

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
10 August 2006 (10.08.2006)

PCT

(10) International Publication Number
WO 2006/084106 A1

(51) International Patent Classification:
B01D 53/04 (2006.01) **B01D 53/22** (2006.01)

(21) International Application Number:
PCT/US2006/003803

(22) International Filing Date: 3 February 2006 (03.02.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/649,711 3 February 2005 (03.02.2005) US

(71) Applicant (for all designated States except US): **DON-ALDSON COMPANY, INC.** [US/US]; 1400 West 94th Street, Minneapolis, MN 55440-1299 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **BABCOCK, Brian** [US/US]; 1667 Colonial Street, Shakopee, MN 55379 (US). **BUTTERFIELD, Amy** [US/US]; 8071 Woodlawn Drive, Moundsview, MN 55112 (US). **ISOAWA, Katsushi** [JP/US]; 553 Hackmore Drive, Eagan, MN 55123 (US). **SOLDNER, Carl** [US/US]; 5759 Ellice Trail, Apple Valley, MN 55124 (US).

(74) Agent: **DEFFNER, Mark, E.**; Pauly, DeVries Smith & Deffner, L.L.C., 900 IDS Center, 80 South Eighth Street, Minneapolis, MN 55402-8773 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

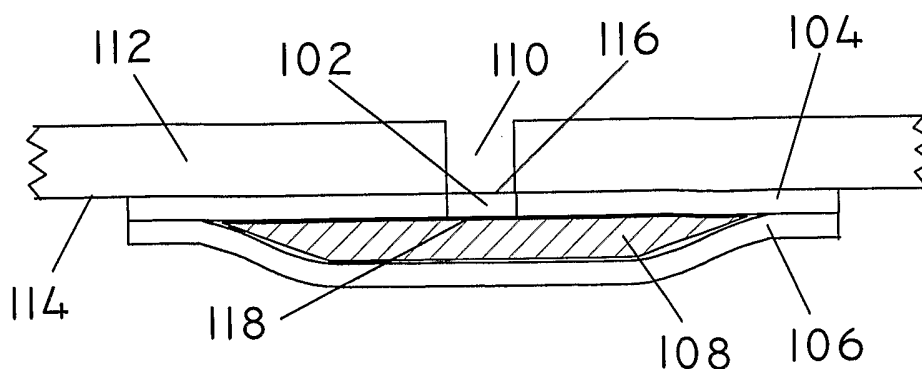
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

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.

(54) Title: BREATHER FILTER FOR REDUCTION OF CONTAMINANT DIFFUSION



(57) Abstract: The present invention relates to breather filters (400) that can reduce or prevent transmission of contaminants by diffusion. In an embodiment, the invention includes a breather filter (400) assembly including a valve. The valve including a first layer (420) defining a first aperture (403), a second layer (422) defining a second aperture (402), and a third layer disposed between the first and second layers, the third layer (408) including filtration media. The first layer (420) can be configured to flex away from the second layer (422) creating an air gap between the first layer and third layer. In an embodiment, the invention includes a breather filter (400) including a first layer (420), a second layer (422), a filter element (408) disposed between the first layer and the second layer, and a valve assembly comprising a first side and a second side. The valve assembly can be configured to change from a closed configuration to an open configuration when an air pressure differential between the first side and the second side exceeds a threshold amount.

WO 2006/084106 A1

BREATHER FILTER FOR REDUCTION OF CONTAMINANT DIFFUSION

This application is being filed as a PCT International Patent application on 03 February 2006, in the name of Donaldson Company, Inc., a U.S. national corporation, applicant for the designation of all countries except the U.S., and Brian Babcock, a U.S. citizen, Amy Butterfield, a U.S. citizen, Katsushi Isogawa, a citizen of Japan, and Carl Soldner, a U.S. citizen, applicants for the designation of the U.S. only, and claims priority to U.S. Patent Application Serial No. 60/649,711 filed on 03 February 2005.

Field of the Invention

The present invention relates to a filter for an electronic enclosure. More specifically, the present invention relates to breather filters that can reduce or prevent ingress of contaminants by diffusion.

Background of the Invention

Hard disk drives and other electronic equipment are often placed within enclosures to provide a clean environment that is necessary for optimal operation of the equipment. However, contaminants may still enter the electronic enclosure from an external source or may be generated from within the enclosure during use. Contaminants, including particles, gases such as water vapor, and liquids can gradually damage the drive, cause deterioration in performance, and in certain situations can even cause sudden and complete drive failure.

When a disk drive or other electronic equipment is in operation, the air in the enclosure often heats up and increases the air pressure in the enclosure. As a result of increased air pressure, air escapes from the enclosure if it has a breather hole or if it is not sealed airtight. Conversely, when a disk drive or other electronic equipment ceases to be in operation, the air in the enclosure cools down and decreases the air pressure in the enclosure. As a result of the decreased air pressure, air moves into the drive if it has a breather hole or if it is not sealed airtight. If contaminants are present in the air moving into the enclosure, the interior of the enclosure can become contaminated.

Breather filters are frequently used to prevent contaminants carried by exchanged air from entering electronic enclosures. Breather filters can be positioned

over a breather hole to remove contaminants from air entering the enclosure. Many breather filter designs include a fluid communication path between the exterior environment and the interior of the electronic enclosure that is always open to the passage of air. Thus, air can move through the breather filter to equalize any air
5 pressure differential that may arise between the inside and the outside of the electronic enclosure. However, because the fluid communication path is always open, contaminants can move through the path by the process of diffusion even absent the ingress or egress of air.

Therefore, a need exists for a breather filter that can reduce or prevent
10 ingress of contaminants by diffusion.

Summary of the Invention

The present invention relates to breather filters that can reduce or prevent ingress of contaminants into an electronic enclosure. In an embodiment, the
15 invention includes a breather filter assembly including a valve. The valve including a first layer defining a first aperture, a second layer defining a second aperture, and a third layer disposed between the first and second layers, the third layer including filtration media. The third layer can be attached to one of the first and second layers. The first layer can be configured to flex away from the second layer creating
20 an air gap between the first layer and the third layer.

In an embodiment, the invention includes a breather filter for an electronic enclosure including a first layer, a second layer, a filter element disposed between the first layer and the second layer, and a valve assembly comprising a first side and a second side. The valve assembly has an open configuration and a closed
25 configuration. The valve assembly is configured to change from the closed configuration to the open configuration when an air pressure differential between the first side and the second side exceeds a threshold amount.

In an embodiment, the invention includes a valve assembly for a breather filter including a first layer defining a plurality of pores, and a second layer also
30 defining a plurality of pores. The valve assembly can be configured to assume a closed position and an open position; such that the first layer and the second layer are adjacent to each other with the pores unaligned in the closed position. In the open position, an air gap separates a portion of the first layer from a portion of the second layer.

In an embodiment, the invention includes a breather filter assembly including a base layer, a valve layer, and a filtration media layer. The filtration media layer can be disposed between the base layer and the valve layer. The valve layer can include a first layer defining a plurality of inner pores and a second layer defining an outer flap. The first layer can be adjacent the second layer and the outer flap can be disposed over the inner pores. The outer flap can be configured to flex away from the inner pores.

The above summary of the present invention is not intended to describe each discussed embodiment of the present invention. This is the purpose of the figures and the detailed description that follows.

Drawings

The invention may be more completely understood in connection with the following drawings, in which:

FIG. 1 is a perspective view of a filter in accordance with an embodiment of the invention.

FIG. 2 is a top schematic view of the filter of FIG. 1.

FIG. 3 is cross-sectional view of the filter of FIG. 1, taken along line A-A' of FIG. 2.

FIG. 4 is a cross-sectional view of a passive valve in a closed state in accordance with an embodiment of the invention.

FIG. 5 is a cross-sectional view of the passive valve of FIG. 4 in an open state.

FIG. 6 is a perspective view of a filter in accordance with an embodiment of the invention.

FIG. 7 is a top schematic view of the filter of FIG. 6.

FIG. 8 is cross-sectional view of the filter of FIG. 6, taken along line B-B' of FIG. 7.

FIG. 9 is a cross-sectional view of the filter of FIG. 6, showing the passage of air through the filter.

FIG. 10 is a cross-sectional view of a filter in accordance with an embodiment of the invention attached to the outside of an electronic enclosure.

FIG. 11 is a cross-sectional view of a filter in accordance with an embodiment of the invention attached to the inside of an electronic enclosure.

FIG. 12 is a perspective view of the filter shown in FIG. 11.

FIG. 13 is a cross-sectional view of another filter in accordance with an embodiment of the invention.

FIG. 14 is an enlarged cross-sectional view of a portion of the filter of FIG. 13.

FIG. 15 is a cross-sectional view of a portion of the filter of FIG. 13 showing the passage of air through the filter.

FIG. 16 is another cross-sectional view of a portion of the filter of FIG. 13 showing the passage of air through the filter.

FIG. 17 is a cross-sectional view of another filter in accordance with an embodiment of the invention.

While the invention is susceptible to various modifications and alternative forms, specifics thereof have been shown by way of example and drawings, and will be described in detail. It should be understood, however, that the invention is not limited to the particular embodiments described. On the contrary, the intention is to cover modifications, equivalents, and alternatives falling within the spirit and scope of the invention.

Detailed Description of the Invention

The term "valve" as used herein shall refer to a device by which the flow of a fluid may be started and stopped, or at least moderated, by a movable part that opens, shuts, or obstructs one or more fluid flow ports or passageways.

The term "active valve" as used herein shall refer to a valve wherein opening and closing of the valve is actuated by a means external to the valve itself, such as by mechanical, hydraulic, pneumatic, electric, or electromagnetic actuation.

The term "passive valve" as used herein shall refer to a valve wherein opening and closing of the valve is directly actuated by pressure forces in the fluid flow stream that the valve controls.

The terms "adsorbent" and "absorbent" as used herein shall both refer to either absorbent or adsorbent materials, unless the specific context indicates to the contrary. That is, the specific nature of the interaction between the captured contaminant and the filter material, is not referenced.

Embodiments of the present invention include breather filters that can reduce or prevent ingress of contaminants by diffusion. Some embodiments of the

invention include valves that open when a threshold air pressure differential exists so that air pressure can be equalized but close when a threshold air pressure differential does not exist so that ingress of contaminants into the breather filter and/or the electronic enclosure by diffusion is prevented or reduced.

5 FIG. 1 is a perspective view of a filter 100 in accordance with an embodiment of the invention. The filter 100 has a top layer 104 and an air valve assembly 102. In some embodiments, the top layer 104 is made of a substantially fluid impermeable material, such as a barrier film. The air valve assembly 102 opens when the pressure differential between the two sides of the valve reaches a
10 threshold. The air valve assembly 102 can be constructed so that the threshold is set at a desired pressure differential.

 FIG. 2 is a top view of the filter of FIG. 1. The air valve assembly 102 is disposed in the middle of the top layer 104. However, it will be appreciated that the air valve assembly 102 can also be offset from the middle of the top layer 104. FIG.
15 3 is a cross-sectional view of the filter 100 of FIG. 1, taken along line A-A' of FIG. 2 and attached to an electronic enclosure 112. It will be appreciated that the filter 100 can be attached to the electronic enclosure 112 using any conventional technique including the use of adhesives or mechanical fasteners. The air valve assembly 102 is aligned with a breather port 110 in the electronic enclosure 112.
20 The top layer 104 of the filter is adjacent to the inner surface 114 of the electronic enclosure 112. Thus, in the embodiment shown, the filter is attached to the inside of the electronic enclosure 112. However, it will be appreciated that the filter can also be attached to the outside of the electronic enclosure 112 in alternative embodiments. The peripheral edges of the top layer 104 are attached to the
25 peripheral edges of a bottom layer 106.

 In some embodiments, the air valve assembly 102 only opens when the air pressure on the top side 116 of the air valve assembly 102 is greater than the air pressure on the bottom side 118 of the air valve assembly 102 by a threshold amount. In other embodiments, the valve assembly 102 only opens when the air
30 pressure on the top side 116 of the air valve assembly 102 is less than the air pressure on the bottom side 118 of the air valve assembly 102 by a threshold amount. In still other embodiments, the valve assembly 102 opens when the air pressure on the top side 116 of the air valve assembly 102 is either greater than or

less than the air pressure on the bottom side 118 of the air valve assembly 102 by a threshold amount.

The bottom layer 106 can be a fluid permeable membrane. In an embodiment, the bottom layer 106 is an expanded polytetrafluoroethylene (PTFE) membrane. However, in some embodiments, the bottom layer 106 is made of a substantially fluid impermeable material but has one or more apertures (not shown). A filter element 108 is disposed between the top layer 104 and the bottom layer 106. The filter element 108 can include various types of filter media (including activated carbon) depending on what types of contaminants are to be removed by the breather filter. Various types of filter media are described in more detail below. The filter element 108 can optionally be contained inside a scrim. In some embodiments, the filter element 108 can absorb water vapor.

Electronic enclosures, such as disk drive housings, are being used inside of increasingly small electronic components. Therefore, it can be advantageous for a breather filter to be no bigger than necessary. In some embodiments, the total thickness of the breather filter is less than about 5 millimeters. In a particular embodiment, the total thickness of the breather filter is less than about 3 millimeters, optionally less than 2 millimeters, and in some embodiments less than 1 millimeter.

The filter shown in FIG. 3 can function to allow air to pass through as necessary to prevent a large pressure differential from building up between the inside and the outside of the electronic enclosure. For example, when the air pressure on the bottom 118 of the air valve assembly 102 is greater than on the top 116 of the air valve assembly, air can pass through the bottom layer 106, filter element 108, and the air valve assembly 102 and then out of the breather port 110 in the electronic enclosure 112. When the air flows out in this manner, the pressure differential across the air valve assembly 102 is reduced and the air valve assembly 102 closes once the differential is below the threshold amount. Conversely, when the air pressure on the top 116 of the air valve assembly 102 is greater than on the bottom 118 of the air valve assembly, air can pass through the breather port 110, the air valve assembly 102, the filter element 108, the bottom layer 106, and into the electronic enclosure 112 equalizing the air pressure across the valve assembly 102.

The filter shown in FIG. 3 can reduce the amount of contaminants that diffuse into the electronic enclosure from the outside in comparison to breather filters that contain a fluid flow path that is always open. One reason for this is

because when the air valve assembly 102 is in a closed state, the amount of contaminants that can pass into the inside of the electronic enclosure is relatively small because the air valve assembly 102 physically blocks the pathway. Further, the filter element 108 can act to adsorb any contaminants that may diffuse through the air valve assembly 102 even when it is in a closed state.

It will be appreciated that the air valve assembly 102 can take on various forms. The air valve assembly 102 may be either an active valve or a passive valve. Passive air valves can generally be manufactured less expensively than active valves. In an embodiment, the filter of the invention includes a passive air valve. Many different types of passive air valves can be used. FIG. 4 illustrates a cross section one example of a passive valve 200. The passive valve 200 includes a first layer 202 and a second layer 206. The first layer 202 has a plurality of pores 204 that are sufficiently large in diameter to allow the passage of air. Similarly, the second layer 206 has a plurality of pores 208 that are sufficient large in diameter to allow the passage of air. In an embodiment, the pores 204 of the first layer 202 and the pores 208 of the second layer 206 are at least about 0.5 millimeter in diameter.

The passive valve 200 has a closed configuration shown in FIG. 4 and an open configuration shown in FIG. 5. In the closed configuration show in FIG. 4, the first layer 202 and the second layer 206 are disposed against one another in a manner such that the pores 204 of the first layer do not line up with the pores 208 of the second layer. Accordingly, the flow of air is blocked across the first layer 202 and the second layer 206 when the passive valve 200 is in the closed configuration. In some embodiments, the valve 200 includes a liquid composition (not shown) in between the first layer 202 and the second layer 206. The liquid composition can enhance the ability of the filter to block airflow across the valve 200 when the valve 200 is in the closed position. The liquid composition can also help to control the amount of force necessary to shift the valve 200 from the closed position to the open position.

The first layer 202 of the passive valve 200 can be made from a material that deforms (or flexes) when a force is applied to it. When the air pressure is greater on the second side 212 of the valve than on the first side 214, the passive valve can assume an open position. Specifically, when the air pressure is greater on the second side 212 of the valve than on the first side 214, the first layer 202 flexes away from the second layer 206 and an airflow path between the pores 208 of the

second layer and the pores 204 of the first layer is created. In the open position, air can flow through the passive valve in the direction of arrows 210. The first layer 202 may be made of any material that can be formed with pores for the passage of air and that has sufficient flexibility to assume an open position when incorporated
5 as part of a passive valve. For example, the first layer 202 of the passive valve can be made of a deformable polymeric film. By way of further example, the first layer can comprise polyurethane, polypropylene, polyester, or polytetrafluoroethylene (PTFE). In some embodiments, the second layer 206 is less flexible than the first layer 202. This can be achieved in many ways. For example, the second layer 206
10 can be made thicker than the first layer 202. By way of further example, the second layer 206 can be made of a material that is less flexible than the material used to make the first layer 202. Also, it will be appreciated, that in certain embodiments both the first layer 202 and second layer 206 are sufficiently flexible so as to allow airflow in either direction (into or out of an enclosure) depending upon the direction
15 of the pressure differential between the first and second sides 214 and 212 of the enclosure.

FIG. 6 is a perspective view of a filter 300 in accordance with an embodiment of the invention. In this view, the filter 300 is shown with a top layer 304 that defines two top ports 302. Depending on the configuration of the filter
20 relative to the electronic enclosure, the top ports 302 can provide fluid communication between the interior of the filter and the exterior of the electronic enclosure or they can provide fluid communication between the interior of the filter and the interior of the electronic enclosure. It will be appreciated that in some embodiments, the filter includes only one top port. However, the filter can also
25 include more than two top ports 302. If the top ports are too small, they may undesirably impede the flow of air.

FIG. 7 is a top schematic view of the filter 300 of FIG. 6, including aspects of the interior and bottom of the filter 300. In this view, a bottom port 306 is shown in dotted lines. Depending on the configuration of the filter relative to the electronic
30 enclosure, the bottom port can provide fluid communication between the interior of the filter and the exterior of the electronic enclosure or between the interior of the filter and the interior of the electronic enclosure. Embodiments of the invention can include more than one bottom port. If the bottom port is too small, it may undesirably impede the flow of air. FIG. 7 shows a filter element 308 inside the

filter. The filter element 308 can function to remove contaminants from the air inside the filter. The filter element can be annular (or ring shaped). However, the filter element can also assume other shapes. The filter element 308 can optionally be contained within a scrim.

5 The filter element 308 can include filter media that removes contaminants from air flowing through the breather filter 300. The filter element 308 can also remove contaminants that otherwise diffuse into the breather filter 300. In some embodiments, the filter element 308 can be made of a material that swells in the presence of water vapor. By way of example, the filter element 308 can include
10 activated carbon, silica gel, a water-absorbing swellable polymer, or combinations thereof. In an embodiment, the filter element 308 includes a superabsorbent polymer. By way of example, the superabsorbent polymer can be AQUAKEEP SA60N Type II from Sumitomo Seika Chemical or NAFION from DuPont, Wilmington, DE.

15 FIG. 8 is cross-sectional view of the filter 300 of FIG. 6, taken along line B-B' of FIG. 7. The top layer 304 is adjacent to the filter element 308. The filter element is attached to the bottom layer 310. In the configuration shown in FIG. 8, the filter element 308 blocks the air flow path in between the top ports 302 and the bottom port 306. FIG. 9 is a cross-sectional view of the filter of FIG. 6, taken along
20 line B-B' of FIG. 7, showing the passage of air through the filter when the pressure differential across the filter exceeds a threshold level. When the air pressure on the first side 314 of the filter is greater than the air pressure on the second side 316 of the filter, such as when the enclosure is rapidly warming, the top layer 304 flexes such that a gap is created in between the top layer 304 and the filter element 308.
25 When this occurs, an airflow path is opened between the top ports 302 and the bottom port 306 and air flows in the direction of arrows 312. It will be appreciated that alternatively the filter element 308 can be attached to the top layer 304 instead of the bottom layer 310.

30 Where the filter element 308 is made of a material that swells in the presence of water or water vapor, as described above, the filter element 308 can serve to more effectively block the airflow path through the filter 300 over time as it is exposed to more water vapor. For example, referring again to the configuration shown in FIG. 8, since the filter element 308 would swell after exposure to water vapor, it would more tightly contact the top layer 304 and the bottom layer 310 and therefore form a

better seal and more effectively block airflow. The swelling of the water-absorbing swellable polymer can also prevent water vapor from diffusing through the polymer itself because of the phenomenon known as gel-blocking.

It will be appreciated that filters of the invention can be affixed to an electronic enclosure over the breather hole on either the outside or inside of the electronic enclosure. By way of example, referring to FIG. 10, a filter in accordance with an embodiment of the invention is shown attached to the exterior surface 322 of an electronic enclosure 318. It will be appreciated that the filter can be attached to the electronic enclosure 318 using any conventional technique including the use of adhesives or mechanical fasteners. The electronic enclosure 318 has a breather hole 320. The filter is arranged so that the bottom port 306 fits over the breather hole 320 of the electronic enclosure. In contrast, FIG. 11 shows a cross-sectional view of a filter in accordance with an embodiment of the invention attached to the interior surface 324 of an electronic enclosure. In this embodiment, a spacer pad 326 provides an air gap in between the surface 324 of the electronic enclosure 318 and the top ports 302. The air gap formed by the spacer pad 326 is large enough that the top layer 304 can flex sufficiently to create an airflow path through the filter. FIG. 12 shows a top perspective view of the filter in FIG. 11. In this view, the spacer pad 326 can be seen disposed on the top layer 304 of the filter.

Referring now to FIG. 13, a cross-sectional view of a filter 400 in accordance with another embodiment of the invention is shown attached to the inner surface of an electronic enclosure 430. It will be appreciated that the filter 400 can be attached using any conventional technique including the use of adhesives or mechanical fasteners. FIG. 14 shows an enlarged view of a portion 432 of the filter of FIG. 13. The filter has a top layer 410 which defines a top port 434. The filter has a valve layer 442 including a first layer 423 and a second layer 422. The first layer 423 includes a plurality of pores 402 (not drawn to scale) and a flap portion 420. The flap portion 420 is flexible and can move. Similarly, the second layer 422 includes a plurality of pores 403 (not drawn to scale) and a flap portion 418.

When the valve layer 442 is in a closed position, the first layer 423 and the second layer 422 are arranged with respect to each other such that the flap portion 418 of the second layer 422 covers the pores 402 of the first layer 423. Similarly, in the closed position, the flap portion 420 of the first layer 423 covers the pores 403 of

the second layer 422. Thus, in the closed position, the flow of air through the valve layer 442 is blocked.

FIG. 15 illustrates how the filter 400 of FIG. 13 operates to allow the passage of air from one side of the electronic enclosure to the other side of the electronic enclosure. When the air pressure on the inside 436 of the electronic enclosure is greater than on the outside 438 by a threshold amount, the first layer flap 420 flexes open to allow air to flow through the filter in the direction of arrow 426. FIG. 16 illustrates how the filter 400 of FIG. 13 operates to allow the passage of air from the outside of the electronic enclosure to the inside of the electronic enclosure. When the air pressure on the outside 438 of the electronic enclosure is greater than on the inside 436, the second layer flap 418 flexes open to allow air to flow through the filter in the direction of arrow 428. Thus, the filter of FIG. 13 allows air to flow back and forth between the inside 436 and the outside 438 of the electronic enclosure 430, but only when a pressure differential exists that is sufficient to cause one of the flaps 418, 420 to flex into an open position.

The magnitude of the pressure differential that is necessary to cause the flaps 418, 420 to flex into an open position will vary based on factors such as the flexibility of the material used to make the flaps, the thickness of the flaps, the size of the flaps, and the like. However, it will be appreciated that the properties of the flaps can be changed such that the pressure differential necessary to open them is as desired for the particular application. The first layer 423 and the second layer 422 of the valve layer 442 can be made of a polymeric film that is substantially impermeable to fluid flow (in the absence of pores 402, 403). In some embodiments, the first layer 423 and the second layer 422 of the valve layer 442 include a barrier film.

In some embodiments, the top port 434 is disposed over a breather port in an electronic enclosure 430 such as depicted in FIG. 13. However, in other embodiments the configuration is reversed, such as that shown in FIG. 17, so that the top port 434 of the filter is on the opposite side of the filter that is adjacent to the breather port 440 of the electronic enclosure 430.

While not shown, it will be appreciated that a valve layer can also be made having only flaps on the first layer and only pores on the second layer. This type of valve layer configuration would provide for the one-way passage of air. Similarly, a

valve layer can be made having only flaps on the second layer and only pores on the first layer.

Filter Media

5 In some embodiments of the invention, the breather filter can contain filter media in a filter element or filter layer. Filter media can include particulate filter media and/or adsorbent filter media. Particulate filter media used with the invention can have efficiency over a wide range of particle sizes including submicron to macroscopic sizes (preferably greater than or equal to 0.02 micrometers). Suitable
10 particulate filter media materials include microfiberglass media, high efficiency electret materials, and membrane materials such as, but not limited to, expanded polytetrafluoroethylene membrane, polypropylene membrane, polycarbonate and polyester membranes, mixed-esters of cellulose membrane, polyvinyl chloride membrane, cellulose triacetate membrane, and thin film composite membranes
15 and/or laminates thereof. An especially suitable particulate filtering media is expanded polytetrafluoroethylene (expanded PTFE or ePTFE) because of its good filtration performance, conformability to cover adsorbent layers, and cleanliness. A preferred expanded PTFE membrane has a filtration efficiency of 99.99% at 0.1 micrometer diameter sized particles with a resistance to airflow of approximately 20
20 mm water column at an airflow of 10.5 feet per minute face velocity. Expanded PTFE is commercially available as GORE-TEX® from W.L. Gore & Associates, Inc. Millipore PVDF can also be used in certain embodiments as a particulate filter media.

Adsorbent media used in some embodiments of the invention may be
25 selected from a broad range of adsorbents and is tailored to the particular gas or gases that are of concern. These gases include water vapor, dioctyl phthalate, silicone, chlorine, hydrogen sulfide, nitrogen dioxide, mineral acid gases, hydrocarbon compounds and any other gas that can oxidize or cause corrosion of any critical element or that can condense onto critical elements so as to effect their
30 operation. The adsorbent media selected may be of a single type or a combination of different media types. It may be a specifically selected adsorbent that targets a specific gas or may be one that has good adsorption properties over a wide range of gases.

Adsorbent media used in embodiments of the invention can include physisorbers such as, but not limited to silica gel, activated carbon, activated alumina, molecular sieves, or drying agents such as clays; or chemisorbents such as, but not limited to calcium carbonate, calcium sulfate, potassium permanganate, sodium carbonate, potassium carbonate, sodium phosphate, powdered or activated metals or other reactants for chemically reacting and scavenging gas phase corrosive materials or contaminants.

If a combination of adsorbents is used, they may be individual layers that are positioned on top of each other, or mixed into one layer. Alternatively, the adsorbent media may be one that has been impregnated with one or more additional adsorbents such as, but not limited to, activated carbons, silica gels or aluminas that have been impregnated with one or more chemisorbents as mentioned above. A preferred broad range adsorbent is activated carbon with a wide pore size distribution that has been impregnated with one or more chemisorbents such as calcium carbonate or sodium carbonate. To fabricate a broad based physisorbent, a wide pore size distribution may be used to provide for a broad range of gasses to be adsorbed. The carbonates are typically good impregnation candidates because the compounds being released due to the chemical reaction of the chemisorbents are carbon dioxide, oxygen, and water. A preferred adsorbent for a given contaminant depends upon the contaminant, the pore size of the physisorbent and chemical composition of the chemisorber that is selected so as to optimize performance on that particular contaminant.

The adsorbent media may include, but is not limited to, one or more of the following constructions: 100% adsorbent material such as a granular adsorbent, a carbonized woven or nonwoven material, and adsorbent impregnated nonwoven material such as a cellulose or polymeric nonwoven that may include latex, acrylic or some other binder system, porous cast adsorbents that may include polymers or ceramics to keep their porous structure, adsorbent impregnated polymers or polymer membranes that serve as a porous scaffold in which void spaces within the scaffold are filled with an adsorbent. Polymeric scaffolds include, but are not limited to, expanded PTFE membranes, polypropylene membranes, polyethylene membranes, polypropylene membranes, polyethylene membranes, polyvinylidene fluoride membranes, polyvinyl alcohol membranes, polyethylene terephthalate membranes and membranes from any other polymer that can be made to have a node and fibril

structure. The adsorbent material may be entirely of one type or a mixture of any number of physisorbers and/or chemisorbers.

In some embodiments, the adsorbent media can include a water-swella-
ble component. In an embodiment, the adsorbent media includes a water-swella-
5 ble absorbent polymer. Water-swella-ble absorbent polymers are also known as
superabsorbent polymers. Water-swella-ble absorbent polymers can include anionic
polymers, such as the alkali metal and ammonium salts of poly(acrylic acid),
poly(methacrylic acid), isobutylene-maleic anhydride copolymers, poly(vinyl acetic
acid), poly(vinyl phosphonic acid), poly(vinyl sulfonic acid), carboxymethyl
10 cellulose, carboxymethyl starch, carrageenan, alginic acid, polyaspartic acid,
polyglutamic acid, and combinations and copolymers thereof, cationic polymers,
such as salts of poly(vinyl amine), poly(ethylene imine), poly(amino propanol vinyl
ether), poly(allyl amine), poly(quaternary ammonium), poly(diallyl dimethyl
ammonium hydroxide), polyasparagins, polyglutamines, polylysines, polyarginines,
15 and combinations and copolymers thereof, mixtures of the anionic and cationic
polymers described above. In an embodiment, the water-swella-ble absorbent
polymer includes one of sodium polyacrylate, polyvinyl amine salt, polyacrylic acid,
polyvinyl amine, and combinations and derivatives thereof. In an embodiment, the
water-swella-ble absorbent polymer includes AQUAKEEP SA60N available from
20 Sumitomo Seika Chemicals. In another embodiment, the water-swella-ble absorbent
polymer can include NAFION available from DuPont, Wilmington, DE.

While the present invention has been described with reference to several
particular implementations, those skilled in the art will recognize that many changes
may be made hereto without departing from the spirit and scope of the present
25 invention.

We claim:

1. A breather filter assembly comprising:
a valve comprising:
a first layer defining a first aperture;
a second layer defining a second aperture; and
a third layer disposed between the first and second layers, the third layer comprising filtration media,
the third layer attached to at least one of the first and second layers; and
the first layer configured to flex away from the second layer creating an air gap between the first layer and the third layer.
2. The breather filter assembly of claim 1, wherein the valve comprises a passive valve.
3. The breather filter assembly of claim 1, wherein the filtration media absorbs water vapor.
4. The breather filter assembly of claim 1, wherein the filtration media comprises a water-swellaable absorbent polymer.
5. The breather filter assembly of claim 1, wherein the first layer and the second layer comprise a substantially non-permeable polymeric film.
6. The breather filter assembly of claim 1, wherein the first layer defines a plurality of apertures.
7. The breather filter assembly of claim 1, wherein the second layer defines a plurality of apertures.
8. The breather filter assembly of claim 1, wherein the third layer is annular.

9. The breather filter assembly of claim 1, the first layer comprising a peripheral edge, and the second layer comprising a peripheral edge attached to the peripheral edge of the first layer.
10. A breather filter assembly comprising:
 - a base layer;
 - a valve layer; and
 - a filtration media layer, the filtration media layer disposed between the base layer and the valve layer;the valve layer comprising a first layer defining a plurality of inner pores and a second layer defining an outer flap; the first layer adjacent the second layer, the outer flap disposed over the inner pores, the outer flap configured to flex away from the inner pores.
11. The breather filter assembly of claim 10, the second layer defining a plurality of outer pores and the second layer defining an inner flap, the inner flap disposed over the outer pores, the inner flap configured to flex away from the outer pores.
12. The breather filter assembly of claim 10, further comprising a liquid composition disposed between the first layer and the second layer.
13. The breather filter assembly of claim 10, wherein the filtration media comprises activated carbon.
14. The breather filter assembly of claim 10, wherein the first layer and the second layer comprise a substantially non-permeable polymeric film.
15. The breather filter assembly of claim 10, wherein the filtration media absorbs water vapor.
16. A breather filter for an electronic enclosure comprising:
 - a first layer defining an aperture;
 - a second layer;
 - a filter element disposed between the first layer and the second layer; and

a valve assembly comprising a first side and a second side, the valve assembly attached to the first layer, the valve assembly having an open configuration and a closed configuration, wherein the valve assembly is configured to change from the closed configuration to the open configuration when an air pressure differential between the first side and the second side exceeds a threshold amount.

17. The breather filter of claim 16, wherein the valve assembly comprises a passive valve.

18. The breather filter of claim 16, wherein the filter element absorbs water vapor.

19. The breather filter of claim 16, wherein the second layer comprises a membrane that is permeable to fluid flow.

20. The breather filter of claim 19, wherein the second layer comprises an expanded polytetrafluoroethylene membrane.

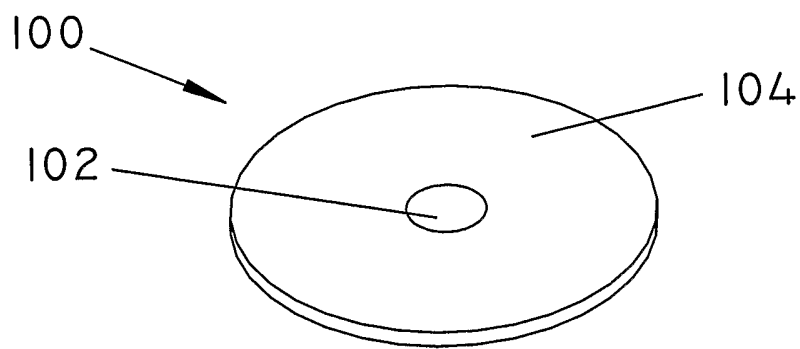


FIG. 1

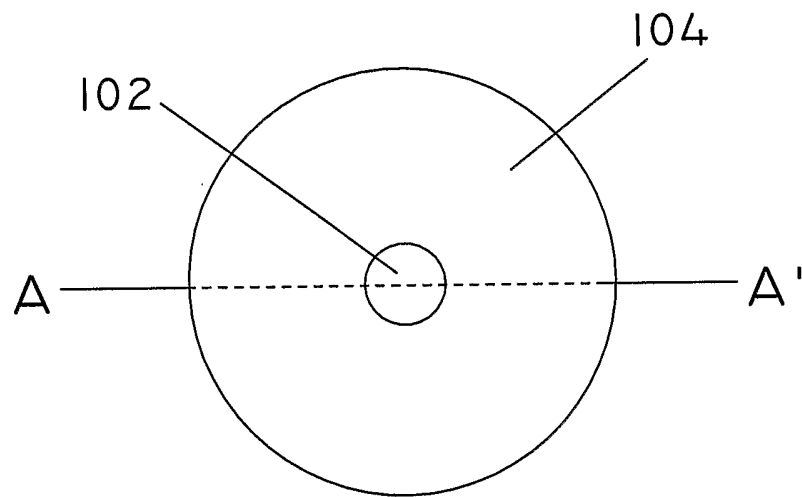


FIG. 2

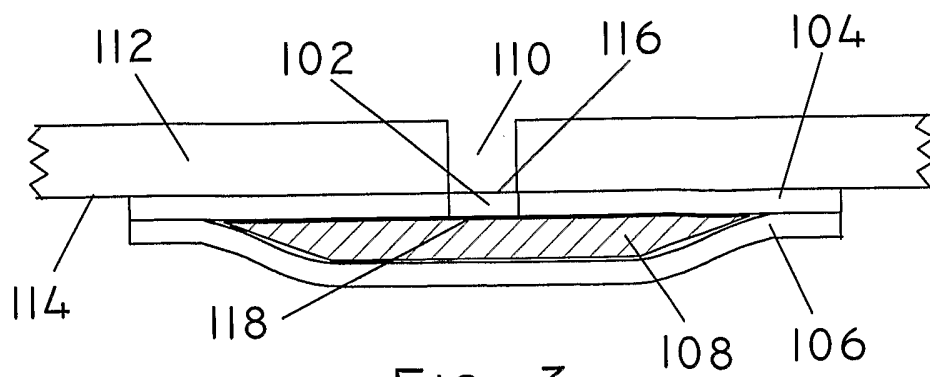


FIG. 3

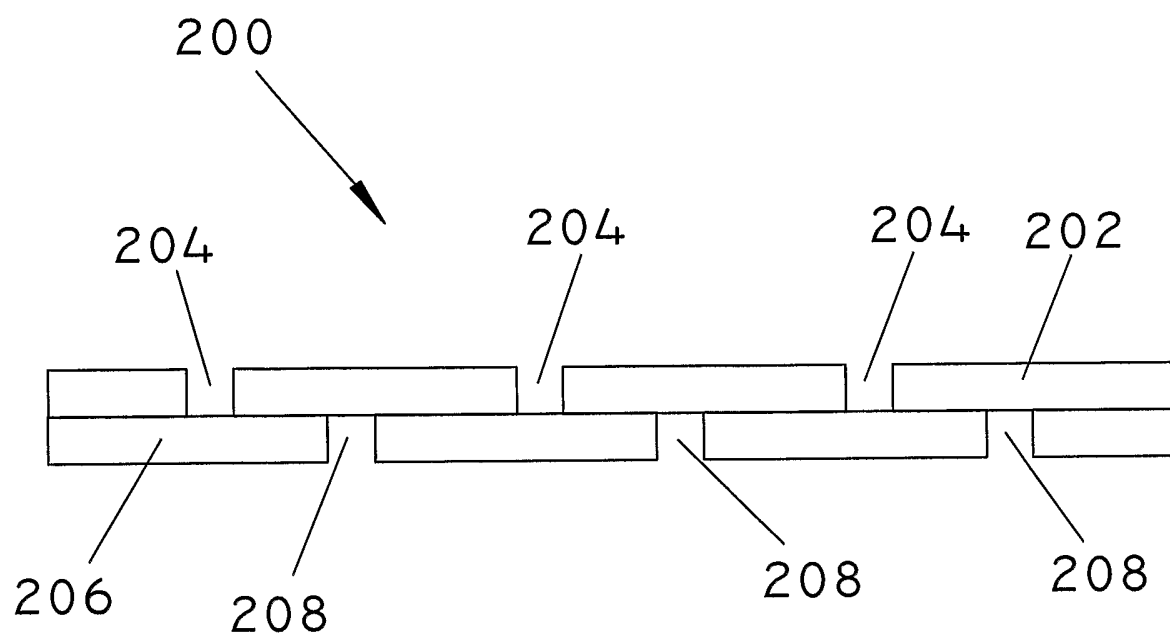


FIG. 4

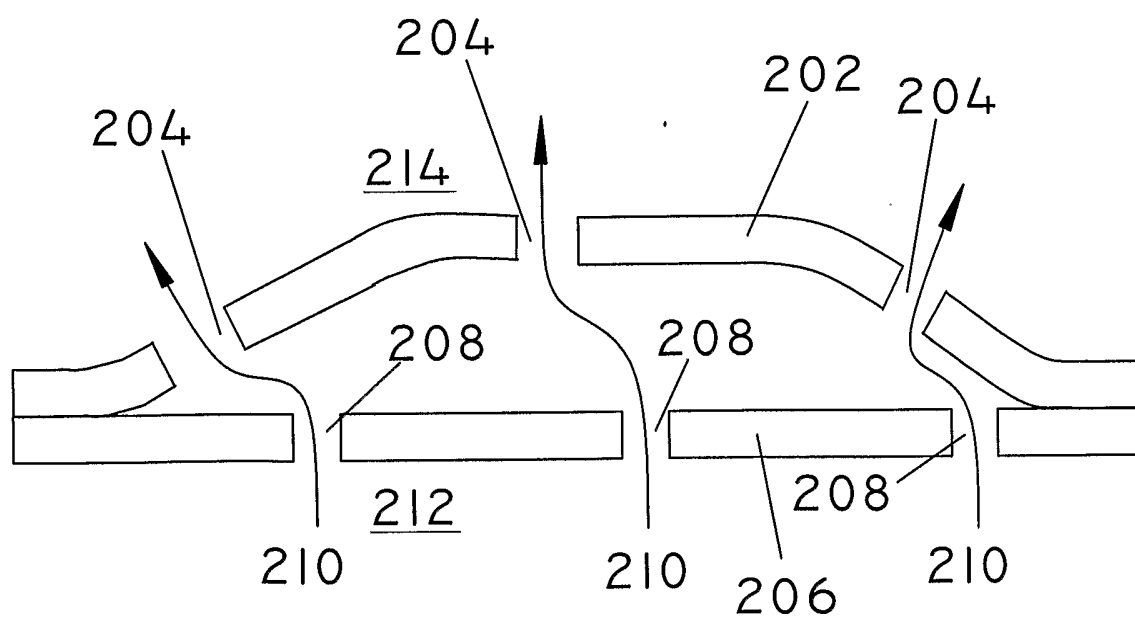


FIG. 5

3/8

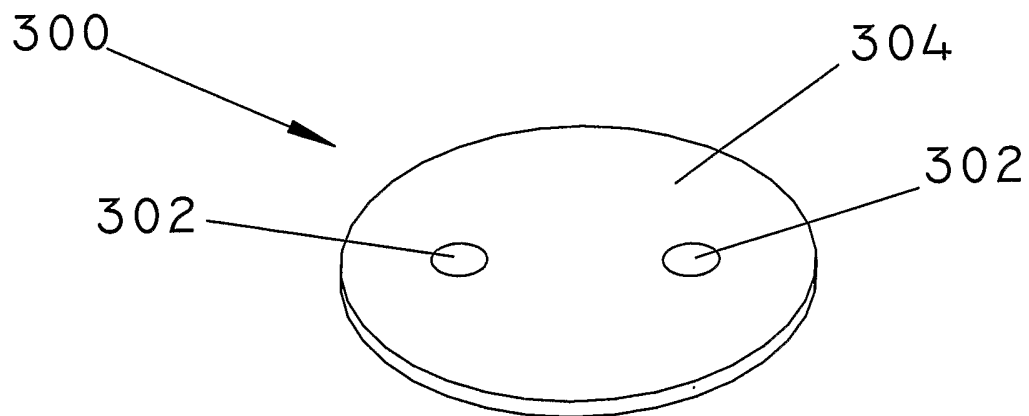


FIG. 6

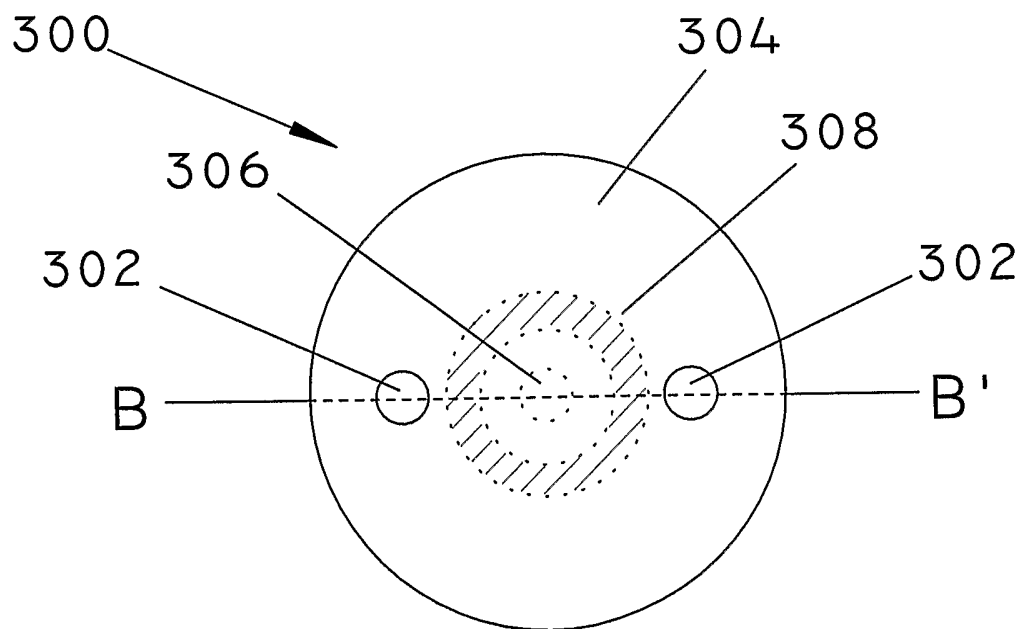


FIG. 7

4/8

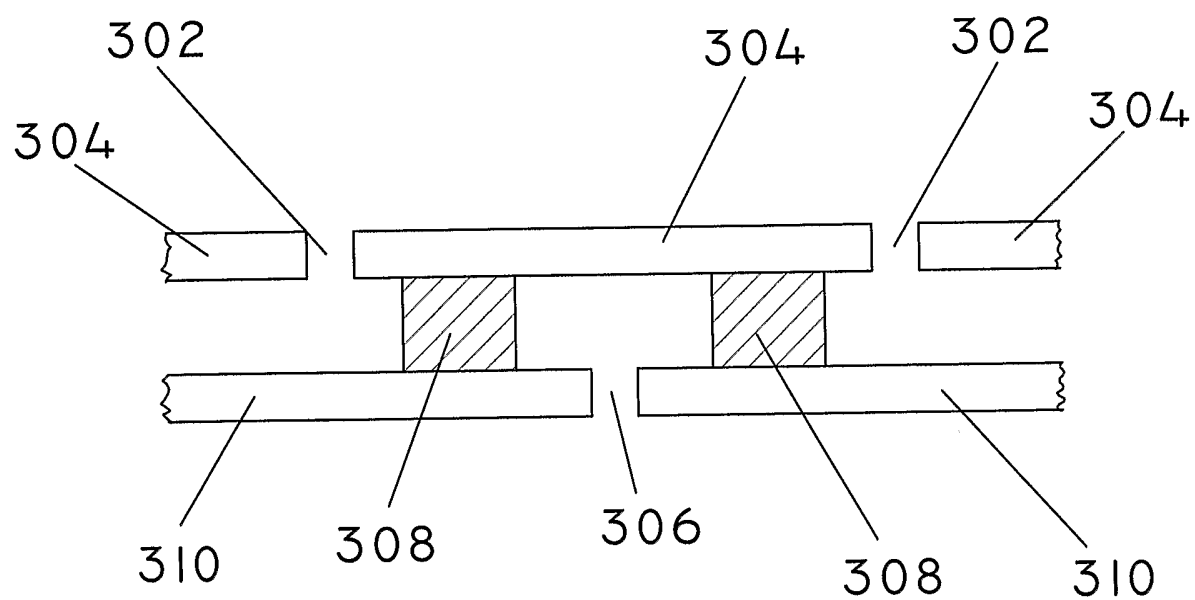


FIG. 8

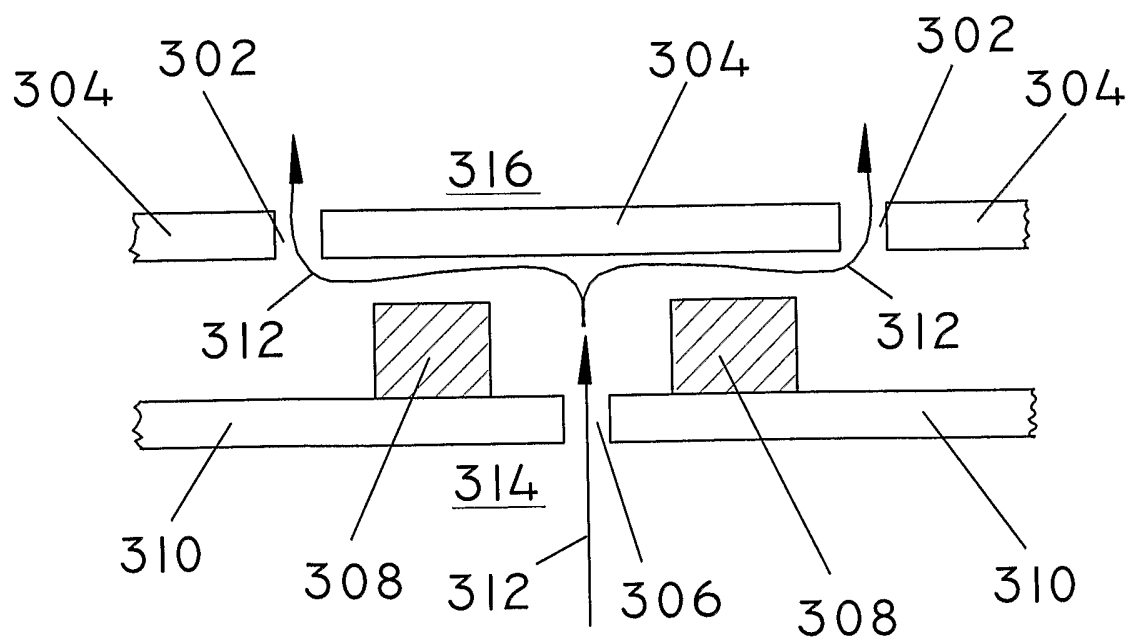


FIG. 9

5/8

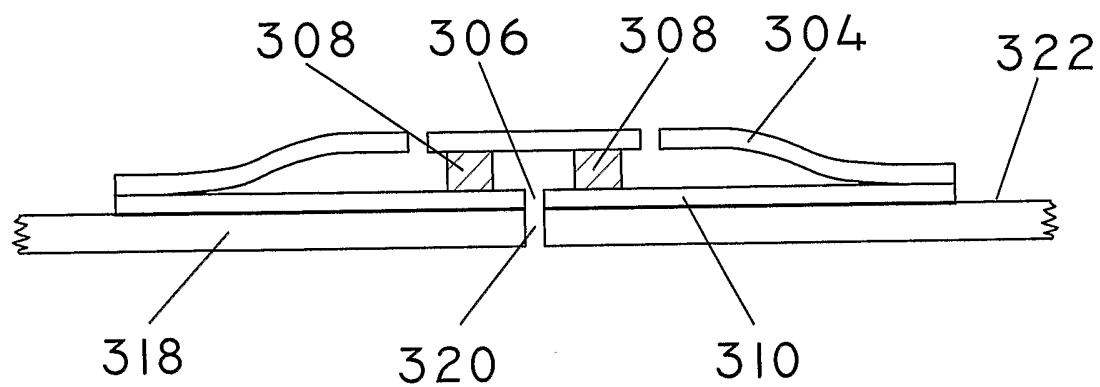


FIG. 10

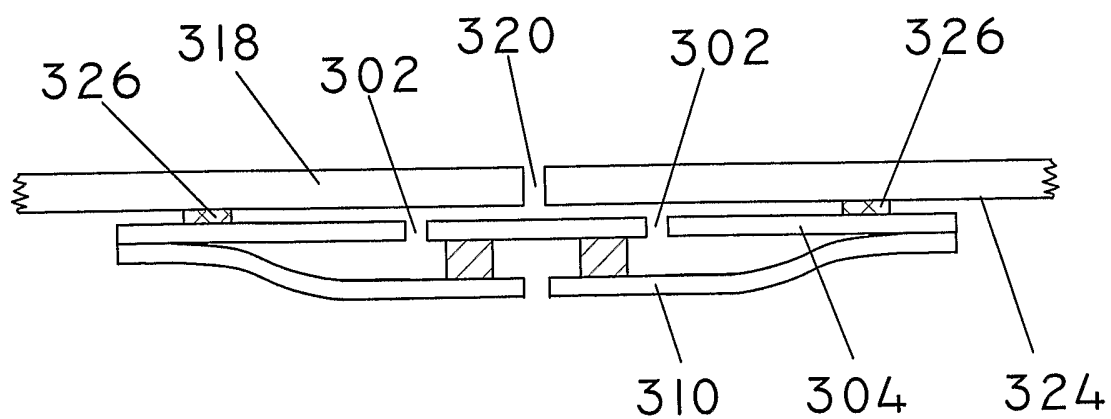


FIG. 11

6/8

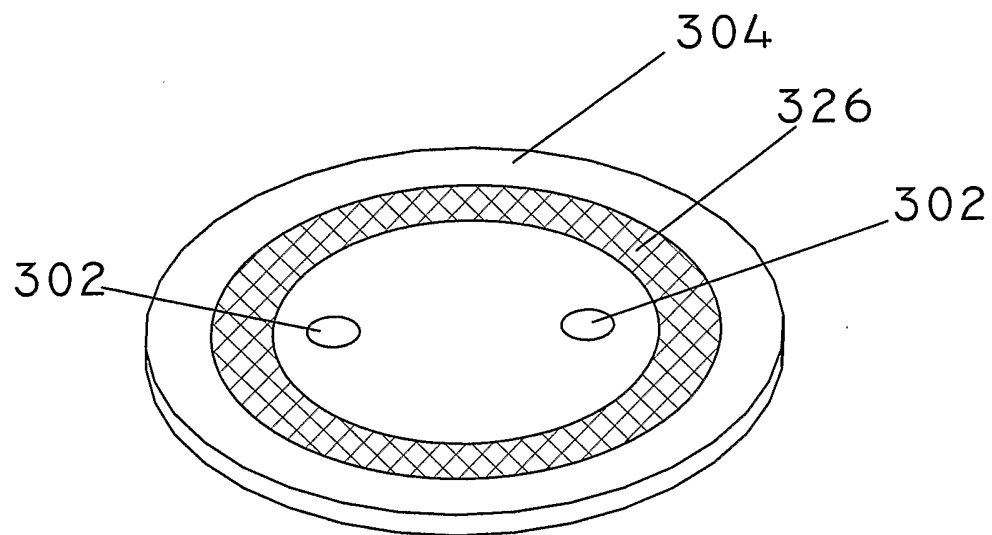


FIG. 12

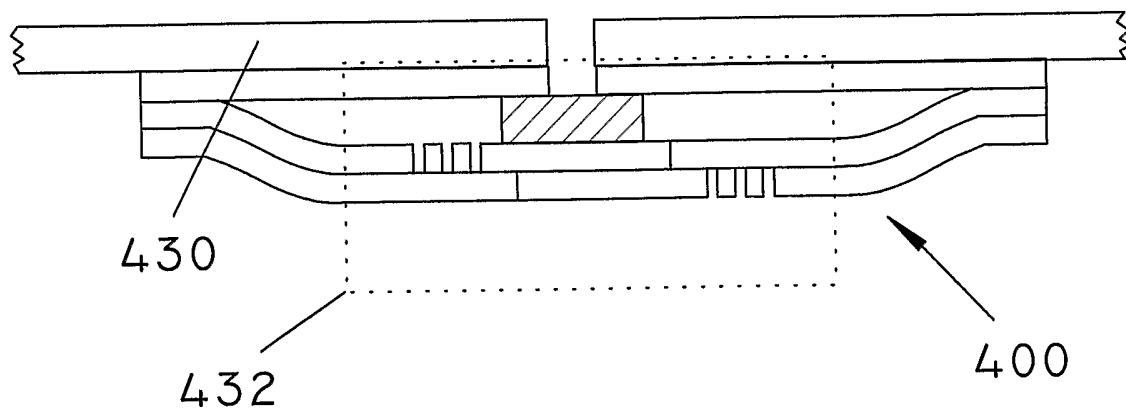


FIG. 13

7/8

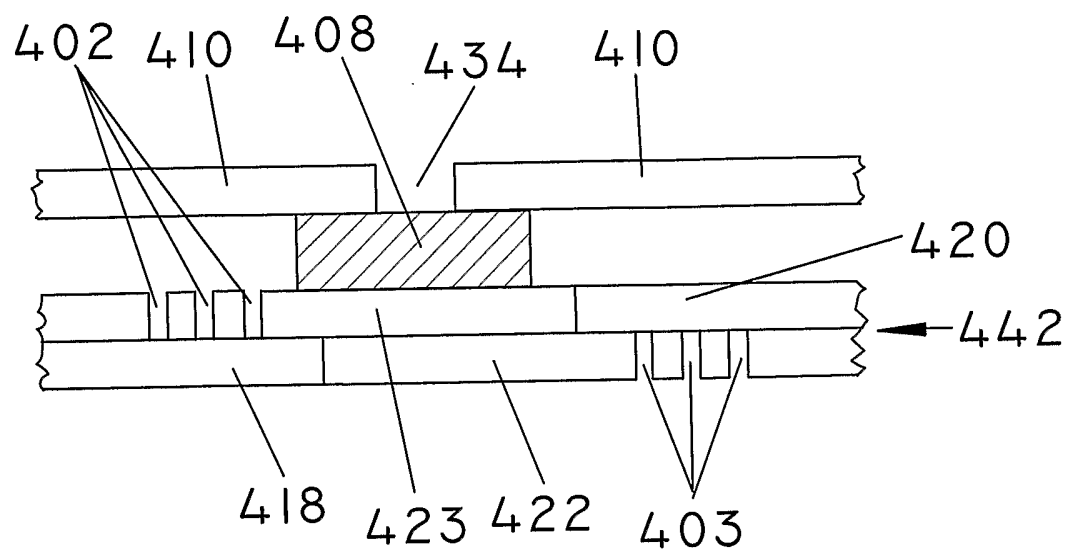


FIG. 14

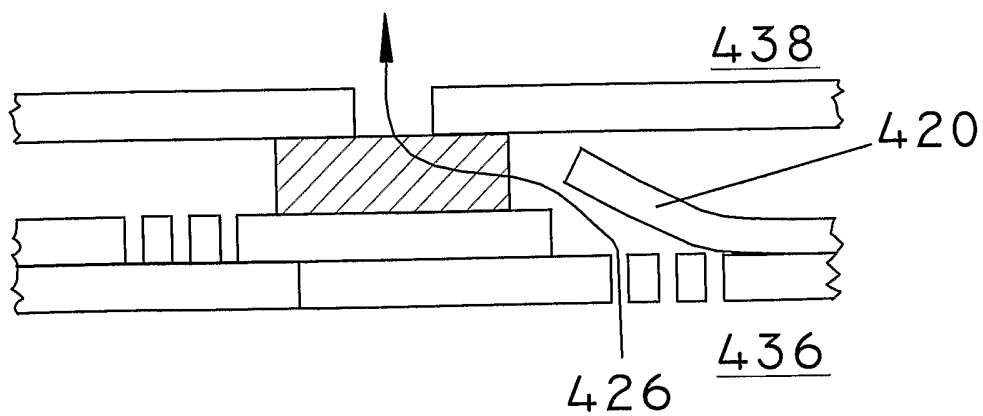


FIG. 15

8/8

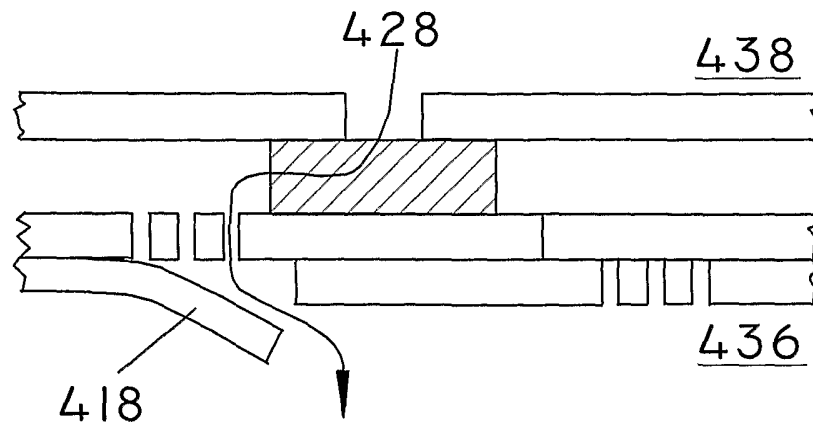


FIG. 16

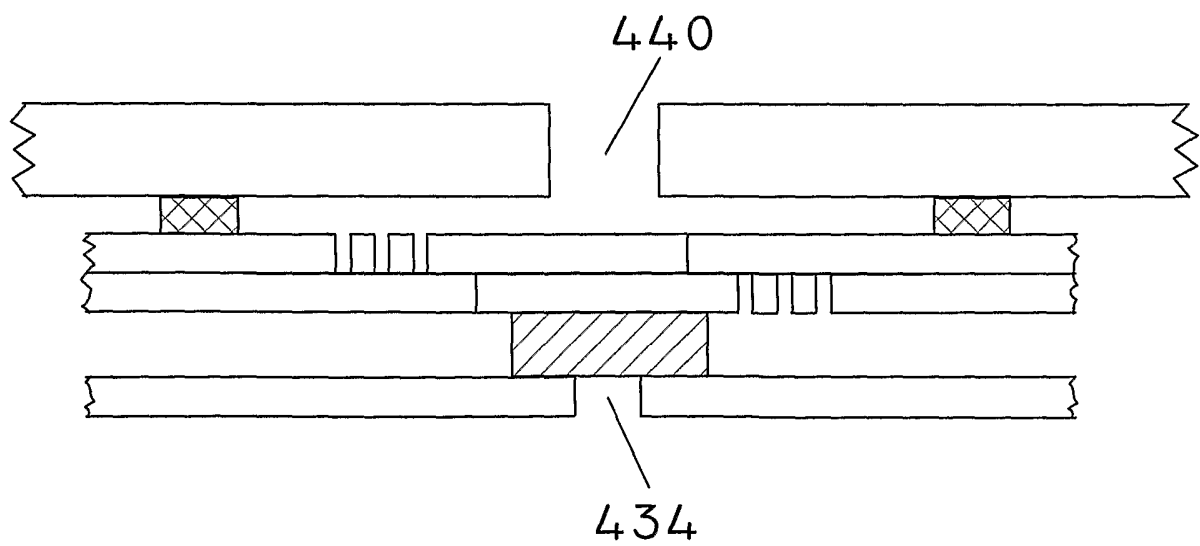


FIG. 17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US06/03803

A. CLASSIFICATION OF SUBJECT MATTER

IPC: B01D 53/04(2006.01),53/22(2006.01)

USPC: 55/385.4,385.6,502,511;96/134,135,147,154;360/97.02

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)

U.S. : 55/385.4,385.6,502,511;96/134,135, 147, 154;360/97.02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,417,743 A (DAUBER) 23 May 1995 (23.05.1995), Figs. 4A-9A.	1-20
A	US 5,997,614 A (TUMA et al) 07 December 1999 (07.12.1999), Figs. 5-21.	1-20
A	US 6,395,073 B1 (DAUBER) 28 May 2002 (28.05.2002), Figs. 4B-8.	1-20
A	US 6,683,746 B1 (KUROKI et al) 27 January 2004 (27.01.2004), Figs. 1-3.	1-20

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

☐ See patent family annex.

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

22 May 2006 (22.05.2006)

Date of mailing of the international search report

29 JUN 2006

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US

Commissioner for Patents

P.O. Box 1450

Alexandria, Virginia 22313-1450

Facsimile No. (571) 273-3201

Authorized officer

Minh-Chau T. Pham

Telephone No. (703) 308-0661