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(54) **Title**: RESPIRATOR DEVICE

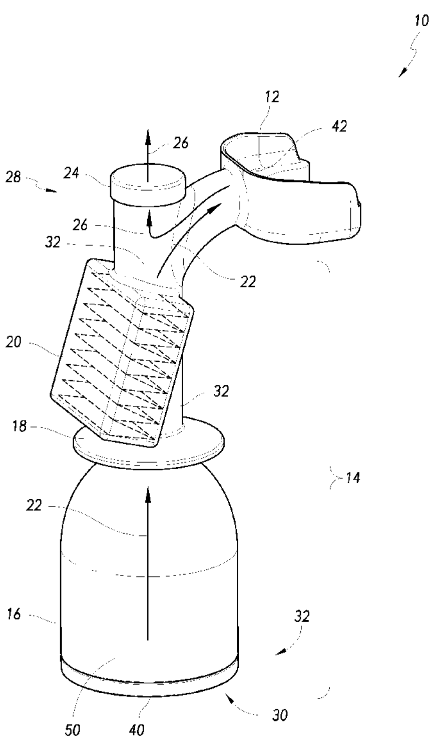

FIG. 1

(57) **Abstract**: A respirator system can be provided that includes a filtering chamber and a flow mechanism. The filtering chamber can have an inlet and an outlet and a flow path from the inlet to the outlet. The filtering chamber can have a longitudinal axis and a central portion that extends along the longitudinal axis. The flow mechanism can be positioned at the chamber inlet. The flow mechanism can include a top surface, a central axis, and a plurality of apertures extending through the flow mechanism. The plurality of apertures can be configured to generate vortical air flow along at least a portion of the flow path when air enters the inlet.

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RESPIRATOR DEVICE

BACKGROUND

[0001] An emergency or fire in a high-rise building requires immediate safe evacuation. Many high-rise building codes require safety features, such as alarms, sprinklers, and other systems. Whether commercial or residential, evacuation from a high-rise building requires quickly descending down the stairs or ascending to the roof top in order to be rescued. Although current rescue technology for mass evacuation can reach as high as a third floor level, safe evacuation from high-rise buildings can benefit tremendously from portable rescue breathing equipment to prevent smoke inhalation.

[0002] Toxic smoke inhalation accounts for the majority of fatalities of a fire — approximately 70% — which means that very few victims actually die from flame. With an increasing number of high-rises, and other factors, such as terrorist threats, reliable evacuation equipment has never been more critical. In response to this demand, a variety of escape devices have been conceived.

SUMMARY

[0003] Personal emergency breathing systems have been designed for use in fires and have addressed the problem of removing carbon monoxide and other toxic gases, i.e., cyanides, benzines, and the like. However, several drawbacks of such systems have been recognized and well documented.

[0004] For example, such systems are often bulky, sometimes require sizing for fitting particular individuals, and generally are not conducive to easy or practical day-to-day carriage or storage. These systems have employed a variety of fitting methods generally relying on multiple or single-strap arrangements requiring individual adjustment to ensure a proper airtight fit to the individual user. A tight fit between the mask and facial skin may not be possible in those who have a beard, painful facial scars, or deformities. Those who require corrective glasses can have trouble putting on the hood and maintaining vision. In an emergency or panic situation, such methods are time-consuming and confusing, especially in the case of multiple-strap arrangements. Claustrophobia is also a very real concern, as well as the clumsiness and consequent time-consuming placement of the device.

[0005] Further, and more importantly, other disadvantages of the such systems include low useful life (usually only 5 minutes) and the failure to prevent inhalation of activated charcoal particulate in the canister. Additionally, certain prior art systems are expensive to manufacture, do not lend themselves to a low retail cost, and hence, are effectively precluded from a cost standpoint from widespread distribution in necessary areas.

[0006] In accordance with an aspect of at least some of the embodiments disclosed herein, the present application discloses and teaches a respirator system and related methods of use for ensuring safe and effective use of filtering material in the respirator system. One of the realizations disclosed herein is that prior art breathing systems are poorly designed and make ineffective use of costly filtering materials, which results in shorter life, poor performance, and unnecessary cost. Further, certain prior art breathing systems can also fail to protect the user from the risk of downstream migration of filtering media, such as activated carbon or charcoal. These drawbacks not only represent potential areas of improvement, but also represent potential areas of harm and risk for the user.

[0007] Various embodiments of a respirator system and methods of use are provided herein that overcome these and other deficiencies through superior design innovations. For example, in some embodiments, a unique respirator canister design is provided that can generate a targeted airflow through the canister in order to fully saturate filter material with incoming air so that the filter material is evenly and effectively used. Thus, the rate of filter material exhaustion can be generally even throughout the canister. An even usage rate can prevent, for example, localized "dead spots" or "channeling," which can cause the life of the system to be cut short, even if (and usually when) unused filter material is still present. Further, various embodiments provide additional filtering means configured to purify air passing through the system so that the user does not inhale any harmful particulates, impurities, or toxicities.

[0008] A respirator canister can be provided that comprises a main filter or filtering chamber and a flow mechanism, flow director, flow guide, vented cover, or directional air intake mechanism (which can be used interchangeably herein). The filtering chamber can have an inlet and an outlet and a flow path from the inlet to the outlet. The filtering chamber can have a longitudinal axis and a central portion that extends along the longitudinal axis. The flow mechanism, flow director, flow guide, vented cover, or directional air intake mechanism can be positioned at least over the inlet of the filtering chamber. Some embodiments can be configured to comprise more than one flow mechanism, flow director, flow guide, vented cover, or directional air intake mechanism, which can be positioned at different locations of the chamber.

[0009] The flow mechanism can be positioned at the chamber inlet. The flow mechanism can comprise a top surface, a central axis, and a plurality of apertures extending through the flow mechanism. The plurality of apertures can be configured to generate vortical air flow along at least a portion of the flow path when air passes through the outlet, either by a vacuum or suction applied at the outlet or by air being forced into the inlet. Apertures in addition to the plurality of apertures can also be provided in the flow mechanism.

[0010] In some embodiments, the plurality of apertures can be configured to direct air into the chamber and away from a central portion of the chamber along at least a portion of the flow path when air is passes through the inlet.

[0011] The plurality of apertures can extend through the flow mechanism in a direction non-normal to the top surface. The direction can have a transverse component substantially normal to the top surface and a longitudinal component substantially normal to the transverse component. Further, each longitudinal component can be tangent to a respective arc extending about the central axis. In some embodiments, each of the longitudinal components can be tangent to a single arc. Further, in some embodiments, each of the longitudinal components can be tangent to their own respective arcs, which can be offset in one or more axes. For example, the plurality of arcs can be offset in a radial or circumferential direction (for generally circular flow mechanisms). The plurality of apertures can be spaced at different distances about the central axis.

[0012] The transverse component of the aperture direction can be oriented substantially parallel relative to the central axis. Further, each longitudinal component of the aperture direction can extend in a substantially common plane. For examples, in some embodiments, the inlet can be generally planar and the longitudinal component of the aperture direction can extend in the plane of the inlet.

[0013] The longitudinal components of the apertures' directions can be tangent to one or more arcs having different radii of curvature. For example, the longitudinal components of the apertures' directions can be tangent to one or more circles having a generally common axis.

[0014] The plurality of apertures can extend obliquely through the vented cover. Further, the plurality of apertures can extend through the cover in a direction oblique to a top surface of the cover. For example, one or more of the apertures can comprise a sidewall that extends generally obliquely relative to a normal to an outer cover surface. Further, one or more of the apertures can comprise a sidewall that extends non-normally relative to an outer cover surface.

[0015] In some embodiments, one or more the apertures can extend through the cover at an acute angle relative to an outer surface of the cover. The acute angle can be between about 5° and about 75°. In some embodiments, the acute angle can be between about 8° and about 45°. Further, the acute angle can be between about 10° and about 20°.

[0016] The apertures can be configured as one or more of a variety of geometric shapes. For example, the plurality of apertures can comprise a plurality of round apertures. Further, the plurality of apertures can also comprise a plurality of circular apertures. Furthermore, each aperture can comprise an elongate slit.

[0017] The plurality of apertures can have a generally uniform size or be sized and shaped distinctly from at least some of the others of the plurality of apertures. For example, the plurality of apertures can comprise a first set of apertures and a second set of apertures. The first set of apertures can form a perimeter of apertures around the second set of apertures. In some embodiments, the first set of apertures can be different from the second set of apertures in size, shape, and/or spacing. For example, the first set can have a closer aperture spacing than the second set. In accordance with some embodiments, the cover can be generally circularly shaped and the first set can form a circular band of apertures encircling the second set.

[0018] The respirator canister can also comprise a second flow mechanism positioned within the filtering chamber downstream of the inlet. For example, the second flow mechanism can be positioned upstream of the outlet.

[0019] The filtering chamber can be generally cylindrical. In accordance with some embodiments, the filtering chamber can be configured to have a height dimension that is within a desired range of dimensions, and a cross-sectional dimension that is also within a desired range of dimensions. For example, in some embodiments, the height can be greater than the width or diameter of the filtering chamber, and in other embodiments, the height can be less than the width or diameter of the filtering chamber. The filtering chamber can be positioned along a straight line extending between the inlet and the outlet.

[0020] In some embodiments, a mask can be used with the canister and mouthpiece. For example, the mask can have an eyepiece and a nosepiece. The nosepiece can be operative to occlude the wearer's nose for preventing respiration through the wearer's nose. The nosepiece can comprise an occlusion device. For example, the nosepiece occlusion device can comprise a nose clip or a one-way nose valve that prevents the user from inhaling ambient air through their nose.

[0021] In some embodiments, the canister can be used with a mouthpiece to provide a respirator device. The mouthpiece can have an air passage configured to facilitate respiration. Further, the outlet of the canister can be fluidly coupled to the air passage of the mouthpiece.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Various features of illustrative embodiments of the inventions are described below with reference to the drawings. The illustrated embodiments are intended to illustrate, but not to limit, the inventions. The drawings contain the following figures:

[0023] Figure 1 is a perspective view of a respirator device, according to some embodiments.

[0024] Figure 2 is a partial cross-sectional perspective view of a canister of the respirator device, according to some embodiments.

[0025] Figure 3 is a partial cross-sectional perspective view of an air intake component of the canister of Figure 2, according to some embodiments.

[0026] Figure 4 is a cross-sectional side view of the air intake component of Figure 3, according to some embodiments.

[0027] Figure 5 is a schematic illustration of an aperture of an air intake component, according to some embodiments.

[0028] Figure 6 is an enlarged schematic illustration of an aperture of an air intake component, according to some embodiments.

[0029] Figure 7 is a cross-sectional side view of a prior art canister.

[0030] Figure 8 is a cross-sectional side view of a canister, according to some embodiments.

[0031] Figure 9 is a cross-sectional side view of another canister, according to some embodiments.

[0032] Figure 10 is a cross-sectional side view of yet another canister, according to some embodiments.

[0033] Figure 11 is a cross-sectional side view of yet another canister, according to some embodiments.

[0034] Figures 12A-C are cross-sectional side views of other embodiments of a canister.

[0035] Figure 13 provides cross-sectional side views of another embodiment of a canister.

[0036] Figures 14A-D are bottom views of aperture configurations of a canister, according to some embodiments.

DETAILED DESCRIPTION

[0037] While the present description sets forth specific details of various embodiments, it will be appreciated that the description is illustrative only and should not be construed in any way as limiting. Additionally, it is contemplated that although particular embodiments of the present inventions may be disclosed or shown in the context of a portable, personal respiration device, such embodiments can be used in other filtration equipment, used for gas or liquid filtration in various other contexts unrelated to emergency safety equipment. Furthermore, various applications of such embodiments and modifications thereto, which may occur to those who are skilled in the art, are also encompassed by the general concepts described herein.

[0038] As noted above, an aspect of at least some of the embodiments disclosed herein relates to improving the efficiency, safety, and longevity of personal breathing apparatuses during emergency situations. Some embodiments provide for unique one or more flow mechanisms, flow management mechanisms, filtering mechanisms, and/or flow efficiency mechanisms that can be used to improve the operation of an emergency safety breathing apparatus.

[0039] Figure 1 illustrates an emergency breathing apparatus 10 having a mouthpiece 12 and an assembly of one or more filter devices formed along a body 14 of the apparatus 10. As illustrated, the filter device can comprise a main filter 16 and one or more secondary filters 18, 20. The main filter 16 can comprise an inlet 30 formed at a base 32 of the body 14 of the apparatus 10. The apparatus 10 can also define a passageway 32 that fluidly interconnects the filter devices and the mouthpiece 12. The mouthpiece 12 can thus enable a user to inhale or draw air through the passageway that has been filtered through the filter devices.

[0040] The main filter 16 can be configured to thoroughly filter contaminants, impurities, particulates, and/or toxicities from ambient air drawn into the apparatus 10. The main filter 16 and, if used, one or more secondary filters 18, 20, can comprise filtering materials operative to remove contaminants, impurities, particulates, and/or toxicities from the ambient air. Further, the main filter 16 and, if used, one or more secondary filters 18, 20 can comprise at least one filtering compartment or layer.

[0041] In accordance with some embodiments, the inlet 30 of the main filter 16 can comprise a flow mechanism, such as a flow director or directional air intake mechanism 40. The terms "flow mechanism," "flow director," "flow guide," "vented cover," or "directional air intake mechanism" can be used interchangeably herein. The flow director or directional air intake mechanism 40 can be configured to direct air passing through the inlet 30 into the main filter 16. The air can pass through the assembly of filter devices until being discharged through an outlet 42 formed at the mouthpiece 12.

[0042] Further, the main filter 16 can comprise a filtering material such as activated charcoal or carbon, granulated or bead activated charcoal, impregnated carbons, polymer coated carbons, extruded charcoal, powdered activated charcoal, and/or the like.

The secondary filters 18, 20 can also be configured to comprise particle filters, such as HEPA filters and/or other materials. For example, if the main filter 16 uses an activated charcoal filtering material, the secondary filters 18, 20 can use HEPA filters to remove any particulate or residue from the active charcoal.

[0043] Figure 1 also illustrates a general flow path 22 of air passing through the apparatus 10. Air can be passed through the apparatus, either by vacuum or forced air. As shown, air can be drawn in from the base 32 of the body 14 and passed through the filters 16, 18, 20 until being expelled through the outlet 42. Additionally, the apparatus 10 can comprise a one-way valve 24 configured to allow exhaled air to be urged out from the apparatus 10 along flow path 26 through an upper portion 28 of the body 14. Thus, when a negative pressure, suction, or vacuum is applied at the outlet 42, such as by breathing in through the mouthpiece 12, air can be drawn up through the body 14 along the flow path 22. Further, the user can exhale through the mouthpiece 12 and air can be urged out through the one-way valve 24. Accordingly, the wearer need not remove the mouthpiece 12 to exhale, but can breathe in and out through the apparatus 10.

[0044] The embodiment illustrated in Figure 1 is an example of a negative pressure, suction, or vacuum-type configuration of an emergency breathing apparatus. The apparatus 10 is configured to draw air into the inlet 30 and through the filters 16, 18, 20 by using a vacuum or suction applied at the mouthpiece 12.

[0045] However, as noted, some embodiments can be provided that use a positive pressure or forced air configuration. For example, a mechanized breathing apparatus can be configured to urge ambient air into the apparatus through one or more filters while implementing aspects of the inventions disclosed herein.

[0046] In some embodiments, the flow director or air intake mechanism 40 can be configured to direct air into the main filter 16 in a manner that optimizes airflow through the main filter 16. Optimizing the airflow by inducing directional flow at the inlet 30 can provide various advantages. For example, the airflow can tend to be more uniform throughout the main filter 16, thus utilizing filter material in an even, consistent, and uniform manner. The filter material can thus achieve optimal usage, which can result in steadier flow through the filter, consistent filtration, and longer filter life. These and other advantages can be extremely important and make a critical difference in emergency situations, such as fires in a dwelling.

[0047] The flow director or air intake mechanism 40 can be positioned at the inlet 30. The flow director 40 can be formed integrally with a housing 50 of the main filter 16 (such that both the flow director 40 and the main filter housing 50 are formed from a single, continuous piece of material). The flow director 40 can also be formed separately from the housing 50 and coupled with the housing 50 during assembly.

[0048] In addition, some embodiments can be provided in which the upper portion 28 of the body 14 comprises a connection port for connecting a supply of gas, such as oxygen, for delivery to the mouthpiece 12. In some embodiments, the connection port can be positioned downstream of one or all of the filter(s) of the apparatus 10. The connection port can comprise a one-way valve that enables the flow of gas into the flow path of the upper portion 28.

[0049] Some embodiments of the apparatus 10 can also include a nosepiece occlusion device. The nosepiece occlusion device can comprise a nose clip or a one-way nose valve that prevents the user from inhaling ambient air through their nose. The nosepiece occlusion device can be coupled to the apparatus 10 or be separate from the apparatus 10.

[0050] Figure 2 illustrates a partial cross-section through the housing 50 of the main filter 16. The flow director 40 is illustrated as a generally circular structure formed at the base of the housing 50, which is illustrated as having a filtering chamber 52 with a generally cylindrical configuration. However, the housing 50 and the flow director 40 can be configured in a variety of geometric patterns and sizes, as discussed and shown herein.

[0051] The filtering chamber 52 can be configured to have a height dimension that is within a desired range of dimensions, and a cross-sectional (diameter or width) dimension that is also within a desired range of dimensions. The height of the chamber 52 can be measured generally along the flow path or central axis 54 of the chamber 52. The cross-sectional dimension of the chamber 52 can be measured in a direction transverse to the flow path or central axis 54 of the chamber 52. For example, the cross-sectional dimension can be a diameter (in circular cross-sectional embodiments) or a width (in square, rectangular, or other cross-sectional embodiments). In some embodiments, the chamber 52 can have a height that is greater than the width or diameter of the chamber 52. However, in other embodiments, the height can be less than the width or diameter of the chamber 52.

[0052] For example, the height of the chamber 52 can be within a range of about 0.5 inches and about 8 inches. The height can be between about 1 inch and about 5 inches. Further, the height can be between about 2 inches and about 4 inches. In addition, the width or cross-sectional dimension can be between about 1 inch and about 5 inches. The with or cross-sectional dimension can be between about 2 inches and about 4 inches. The with or cross-sectional dimension can also be between about 2 1/2 inches and about 3 1/2 inches.

[0053] In some embodiments, the ratio of the height to cross-sectional dimension can be can be between about 1:6 and about 6:1. For example, when the height is less than the cross-sectional dimension, the ratio of the height to the cross-sectional dimension can be between about 1:5 and about 1:1. Further, the ratio of the height to cross-sectional dimension can be between about 1:4 and about 2:3. The ratio of the height to cross-sectional dimension can also be between about 1:3 and about 1:2. Additionally, when the height is greater than the cross-sectional dimension, the ratio of the height to the cross-sectional dimension can be between about 5:1 and about 1:1. Further, the ratio of the height to cross-sectional dimension can be between about 4:1 and about 3:2. The ratio of the height to cross-sectional dimension can also be between about 3:1 and about 2:1. Furthermore, any of the various ratios within the ranges of ratios disclosed herein can be implemented with any of the dimensions within the ranges of dimensions disclosed herein.

[0054] The chamber 52 can be configured to remove contaminants, impurities, and/or toxicities from the air passing through the apparatus 10. Thus, the chamber 52 can be a detoxification mechanism or chamber that can be used in fires to remove carbon monoxide and other toxic gases from the ambient air.

[0055] As shown in Figure 2, the flow director 40 can comprise a plurality of apertures 60 that extend through the flow director 40 in a manner configured to generate vortical flow through the main filter 16. The illustrated embodiment of the flow director 40 includes a plurality of apertures 60 that extend from a bottom surface 70 to a top surface 72 of the flow director 40. One or more of the plurality of apertures 60 can extend transversely through the flow director 40, as shown in Figure 3.

[0056] For example, the flow director 40 can comprise a central axis 80. One or more of the plurality of apertures 60 can extend through the flow director 40 obliquely relative to the central axis 80. Accordingly, air drawn through the apertures 60 can be directed in a desired path within the housing 50 of the main filter 16.

[0057] Although the illustrated embodiment of Figures 2-4 shows that each of the apertures 60 is configured generally identically and only spaced apart from each other by rotation about the axis 80, embodiments can be provided in which some of the apertures 60 have unique orientations that are different from those of another of the apertures 60.

[0058] Some of the apertures 60 can be configured to generate vortical air flow through the flow director 40 while others of the apertures (not shown) can be configured to draw air more directly into the housing 50. For example, some of the aperture 60 can be oriented at a large angle relative to the axis 80 (e.g., between about 30° and 80°; see angle 120 in Figure 4). However, others of the apertures can be oriented at a small angle relative to the axis 80 (e.g., less than about 30°; see angle 120 in Figure 4) or even in a direction that is generally parallel relative to the axis 80. Such aperture configurations can be implemented in flow director patterns, such as those illustrated in Figures 14A-D. As discussed later herein, the configuration of individual apertures or groups of apertures can be unique in order to direct air in a desired course to ensure that airflow is generally uniform throughout the filter material disposed within the housing 50.

[0059] Figure 2 also illustrates schematically how the apertures 60 can redirect air along flow path lines 82 in the housing 50. Figure 4 also shows the flow path line 82 of air that is drawn into the aperture 60 and redirected along the path that is oblique relative to the upper surface 72 of the flow restrictor 40. As illustrated in Figures 2 and 4, air passing through the apertures 60 can begin to circulate in the chamber 52 to generate vortical air flow 82 in the housing 50. As will be appreciated by a person of skill in the art, the simulated air flow diagram of Figure 2 shows that the airflow lines 82 extend through the apertures 60 and along the inner wall of the chamber 52 in a generally helical direction to form vortical flow. As discussed further herein, the size or spacing of the chamber can vary in order to achieve desired vortical air flow properties upstream of one or more of the filters. Thus, the downstream effect of the plurality of apertures 60 can be the generation of vortical air flow along at least a portion of the flow path 22 of the apparatus 10, which can provide or contribute to various advantageous results, as discussed herein.

[0060] Figures 5 and 6 illustrate geometric representations of one or more apertures of the plurality of apertures 60 of the flow director 40. Figure 5 illustrates that the aperture 60 can extend in a direction 90. In this embodiment, because the top surface 72 of the flow director 40 is generally flat, the orientation of the direction 90 of the aperture 60 extends substantially non-normally relative to the top surface 72.

[0061] Further, the direction 90 of the aperture 60 can also extend at a non-perpendicular and nonparallel angle relative to the flow path 22 and/or the central axis 80 of the flow director 40. In embodiments wherein the top surface 72 of the flow director 40 has a generally curvilinear surface contour (such as a concave or convex surface contour), the direction 90 of the aperture can also extend nonparallel relative to the flow path 22.

[0062] For example, the direction 90 can extend away from the flow path 22 and/or central axis 80. In some embodiments, redirection of airflow into other areas of the housing 50 away from the central axis 80 and/or the flow path 22 can tend to ensure that the air is circulated through as much of the filter material as possible during the filtration process. The filter material can thus be efficiently and evenly used during the life of the apparatus 10.

[0063] Referring again to Figures 5 and 6, the direction 90 of the aperture 60 can also be described in mathematical terms using vectors. The direction 90 can comprise a vector having longitudinal and transverse components. For example, the direction 90 can comprise a longitudinal or first component 92 and a transverse or second component 94.

[0064] The longitudinal or first component 92 can extend in a horizontal plane. In the illustrated embodiment, the first component 92 can extend within the plane defined by the upper surface 72 of the flow director 40. The first component 92 can be substantially normal or perpendicular relative to the second component 94.

[0065] The transverse or second component 94 can extend in a generally vertical plane, which can be oriented substantially perpendicular or normal relative to the horizontal plane, such as the flow director upper surface 72. The first component 92 can be configured to extend along a tangent line 96 that is tangent to an arc 100 and perpendicular relative to a radius 98. The radius 98 can be defined as extending from the central axis 80 all the flow director 40. Further, the arc 100 can be defined as the arc traced by the distal end point of the radius 98. Furthermore, the tangent line 96 can represent a straight line that intersects the arc 100 at a single point.

[0066] Thus, in embodiments comprising a plurality of apertures 60, the apertures 60 can be formed using generally the same configuration, rotated about the central axis 80. Thus, each of the apertures can comprise a first component 92 that extends generally parallel relative to the central axis 80 of the flow director 40. Further, each of the apertures can comprise a second component 94 that extends in a generally common horizontal plane.

[0067] Figure 6 also illustrates that the direction 90 of the aperture 60 can be defined relative to walls of the aperture 60. For example, the aperture 60 can comprise a forward wall 102, a rearward wall 104, and side walls 106. In the illustrated embodiment, both the front wall 102 and the rear wall 104 extend in the direction of vectors 110 at a substantial angle relative to a vertical axis (for example, relative to the central axis 80 of the flow director 40 and/or the second component 94).

[0068] As shown in Figures 4 and 6, a relative angle 120 between the vectors 110 and a vertical axis can be between about 30° and 80°. In some embodiments, the relative angle 120 can be between about 50° and 60°. Further, some embodiments can be configured such that the relative angle is about 55°.

[0069] In accordance with some embodiments, an aperture configuration with a small relative angle 120 can still redirect air flow to generate vortical air flow. This desired aperture configuration can be achieved by relating the relative angle 120 to a thickness of the flow director 40. For example, even when the relative angle 120 is in the smaller end of the 30° to 80° range, the flow director thickness can be large enough such that a vertical line cannot pass through the aperture without contacting two of its sidewalls. Similarly, if the flow director thickness is not substantial, a larger relative angle 120 can be provided such that a vertical line cannot pass through the aperture without contacting two of its sidewalls. For example, in Figure 4, the axis line 80 is unable to pass through the aperture without contacting two of its sidewalls.

[0070] In addition, Figure 6 illustrates that at least some portion of the walls of the aperture 60 can be generally vertical. As shown, the side walls 106 can extend generally vertically and generally mirror each other. Further, the forward wall 102 and the rearward wall 104 can generally mirror each other. In some embodiments, at least one of the forward wall 102, the rearward wall 104, or the sidewalls 106 can extend at a substantial angle relative to the central axis 80 and/or the flow direction 22 in order to redirect airflow through the aperture to a desired direction (such as the air flow direction 90, illustrated in Figure 6).

[0071] The embodiment illustrated in Figure 6 also shows the aperture 60 formed with a round cross-section. The apertures 60 can be formed with a round, oval, square, rectangular, or circular cross-section that extends from the top surface 72 to the bottom surface 70 of the flow director 40. However, the aperture 60 can also be formed having a square, rectangular, or other polygonal-shaped cross section. Thus, in some embodiments, the aperture 60 can have a generally constant cross-sectional profile. However, other embodiments can be provided in which the cross-sectional profile of the aperture varies. When the cross-sectional profile of the aperture varies, the forward wall and the rearward wall may not mirror each other, and/or the side walls may not mirror each other.

[0072] Figure 7 illustrates a prior art filtering apparatus. As shown in Figure 7, a prior art filter 130 comprises a centrally disposed inlet 132 at a first end of the filter 130 and a centrally disposed outlet 134 at the second end of the filter 130. The Applicant has found that the configuration illustrated in Figure 7 demonstrates a deficiency of "channeling" that is common to prior art filtering apparatuses. As shown, "channeling" occurs when air passing along the flow path 136 is directed generally straight from the inlet 132 to the outlet 134. Thus, centralized filter material 137 disposed along the flow path 136 is exhausted in a short period of time. One of the negative consequences of channeling is that perimeter filter material 138 may remain largely unaffected and unused due to the collimation of airflow along the flow path 136. In general, such apparatuses exhibit poor filtering characteristics, short life spans, and poor efficiency.

[0073] In contrast, various embodiments of the filtering apparatus disclosed herein can provide superior performance, long lifespans, and excellent material efficiency. Figure 8 illustrates a cross section of the main filter 16 shown in Figure 1. As illustrated, the chamber 52 of the main filter body 50 can comprise one or more compartments. The one or more compartments can accommodate filter material or provide open volume space for vortical air flow to be generated upstream of the filter material.

[0074] For example, a first compartment 140 can extend adjacent to the flow director 40 to receive air passed through the apertures 60. The chamber 52 can also comprise a second compartment 142 configured to receive a filter material 144. The filter material can comprise one or more of a variety of filtering media. For example, the filtering media can include activated charcoal or carbon, such as granulated activated charcoal, powdered activated charcoal, HEPA filters, and other filtering materials.

[0075] As shown in Figure 8, the airflow into the first compartment 140 can be generally vortical, thus causing the air to circulate broadly within the first compartment 140 as it is drawn into the filter material 144. As the air continues to pass through the filter material 144, contaminants, impurities, particulates, and/or toxicities in the air can be removed by the filter material 144. The air can move through the filter material 144 along the path lines 150, which generally converge toward the chamber exit 152. In contrast to the prior art filter 130 of Figure 7, the airflow through the main filter 16 of Figure 8 can be evenly spread throughout the filter material 144, thus resulting in even usage, better filtration, and potentially longer filter life. The vortical flow along at least a portion of the flow path 22 can thus provide various advantageous results that are superior to prior art products.

[0076] Figure 9 illustrates another embodiment of a main filter 180, which comprises a flow director 182 positioned at an inlet 184 of a filter chamber 186. The filter chamber 186 can comprise a first compartment 190, a second compartment 192, and a third compartment 194 that are housed within a body 196 of the main filter 180. The flow director 182 can comprise a plurality of apertures 200 that are configured to generate vortical air flow along at least a portion of flow path 22. As with other embodiments disclosed herein, the main filter 180 can be used in a positive pressure or negative pressure configuration. Thus, in some embodiments, when a vacuum or suction is applied at outlet 210, air can be drawn into the apertures 200 and a vortical air flow pattern can be in the first compartment 190 by virtue of the configuration of the apertures 200. The airflow can then be drawn through filter material 212 along the path lines 214.

[0077] In accordance with some embodiments, the main filter 180 can be configured such that the third compartment 194 extends along an outgoing area 220 that is about equal to or greater than an incoming area 222. The outgoing area 220 and the incoming area 222 can each be representative of the total exposed area for the filter material 144 within the filter chamber 186. Thus, the outgoing area 220 and the incoming area 222 can be measured using the internal dimensions of the filter chamber 186, as opposed to attempting to calculate the surface area of exposed filter material 144. Thus, for generally circular, planar areas, the outgoing area 220 and the incoming area 222 can be measured using the formula for calculating the area of a circle, πr^2. Other geometries can be calculated using corresponding formulas for the area, which may require adjusting the area based on aspects of the geometry, such as additional voids or areas that may be covered and not visible for receiving passing airflow.

[0078] In embodiments in which the outgoing area 220 is about equal to or greater than the incoming area 222, the flow path lines 214 can extend generally vertically through the filter material 212, as shown in Figure 9. The vortical air flow generated in the first compartment 190 can tend to ensure that the air is evenly pulled into the filter material 212 through the incoming area 222. Thus, the air can evenly saturate the filter material 212 as it passes toward the outlet 210. In this embodiment, it is noted that even saturation of the filter material 212 can be enhanced by making the outgoing area 220 similar to or equal to the incoming area 222. Further, the third compartment 194 can also enhance the even saturation of the filter material 212 (which allows for an even pressure draw along the outgoing area 222 to the vacuum or suction applied at the outlet 210).

[0079] However, even saturation of the filter material 212 can also be achieved when the outgoing area 220 is less than the incoming area 222, such as in the embodiment illustrated in Figure 8. In order to achieve even saturation in such embodiments, the housing 50 can comprise a taper 160 that generally follows the flow path lines 150 of the air passing through the filter material 144. Example embodiments of filter bodies are shown in Figures 12A-C.

[0080] As noted above, in accordance with some embodiments, one or more filters can be integrated into a combined filter assembly of the apparatus. The filter assembly can include one or more types of filter material and be configured to improve airflow through the device. As shown in some of the embodiments disclosed herein, the filter assembly can comprise one or more layers of one or more types of filter material. These layers can be in fluid communication and disposed in a single compartment or separate compartments that are fluidly interconnected.

[0081] Figure 1 illustrates an apparatus embodiment in which multiple filter elements or layers are fluidly interconnected in a manner that successively increases and reduces the cross section of the flow pathway. As a result, the pressure and velocity of air passing through the apparatus 10 can vary along the flow pathway of the apparatus 10.

[0082] Some embodiments can be configured such that multiple filter layers can be coupled to each other in a manner that reduces flow resistance. By reducing the flow resistance, the required suction at the outlet (or a mouthpiece) of the apparatus can be reduced. Accordingly, the user of the apparatus may experience less fatigue when drawing air from the apparatus. Further, in embodiments using a mechanical pump, lower suction can also reduce pumping requirements, such as reducing the pump size, reducing the required energy, and improving the overall efficiency.

[0083] For example, Figure 10 illustrates an embodiment of a combined filter assembly 226. The combined filter assembly 226 comprises a first filter component 227 and a second filter component 228. The first and second filter components 227, 228 can be coupled to each other to form a flow interface 229. As illustrated by the arrows indicating the flow path of air through the first and second filter components 227, 228, air can be drawn in through a flow director or inlet 230 of the first filter component 227. The flow director or inlet 230 can be configured to implement features of a flow director or inlet discussed herein. The air can be drawn through the assembly 226, being filtered in the first filter component 227, and then filtered again in the second filter component 228.

[0084] The flow interface 229 allows the first and second filter components 227, 228 to be interconnected in fluid communication with each other. As shown in the illustrated embodiment of Figure 10, the cross section of the flow path, or inner cross section of the first and second filter components 227, 228, can remain generally constant at the flow interface 229. Because the illustrated embodiment does not create a flow restriction or flow limiting venturi at the flow interface 229, certain fluid dynamic conditions can be avoided, such as choked flow or critical flow.

[0085] In general, choked or critical flow is a condition in which flow through a restriction will not increase by increasing the suction (or reducing downstream pressure) while maintaining upstream pressure constant. This condition can be observed in some prior art apparatuses. A restriction or constriction in the configuration of the apparatus can limit the flow rate to a set maximum, making it more challenging to breathe through the apparatus at a flow rate above the limited flow rate.

[0086] Some embodiments disclosed herein can be configured to reduce and/or eliminate restrictions in the flow path in order to provide limit-free flow through the apparatus. For example, as illustrated in Figure 10, the flow interface 229 of the assembly 226 can have a reduced or variable cross section, thereby allowing flow through the interface 229 to be unrestricted. As a result, a vacuum or suction applied at the outlet 233 can directly affect the flow rate through the apparatus, not being limited to a set maximum flow rate, which may not provide sufficient flow for some users. Further, the breathing through the apparatus can tend to be less strenuous when the flow rate is not constricted by apparatus geometry.

[0087] The flow interface 229 can comprise a mechanical interconnection, such as a threaded, adhesive, interference, and/or snap fit engagement between the first and second filter components 227, 228. In the illustrated embodiment, the flow interface 229 comprises a first threaded portion 231 on the first flow component 227, and a second threaded portion 232 on the second flow component 228. The first and second threaded portions 231, 232 can be interconnected securely. The flow interface 229 can also comprise one or more gaskets or sealing components that provide an airtight seal when the first and second threaded portions 231, 232 are coupled together.

[0088] According to some embodiments, the filter assembly can be modular. For example, with the interconnectivity of the first and second filter components 227, 228 at the flow interface 229, some embodiments can be configured as a modular assemblies that allow the user to interchange filter components based on a particular need or use. For example, a kit can be provided, which can include several different filter components that have different features, such as filter material, filter life, flow director, profile or size, and/or other aspects of the filter components. Thus, the assembly can be custom tailored to specific applications at specific times.

[0089] The modularity of some embodiments can also allow for the interchanging of filters or filter assemblies with mouthpieces and/or breathing apparatuses, such as helmets or hoods. Any of the filters or filter assemblies disclosed herein can be configured to comprise an interconnecting portion that allows the filter assembly to be removably interconnected with a mouthpiece and/or filter apparatus. The interconnection can be a mechanical interconnection, such as a threaded, adhesive, interference, and/or snap fit engagement between the filter or filter assembly and the mouthpiece or breathing apparatus. Thus, in use, a user can carry one or more spare filters or filter assemblies, which can replace an exhausted filter or filter assembly. A replaceable system of filters or filter assemblies can be implemented in a variety of devices, such as mouthpiece or handheld-type, hooded-type, helmet-type and/or other types of breathing apparatuses.

[0090] Additionally, as illustrated in Figure 10, some embodiments can be configured to comprise one or more intermediate layers 234 that can separate one or more layers of filter material. As illustrated, the intermediate layers 234 can also provide a boundary for an open chamber 235. The open chamber 235 can facilitate an even pressure draw from the first filter component 227 through the intermediate layers 234 and into the second filter component 228.

[0091] Figure 11 illustrates yet another embodiment of a main filter 240 which comprises more than one flow director in order to enhance the air distribution, mixing, saturation, and filtration quality of the filter. The main filter 240 can comprise a filter body 242 having an inlet 244, and an intermediate portion 246, and an outlet (not shown). A first flow director 250 can be positioned at the inlet 244, and a second flow director 252 can be positioned at the intermediate portion 246. Further, the main filter 240 can also comprise various compartments for accommodating filter material or open volume space for air. The main filter 240 can comprise at least a first chamber 260, a second chamber 262, a third chamber 264, a fourth chamber 266, and a fifth chamber 268.

[0092] Although, the embodiment of Figure 11 illustrates only two filtering layers 270, 272, some embodiments can be provided that comprise three or more filtering layers. In some embodiments, additional chambers or compartments can be used to provide further filtering layers for vortical air flow redirection. Each filtering layer can comprise a flow director and filter material. Further, each filtering layer can optionally include open chambers or compartments positioned upstream and/or downstream of the filter material in order to further facilitate vortical air flow and/or even pressure draw from the filter material.

[0093] Referring to Figure 11, the intermediate portion 246 can be positioned at a midpoint of the filter body 242 in embodiments having two filtering layers. However, even in two-layer embodiments, the intermediate portion 246 can be positioned at any location between the inlet 244 and the outlet of the main filter 240. Thus, the relative sizes of multiple filtering layers can be different from each other, whether there are two layers, three layers, or more.

[0094] Additionally, the first flow director 250 can be identical to or different from the second flow director 252. The first and second flow directors 250, 252 can thereby produce similar or dissimilar vortical air flow patterns, as desired. Further, the second flow director 252 may also be configured to induce turbulent flow or mixing of the air being drawn from the first filtering layer 270, to achieve even mixing of the air so as to avoid concentrations of contaminants, impurities, or toxicities in certain areas of the filter 240, as discussed below.

[0095] The embodiment illustrated in Figure 11 also demonstrates that air drawn into the main filter 240 can be filtered once through the first filtering layer 270 and then vortically redirected, mixed, and redistributed through the second filtering layer 272. An advantage of such a multiple layer system is that filter material is evenly saturated with contaminants, impurities, or toxicities filtered from the passing air. Thus, air in the fourth chamber 266 can be vortically recirculated and evenly mixed (e.g., homogenously mixed), such that the filter material in the fifth chamber 268 can be evenly saturated and used to filter contaminants, impurities, particulates, or toxicities from the air. With even saturation, embodiments can reduce and/or eliminate “dead spots” or areas of filter material that have been exhausted or fully reacted with passing air, which can render such “dead spots” less effective or useless as filter material. The resulting mixture and even saturation between the air and the filter material can allow the filter to achieve steady, effective filtering until the filter is fully exhausted. For example, all of the filter material can thus be utilized at the same rate until filter exhaustion is achieved.

[0096] Referring now to Figures 12A-C, various schematic embodiments of filter bodies are shown. Figure 12A illustrates an embodiment of a filter body 300 that is similar to the shape of the main filter 16, discussed above. The filter body 300 can have a shape that is rounded and increasingly tapers from an inlet 302 toward an outlet 304. Flow path lines 306 illustrate the general flow direction of air through the body 300 as it converges to the outlet 304.

[0097] Figure 12B illustrates a filter body 320 having a shape that is generally conical and tapers from inlet 322 generally linearly toward outlet 324. The flow path lines 326 illustrate the general flow direction of air through the body 320 as it converges to the outlet 324.

[0098] Similarly, Figure 12C illustrates a filter body 340 having a shape that is rounded and decreasingly tapers from inlet 342 toward outlet 344. The flow path lines 346 illustrate the general flow direction of air through the body 340 as it converges to the outlet 344.

[0099] Figure 13 illustrates a schematic embodiment of a filter 360. The filter can comprise an inlet 362 and an outlet 364. However, the filter can also comprise one or more internal flow diffusers 366. The flow diffuser(s) 366 can be positioned within the chamber of the filter 360. In some embodiments, the flow diffuser(s) 366 can be positioned against and surrounded by the filter material with no compartments or volume gaps between the flow diffuser(s) 366 and the filter material.

[0100] The flow diffuser(s) 366 can be configured to distribute or diffuse air flow throughout the filter material. When multiple flow diffuser(s) are used, they can be spaced close together or apart from each other within the filter chamber.

[0101] In some embodiments, the flow diffuser(s) can comprise a plurality of apertures or micro-perforations that diffuse the flow across a wide area of the filter material. Thus, the flow diffuser(s) can redirect or reorient flow through the filter 360. Further, in some embodiments, the flow diffuser(s) can be fixedly or rigidly mounted within the filter 360. However, in some embodiments, the flow diffuser(s) can also be freely movable (rotatable and/or slidable) within the filter 360, such that during use, the flow diffuser(s) can dynamically modify the airflow through the filter 360.

[0102] Similar to the multiple layer systems discussed above, multiple layer diffuser systems can also be implemented by implanting one or more flow diffusers into the filter material in order to cause the air flow through the filter to be less laminar and more thoroughly diffused throughout the filter material. Thus, in a single filtering layer, various layers of diffusers can be used in a compact space to diffuse air passing through the filtering material, thereby improving filter material saturation.

[0103] Figures 14A-D illustrate example aperture patterns for a flow director (or flow diffuser). Figure 14A illustrates a flow director 400 having a plurality of apertures formed generally in circular groupings. As shown, a first group of apertures 402 can be positioned adjacent to the perimeter of the flow director 400. Further, second, third, and fourth groups of apertures 404, 406, 408 can be respectively positioned within the perimeter of the first group of apertures 402, with the fourth group of apertures 408 being the innermost groups of apertures. The size of the apertures can vary, such as decreasing in size with each consecutive inner group. Further, the number of apertures can also vary, such as decreasing in number with each consecutive inner group, which is shown in Figure 14A.

[0104] Figure 14B illustrates an arrangement in which a flow director 430 comprises a plurality of apertures 432 that have generally identical sizes. The apertures 432 can be spaced randomly on the flow director 430 or be positioned in a concentric circular pattern. The radial outermost areas of the pattern can have the greatest number of apertures 432. In some embodiments, the aperture density (the number of apertures per unit area), can also be greater toward the radial outermost areas.

[0105] Although Figures 14A-B illustrate specific embodiments of flow directors, various patterns, the flow director sizes and shapes, and aperture configurations can be implemented. The perimeter or cross-sectional shape of the flow director can vary, and the embodiments illustrated in Figures 14A-D are shown as circular or square perimeter or cross-sectional shapes. The flow director can also comprise various other perimeter or cross-sectional shapes, as discussed herein. Additionally, the aperture patterns are examples of patterns that can be implemented with round, square, rectangular, honeycomb, and/or other shaped apertures. The size of the apertures can also vary depending on the distance of the apertures from a center most point of the flow director. Accordingly, the aperture patterns can be varied and interchanged with different aperture patterns and different perimeter or cross-sectional shaped flow directors. For example, the aperture pattern shown in Figure 14A can be used with a flow director that has a square-shaped perimeter. Similarly, for example, either of the aperture patterns 440, 442 shown in Figures 14C and 14D can be used with a flow director that has a circular-shaped perimeter.

[0106] For example, the pattern of the apertures can comprise identical or different aperture density (e.g., the number of apertures per unit area), identical or different aperture area density (e.g., the total aperture area per unit area), specific arrangements or groups of apertures in geometric patterns, randomized groupings or patterns, and the like.

[0107] Additionally, the size and/or shape of the flow director can be round, circular (as shown in Figures 14A-B), square, or other polygonal shapes. As shown in the illustrated embodiments, the flow director can have a generally flat or planar shape. However, in some embodiments, the flow director can have a three-dimensional shape, such as a convex or concave shape, with a smooth curvilinear and/or multifaceted surface. In such embodiments, the features and function of the apertures discussed herein can be implemented and accomplished.

[0108] Further, the configuration of apertures can be modified to include apertures having identical or different sizes, identical or different shapes (e.g., round, circular, polygonal, slit, and the like), configurations for producing laminar, turbulent, and/or vortical flow, as well as other features or configurations discussed above with respect to Figures 2-6.

[0109] Although embodiments of these inventions have been disclosed in the context of certain examples, it will be understood by those skilled in the art that the present inventions extend beyond the specifically disclosed embodiments to other alternative embodiments and/or uses of the inventions and obvious modifications and equivalents thereof. In addition, while several variations of the inventions have been shown and described in detail, other modifications, which are within the scope of these inventions, will be readily apparent to those of skill in the art based upon this disclosure. It is also contemplated that various combinations or sub-combinations of the specific features and aspects of the embodiments may be made and still fall within the scope of the inventions. It should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the disclosed inventions.

WHAT IS CLAIMED IS:

1. A respirator canister comprising:

a filtering chamber having an inlet and an outlet and a flow path from the inlet to the outlet; and

a flow director positioned at the inlet, the flow director comprising a top surface, a central axis, and a plurality of apertures extending through the flow director in a direction substantially non-normal to the top surface, the direction having a transverse component substantially normal to the top surface and a longitudinal component substantially normal to the transverse component, wherein each longitudinal component is tangent to a respective arc extending about the central axis;

wherein the plurality of apertures are configured to generate vortical air flow along at least a portion of the flow path when air enters the inlet.

2. The respirator canister of Claim 1, wherein the transverse component is oriented substantially parallel to the central axis.

3. The respirator canister of Claim 1, wherein each longitudinal component extends in a substantially common plane.

4. The respirator canister of Claim 3, wherein the inlet is generally planar.

5. The respirator canister of Claim 1, further comprising a second flow director positioned within the filtering chamber between the inlet and the outlet.

6. The respirator canister of Claim 1, wherein the filtering chamber is generally cylindrical.

7. The respirator canister of Claim 1, wherein the plurality of apertures are spaced at different distances about the central axis.

8. The respirator canister of Claim 1, wherein the plurality of apertures comprises a plurality of round apertures.

9. The respirator canister of Claim 8, wherein the plurality of apertures comprises a plurality of circular apertures.

10. A respirator device comprising:

a mouthpiece having an air passage configured to facilitate respiration; and a canister having a filtering chamber comprising an inlet and an outlet, the inlet in fluid communication with the outlet, the outlet fluidly coupled to the mouthpiece air passage, the inlet comprising a vented cover having a plurality of apertures that extend obliquely through the cover;

wherein the plurality of apertures are configured to generate vortical air flow within at least a portion of the filtering chamber when air enters the inlet.

11. The device of Claim 10, wherein the plurality of apertures comprises a plurality of round apertures.

12. The device of Claim 11, wherein the plurality of apertures comprises a plurality of circular apertures.

13. The device of Claim 10, wherein the filtering chamber is positioned along a straight line extending between the inlet and the outlet.

14. The device of Claim 10, further comprising a mask having an eyepiece and a nosepiece, the nosepiece being operative to occlude the wearer's nose for preventing respiration through the wearer's nose.

15. The device of Claim 14, wherein the nosepiece comprises a clip.

16. A respirator canister comprising:

a filtering chamber having an inlet, an outlet, a longitudinal axis extending between the inlet and outlet, and a flow path from the inlet to the outlet, the filtering chamber having a central portion that extends along the longitudinal axis; and

a directional air intake mechanism positioned at the inlet and having a plurality of apertures that are configured to direct air into the chamber and away from the central portion along at least a portion of the flow path when air enters the inlet.

17. The respirator canister of Claim 16, wherein the intake mechanism comprises a cover positioned over the inlet and having an outer surface, and wherein the air intake mechanism is formed in the cover.

18. The respirator canister of Claim 17, wherein the air intake mechanism comprises a plurality of apertures extending through the cover in a direction oblique to a top surface of the cover.

19. The respirator canister of Claim 18, wherein each aperture comprises a sidewall that extends generally obliquely relative to a normal to an outer cover surface.

20. The respirator canister of Claim 18, wherein each aperture comprises a sidewall that extends non-normally relative to an outer cover surface.

21. The respirator canister of Claim 18, wherein the plurality of apertures comprises circular apertures having a generally uniform size.

22. The respirator canister of Claim 21, wherein the plurality of apertures comprises a first set of apertures and a second set of apertures, the first set forming an outer perimeter of apertures around the second set, the first set having a closer aperture spacing than the second set.

23. The respirator canister of Claim 22, wherein the cover is generally circularly shaped and the first set forms a circular band of apertures encircling the second set.

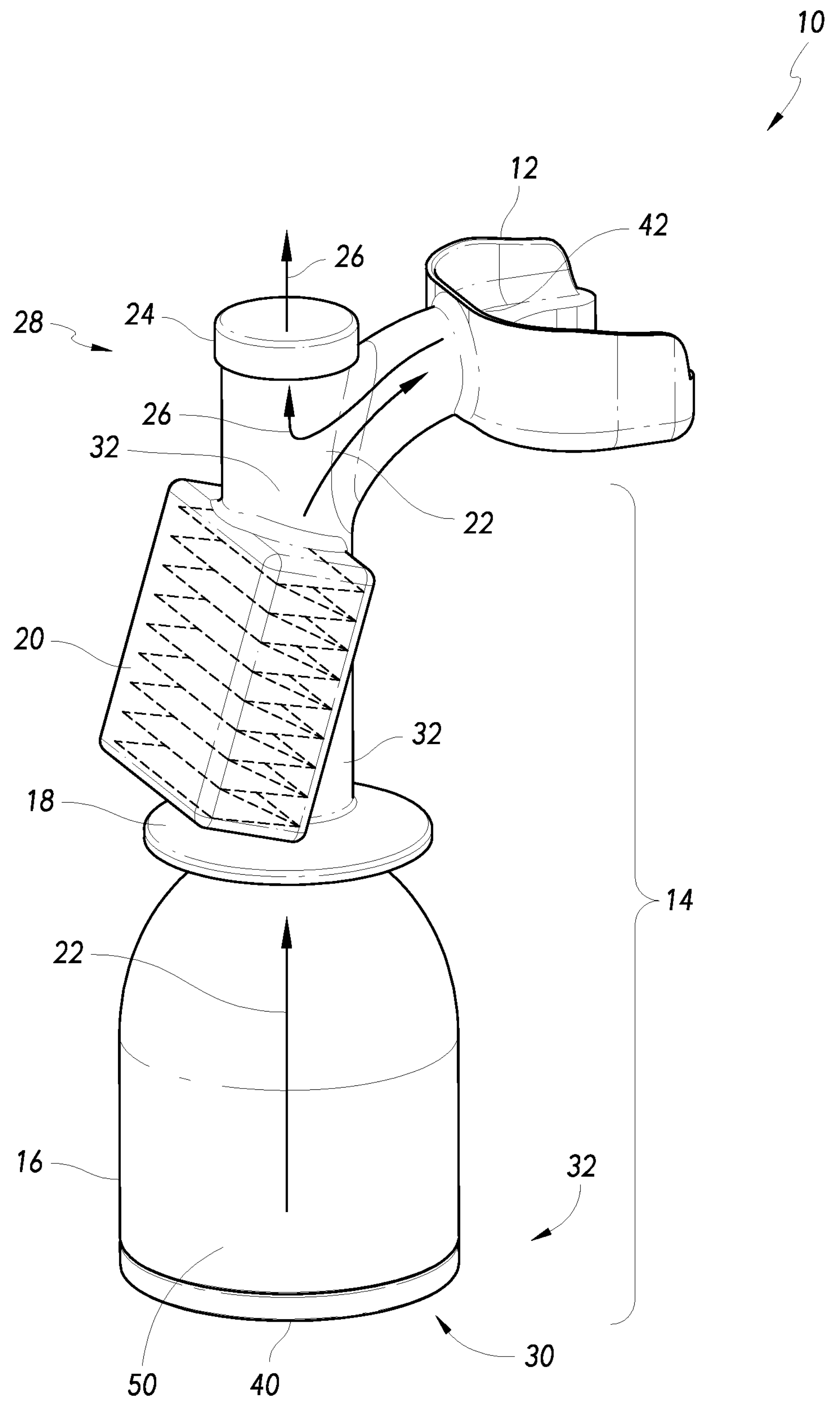

FIG. 1

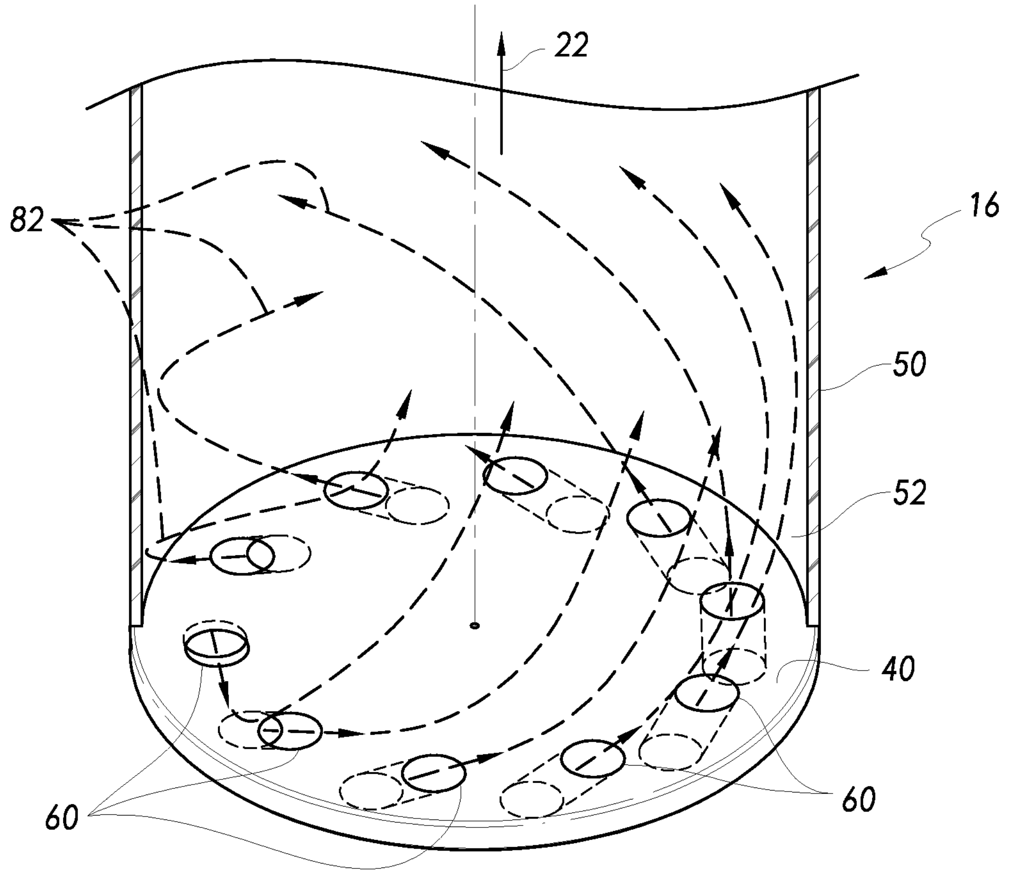

FIG. 2

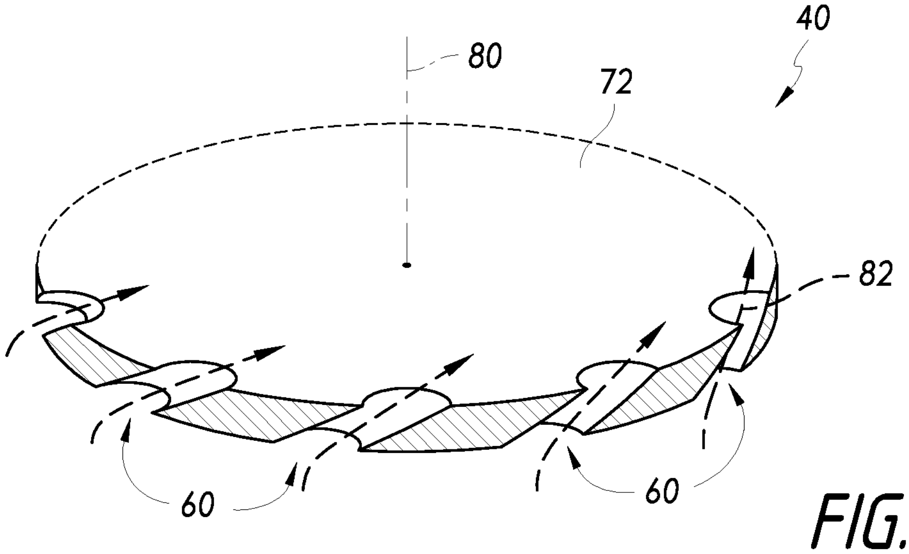

FIG. 3

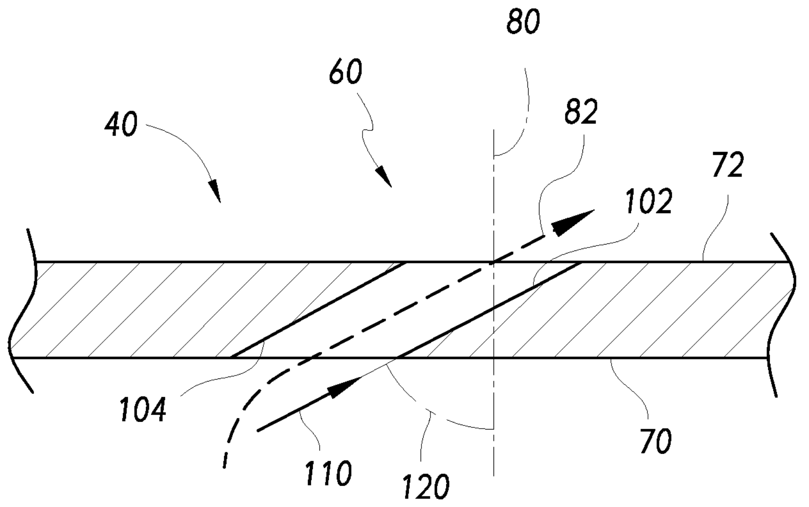

FIG. 4

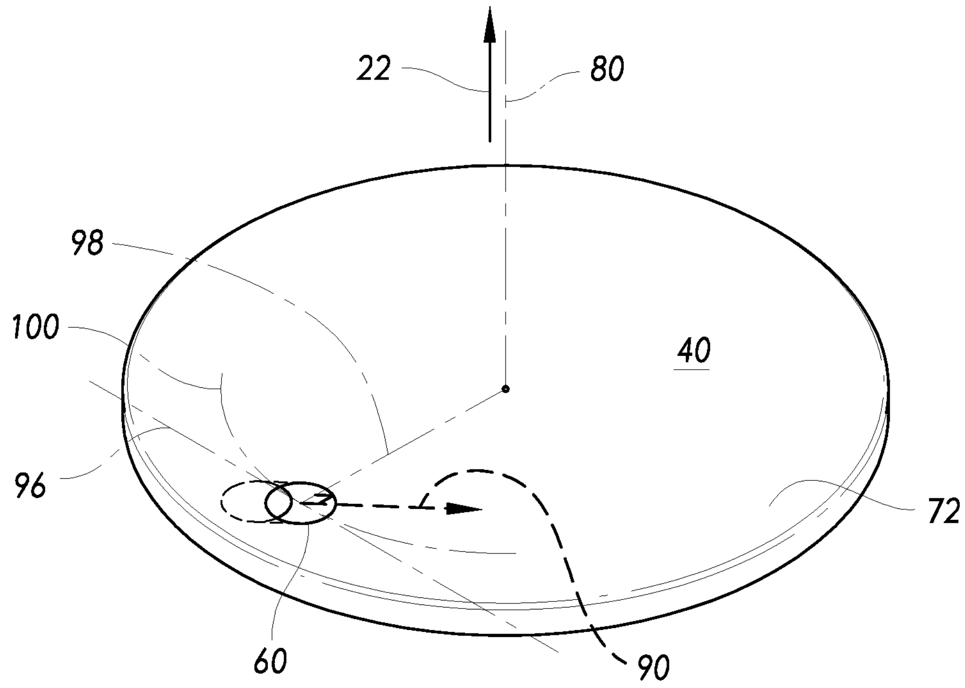
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FIG. 5

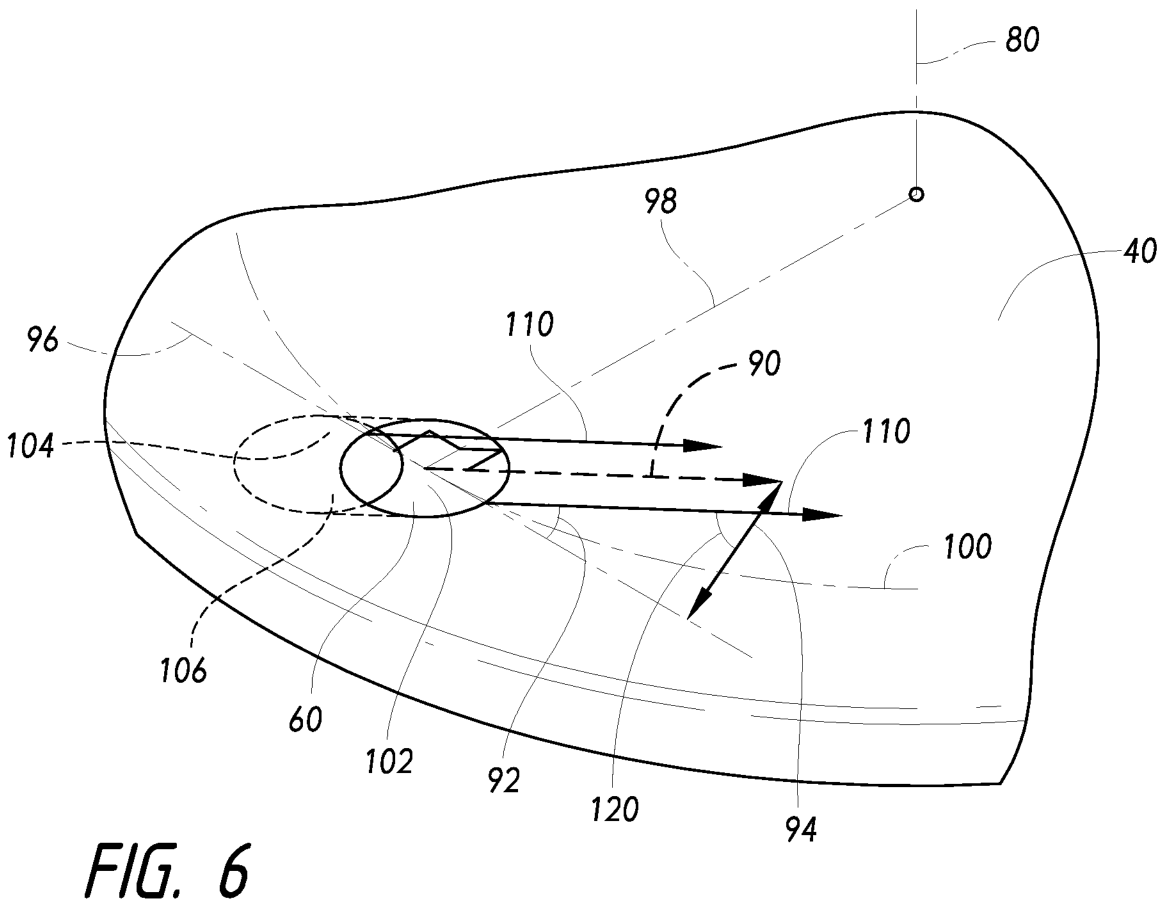
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FIG. 6

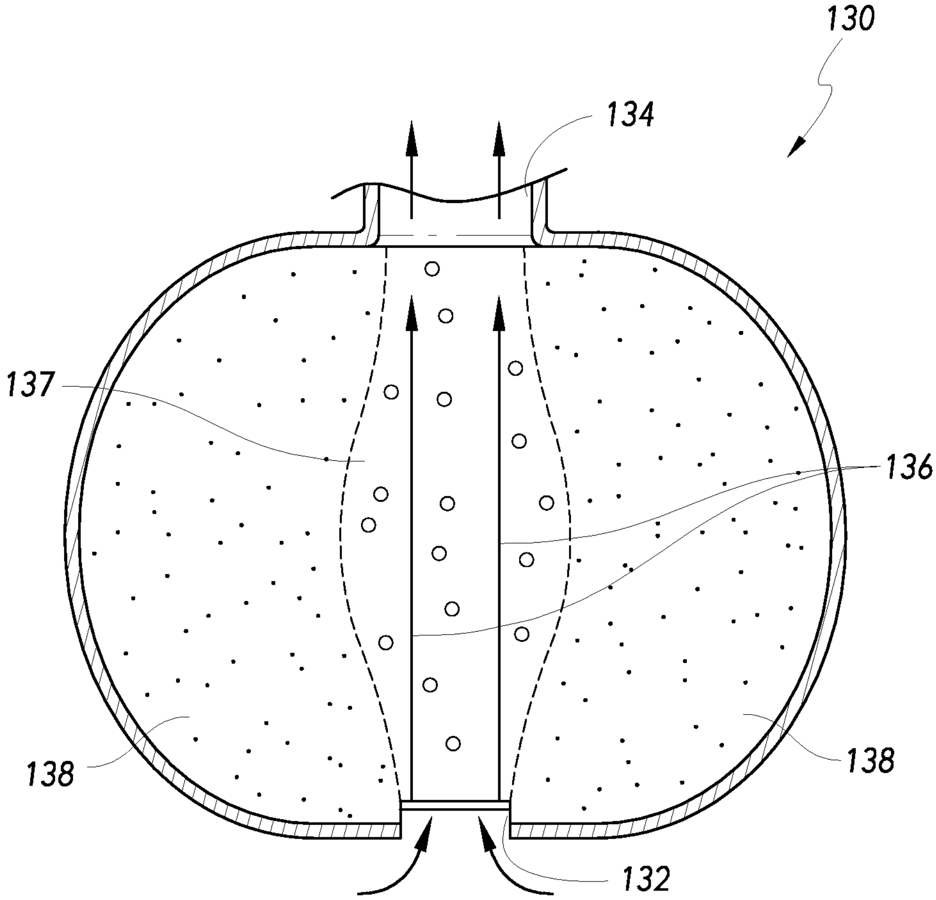
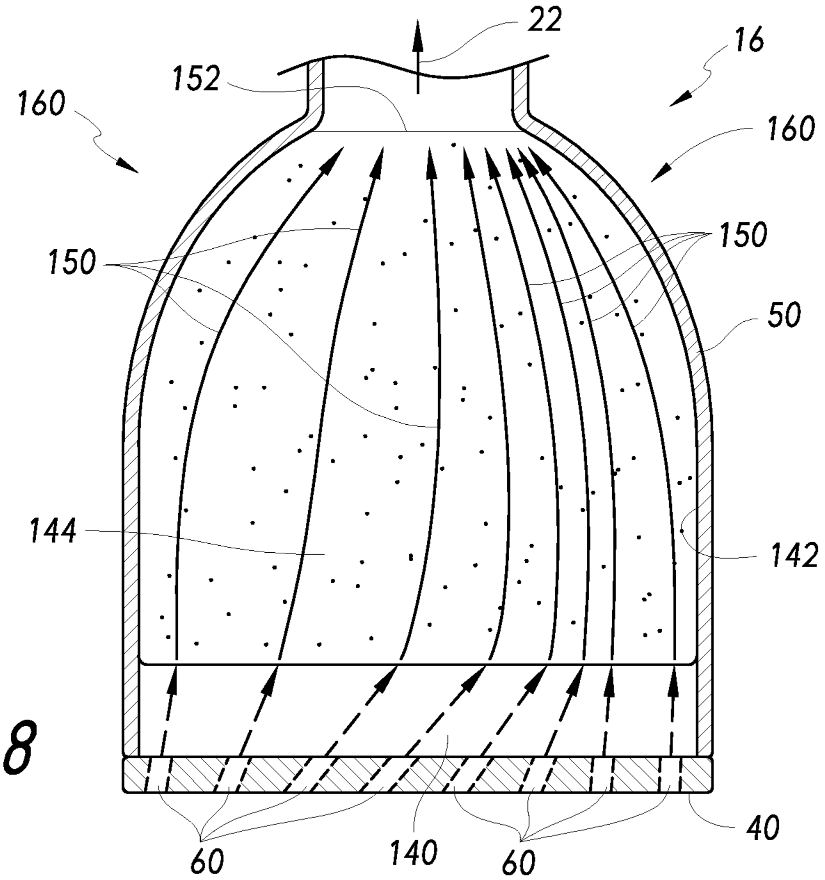


FIG. 7
(PRIOR ART)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140
60
40

FIG. 8

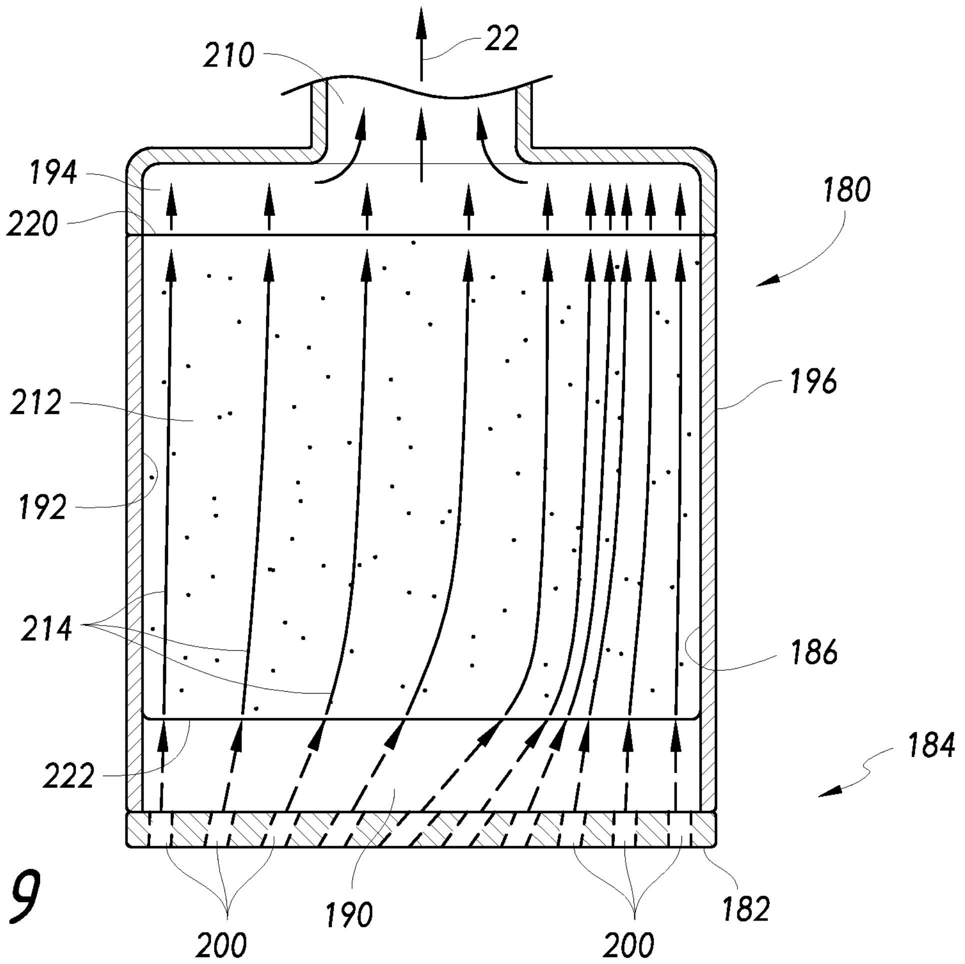
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FIG. 9

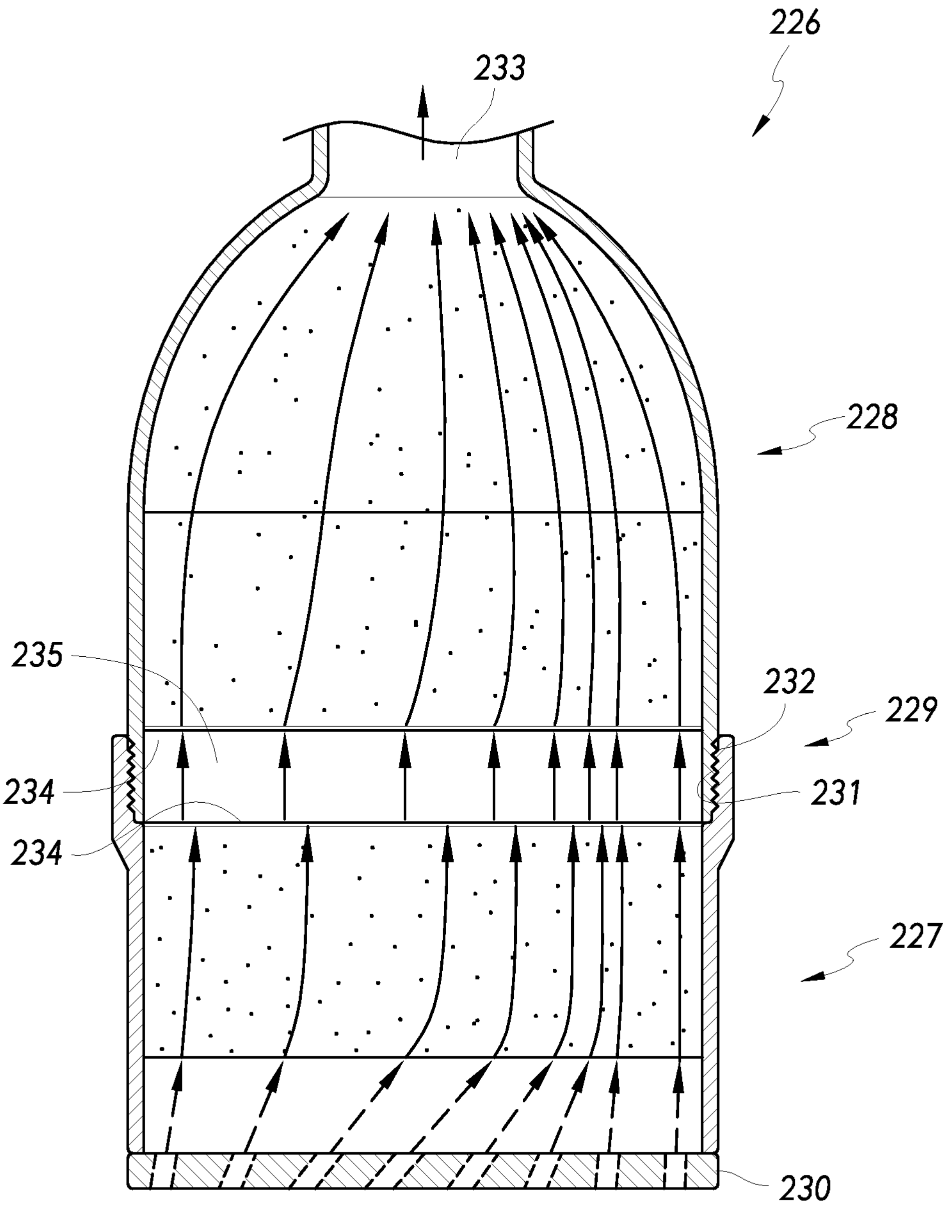

FIG. 10

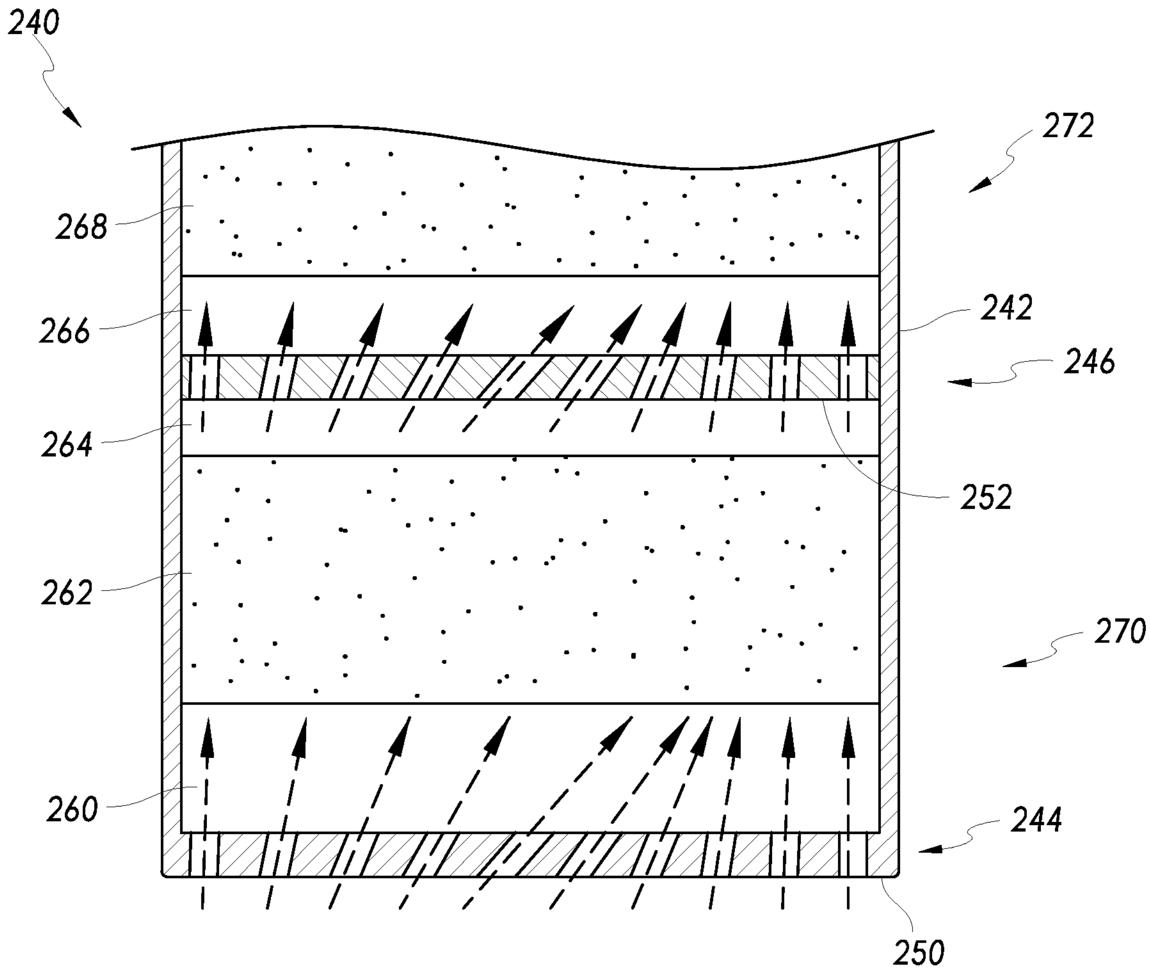

FIG. 11

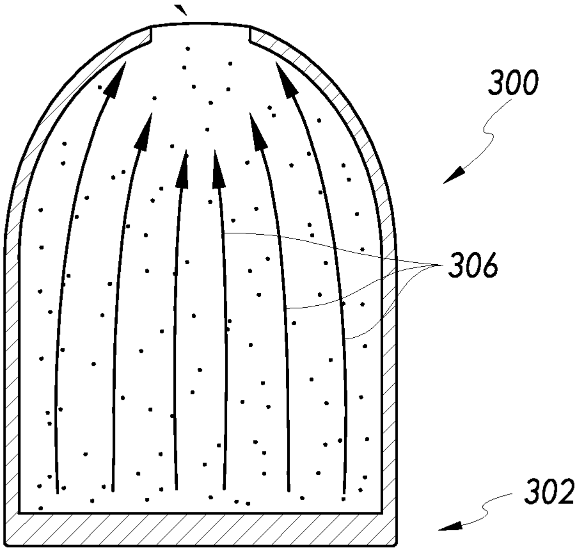

FIG. 12A

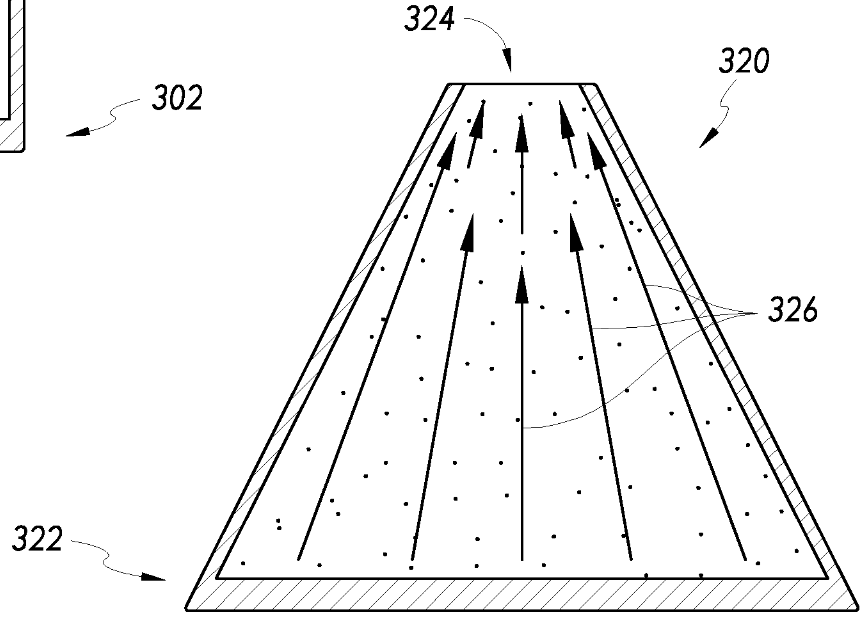

FIG. 12B

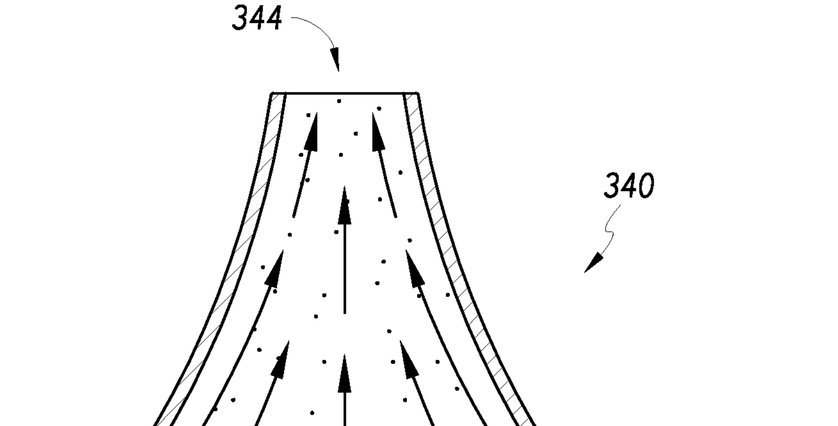

FIG. 12C

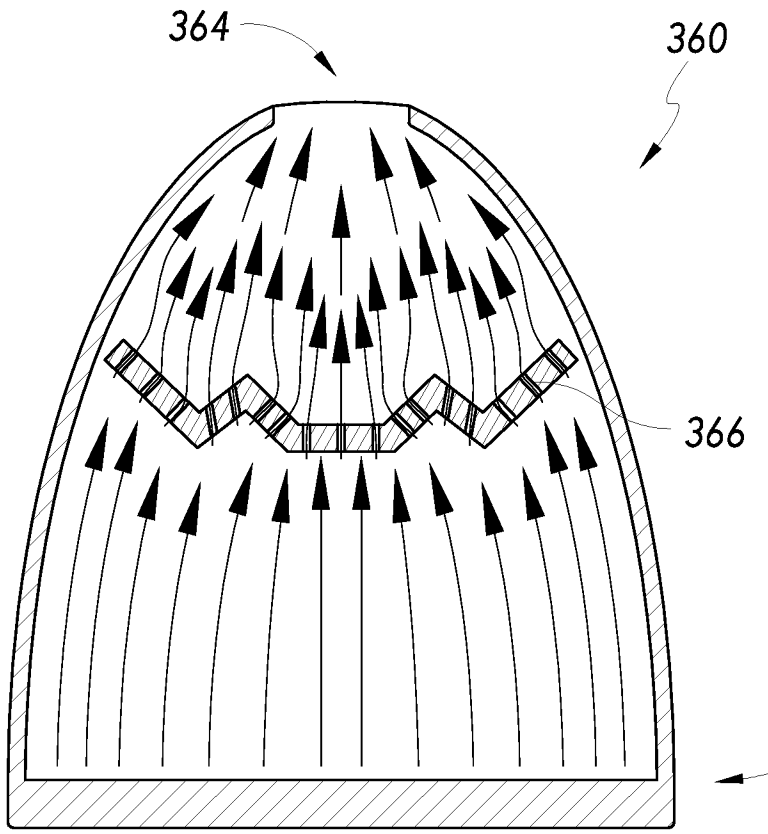

FIG. 13

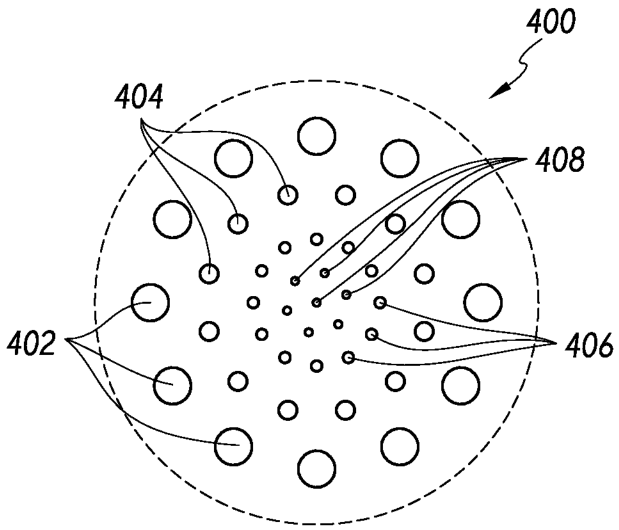

FIG. 14A

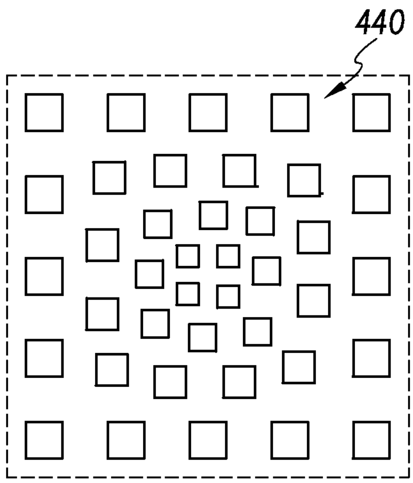

FIG. 14C

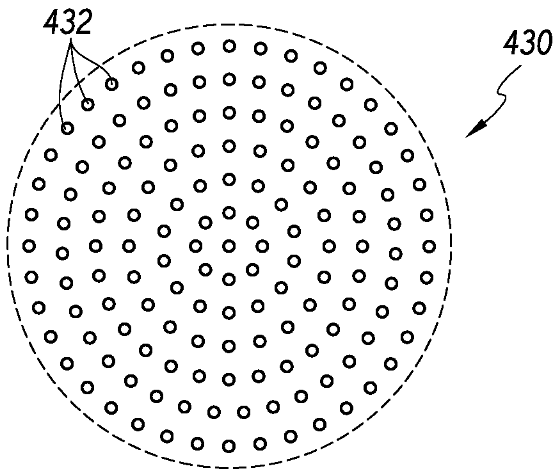

FIG. 14B

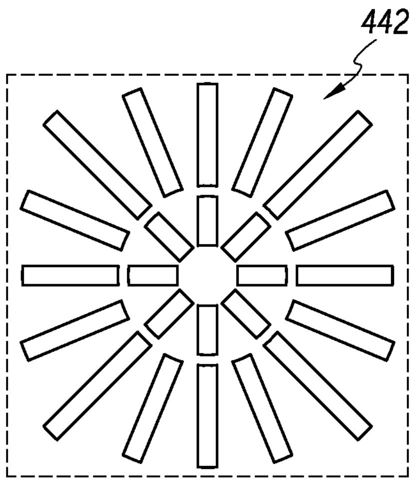

FIG. 14D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/55839

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A62B 23/02 (2013.01)
USPC - 128/206.17, 206.12
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)
IPC(8) - A62B 23/02 (2013.01)
USPC - 128/206.17, 206.12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
128/205.29, 205.12; 200.24-207.18; A62B 23/00
(Search term limited; see below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWest (PGPB, USPT, EPAB, JPAB); Google; PatBase (All);
Search Terms: Respirator, respiration, mask, emergency, smoke, fire, filter, air, airflow, stream, gas, vortex, vortices, vortical, cyclone, twister, tornado, spiral, swirl, spin, oblique, tangent, hole, aperture, inlet, port, opening, conduit, channel, tube, passage, passageway, rou

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 2003/0106556 A1 (ALPEROVICH et al.) 12 June 2003 (12.06.2003) Entire document, especially Abstract, para[0011], para[0038]- para[0040] and FIGS. 1-4.	1-5, 16-20 ---------- 6-9, 13, 21-23
X -- Y	US 4,155,359 A (ZAGORSKI) 22 May 1979 (22.05.1979) Entire document, especially Abstract, col 2, ln 67- col 3, ln 9; col 3, ln 56- col 4, ln 35 and FIGS. 1, 3, 6.	10 -------- 11-15
Y	US 5,787,884 A (TOVEY) 04 August 1998 (04.08.1998) Abstract, col 6, ln 27-39 and FIGS. 2-3.	6
Y	US 3,747,597 A (OLIVERA) 24 July 1973 (24.07.1973) Entire document, especially Abstract, col 1, ln 27- col 2 ln 15 and FIGS. 1-2	7-9, 11-12, 21-23
Y	US 2003/0075173 A1 (SHAHAF) 24 April 2003 (14.04.2003) Abstract, para[0020], para[0032]-para[0034] and FIG. 3.	14-15
A	US 2006/0144398 A1 (DOSHI et al.) 06 July 2006 (06.07.2006) Entire document.	1-23

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

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Date of the actual completion of the international search	Date of mailing of the international search report
31 October 2013 (31.10.2013)	02 DEC 2013

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