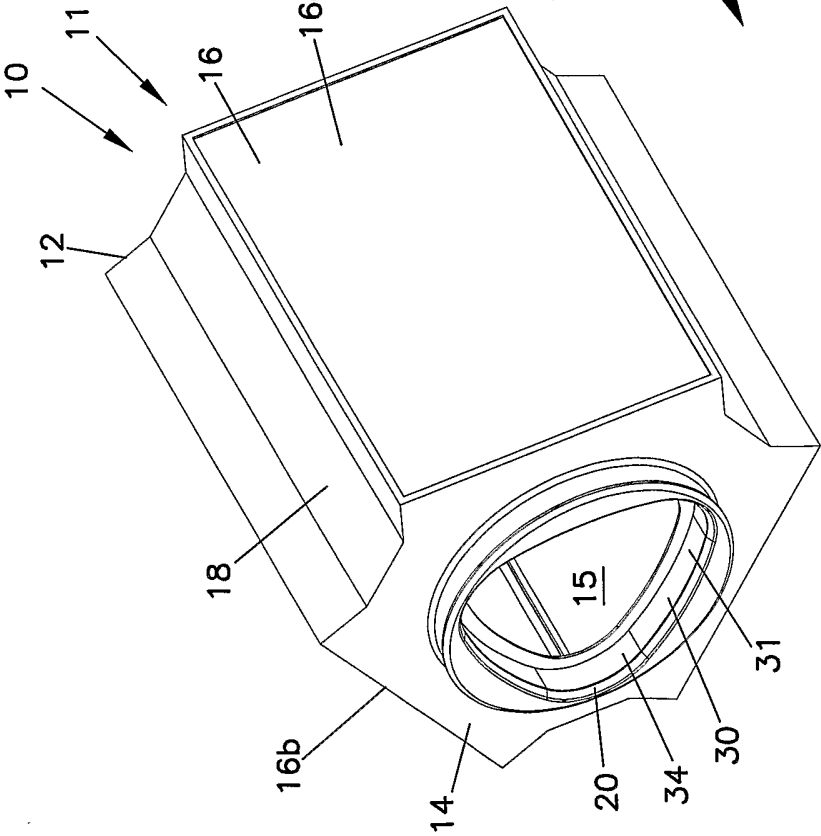


FIG. 3A

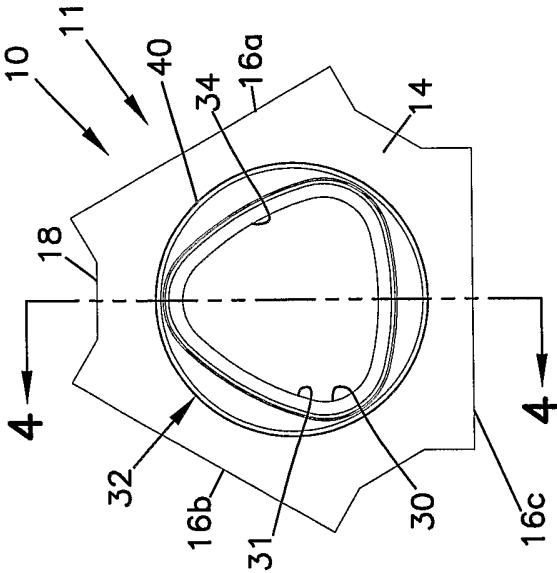


FIG. 3B

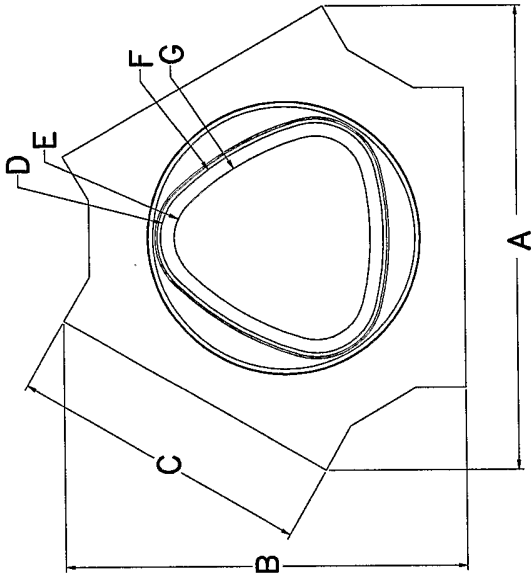


FIG. 4B

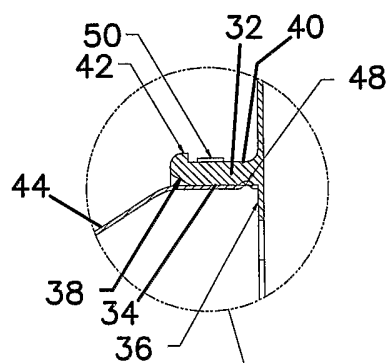


FIG. 4A

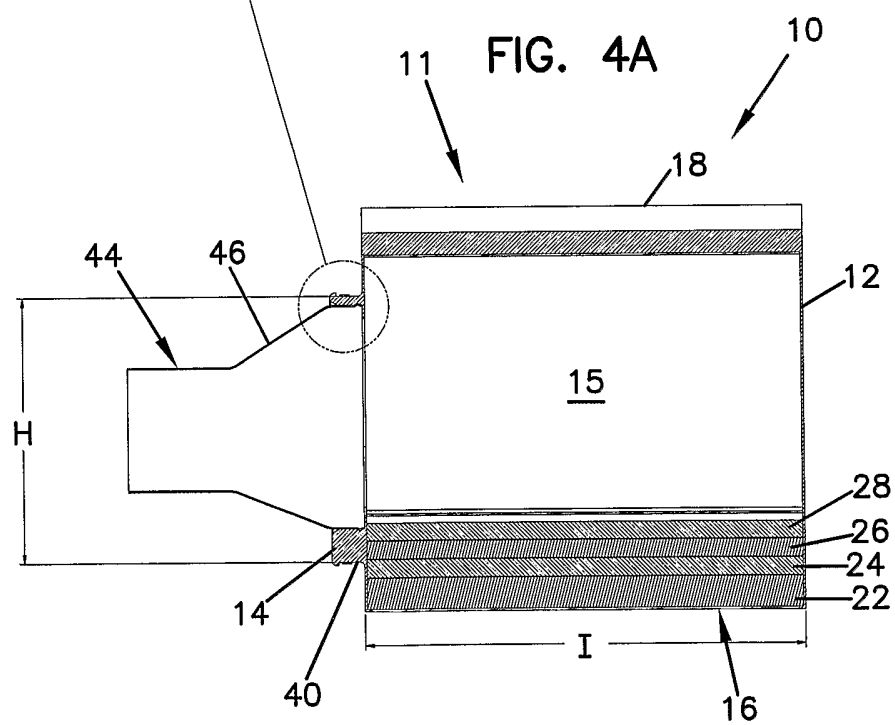


FIG. 5

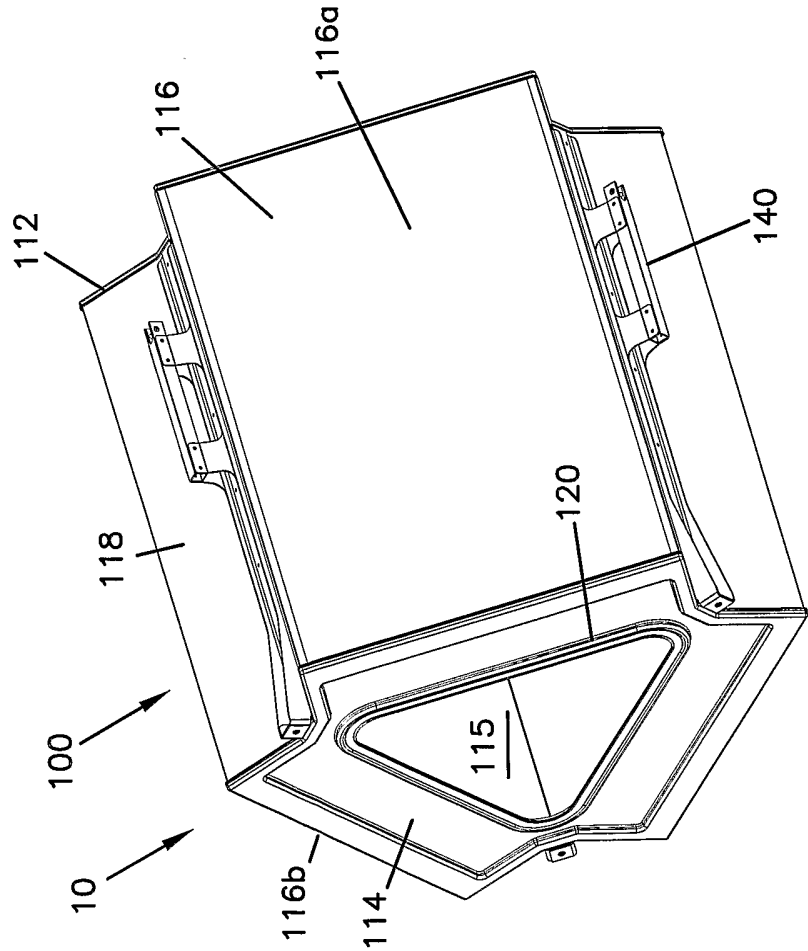


FIG. 6C

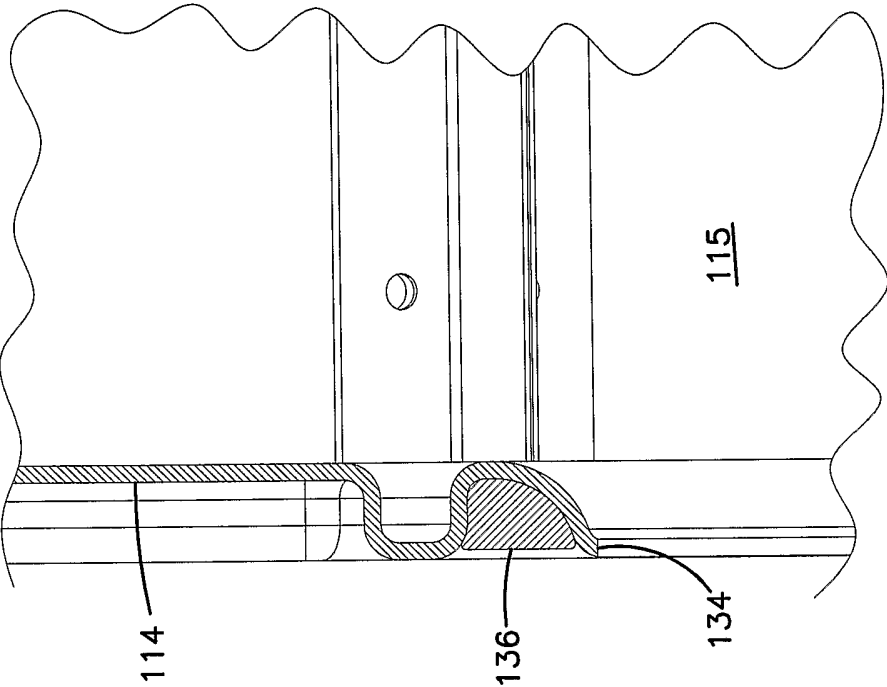


FIG. 6A

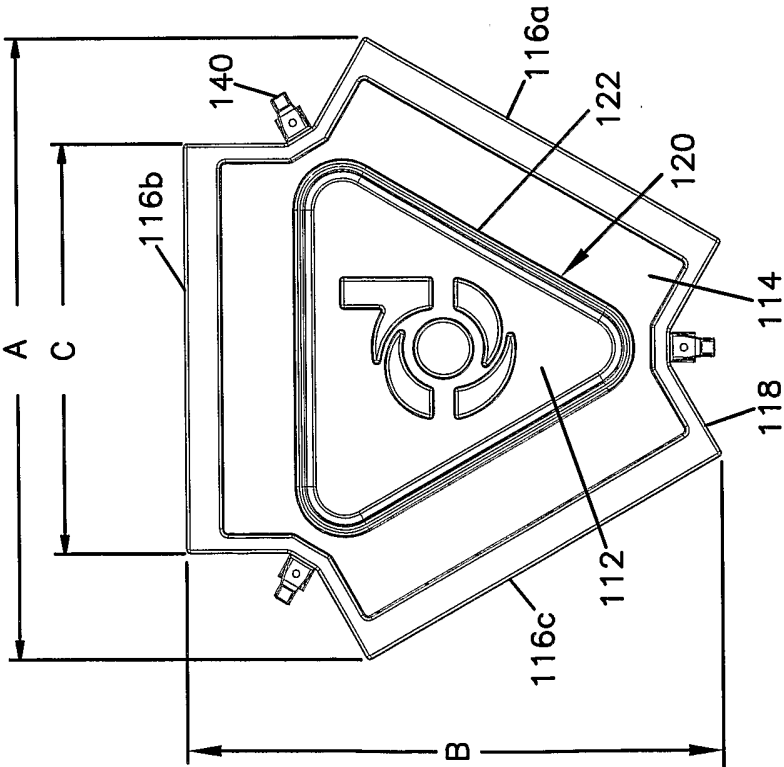


FIG. 6B

