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(54) Title: HANDLE GEOMETRY FOR PLASTIC END PLATES

(57) Abstract: Filter elements for filtration systems are described. A filter element is comprised of filter media positioned between a first endplate and a second endplate. In some arrangements, one of the endplates includes a handle formed within the profile boundary of the endplate, which has an inner projection that provides alignment of the filter element within the housing (or within a primary filter element in arrangements where the filter element is a secondary or safety filter element). In other arrangements, the endplate includes an insert having the handle. The handle provides an easily accessible and ergonomic gripping area for a service technician to grab during removal of the filter element from the housing (or from the primary filter element). The handle is positioned within the profile boundary of the endplate to maintain the compact size of the filter element.

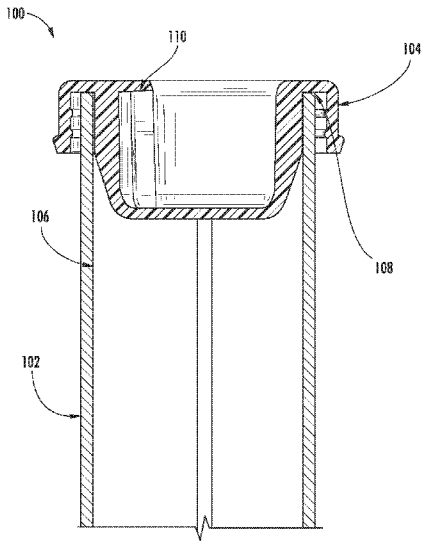


FIG. 1

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HANDLE GEOMETRY FOR PLASTIC END PLATES

TECHNICAL FIELD

[0001] The present application relates to filter elements for use with filtration systems.

BACKGROUND

[0002] Internal combustion engines generally combust a mixture of fuel (e.g., gasoline, diesel, natural gas, etc.) and air. Prior to entering the engine, intake air is typically passed through a filter element to remove contaminants (e.g., particulates, dust, water, etc.) from the intake air prior to delivery to the engine. The filter element requires periodic replacement as the filter media of the filter element captures and removes particulate from the intake air passing through the filter media. Accordingly, the filter element is typically removably received in the housing to facilitate easy replacement. However, removal of a used filter element from the housing may be difficult. For example, a filter element may become dirty or oily during use, thereby making it difficult for a service technician to get a strong enough grasp on the filter element to pull it out of the housing. Further, the geometry of the housing and the filter element may not provide an ergonomic way to remove the filter element from the housing during servicing.

SUMMARY

[0003] Various example embodiments relate to filter elements. One such filter element includes a first endplate and a second endplate. The first endplate comprises a first endplate having a top wall having a central opening and an inner projecting wall extending from the top wall so as to define an inner space. The filter element further includes filter media positioned between the first endplate and the second endplate. The filter element includes a handle that extends from the first endplate at least partially into the inner space, thereby creating an undercut in the inner space to define a handling area.

[0004] Another example embodiment relates to a filter element. The filter element includes a first endplate and a second endplate. The first endplate comprises a central opening defined by

an inner projecting wall that defines an inner space. The filter element further includes filter media positioned between the first endplate and the second endplate. The filter element includes a handle that extends across the central opening from a first side of the inner projecting wall to a second side of the inner projecting wall.

[0005] A further example embodiment relates to an endplate for a filter element. The endplate includes a top wall having a central opening and an inner projecting wall extending from the top wall so as to define an inner space. The endplate further includes a handle that extends from the top wall at least partially into the inner space, thereby creating an undercut in the inner space to define a handling area.

[0006] Another example embodiment relates to an endplate for a filter element. The endplate includes an endplate body having an inner projecting wall that defines a central opening and an inner space. The endplate further includes a handle that extends across the central opening from a first side of the inner projecting wall to a second side of the inner projecting wall.

[0007] These and other features, together with the organization and manner of operation thereof, will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the several drawings described below.

BRIEF DESCRIPTION OF THE FIGURES

[0008] FIG. 1 shows a cross-sectional view of a filter element according to an example embodiment.

[0009] FIG. 2 shows a perspective view of the first endplate of the filter element of FIG. 1.

[0010] FIG. 3 shows a cross-sectional view of the first endplate of the filter element of FIG. 1.

[0011] FIG. 4 shows a cross-sectional view of a top portion of filter element according to an example embodiment.

[0012] FIG. 5 shows a perspective view of the filter element of FIG. 4 installed in a housing.

[0013] FIG. 6 shows a perspective view of a top portion of the filter element of FIG. 4.

[0014] FIG. 7 shows a perspective view of a handle insert of the filter element of FIG. 4.

[0015] FIG. 8 shows a cross-sectional view of a filter element according to another example embodiment.

[0016] FIG. 9 shows a cross-sectional view of a top portion of the filter element of FIG. 8 installed in a housing.

[0017] FIG. 10 shows a close-up cross-sectional view of the top portion of the filter element of FIG. 8 installed in the housing.

[0018] FIG. 11 shows a perspective view of the filter element of FIG. 8 being removed from the housing.

[0019] FIG. 12 shows a perspective view of the filter element of FIG. 8 being removed from the housing.

[0020] FIG. 13 shows a perspective view of the top portion of the filter element of FIG. 8.

[0021] FIG. 14 shows a perspective view of a handle insert of the filter element of FIG. 8.

DETAILED DESCRIPTION

[0022] Referring to the figures generally, filter elements for filtration systems are described. A filter element is comprised of filter media positioned between a first endplate and a second endplate. In some arrangements, one of the endplates includes a handle formed within the profile boundary of the endplate, which has an inner projection that provides alignment of the filter element within the housing (or within a primary filter element in arrangements where the filter element is a secondary or safety filter element). In other arrangements, the endplate includes an insert having the handle. The handle provides an easily accessible and ergonomic

gripping area for a service technician to grab during removal of the filter element from the housing (or from the primary filter element). The handle is positioned within the profile boundary of the endplate to maintain the compact size of the filter element.

[0023] Referring to FIG. 1, a cross-sectional view of a filter element 100 is shown according to an example embodiment. The filter element 100 is a cylindrical filter element. In some arrangements, the filter element 100 is a primary filter element. In other arrangements, the filter element 100 is a secondary or safety filter element that is structured to be positioned within a central opening of a primary filter element. The filter element may be any of a fuel filter element, a lubricant filter element, an air filter element, a water filter element, or the like. The filter element 100 comprises filter media 102 arranged in a cylindrical form. The filter media 102 is positioned between a first endplate 104 and a second endplate (not shown). In some arrangements, the filter media 102 is any combination of felt filter media, woven filter media, pleated filter media, fiber filter media, or the like. In some arrangements, the filter media 102 is supported by a center tube 106. In such arrangements, the filter media 102 and the center tube 106 are received in a U-shaped channel 108. In some arrangements, the filter media 102 and the center tube 106 are be bonded to the first endplate 104 with a polyurethane adhesive within the U-shaped channel 108. As described in further detail below with respect to FIGS. 2 and 3, filter element 100 includes a handle 110 that extends from the first endplate 104.

[0024] Referring to FIG. 2, a perspective view of the first endplate 104 is shown. Referring to FIG. 3, a cross-sectional view of the first endplate 104 is shown. The first endplate 104 may be formed by an injection molding process. In some arrangements, the first endplate 104 is an open endplate (e.g., the first endplate 104 includes an opening to allow fluid to flow into or out of the central space of the filter element 100 by way of the inner space 308). In other arrangements, the first endplate 104 is a closed endplate. The U-shaped channel 108 is formed by an inner projecting wall 302, a top wall 304, and an outer projecting wall 306. The inner projecting wall 302 and the outer projecting wall 306 both extend from the top wall 304. In some arrangements, the inner projecting wall 302 extends a longer distance from the top wall 304 than the outer projecting wall 306. In some arrangements, the inner projecting wall 302 and the outer

projecting wall 306 are perpendicular to the top wall 304. The inner projecting wall 302 defines an inner space 308. The inner projecting wall 302 includes an inwardly ramped portion 310. The inwardly ramped portion 310 provides an alignment feature for the filter media 102 and the center tube 106 during assembly of the filter element 100. In some arrangements, the outer projecting wall 306 includes at least one inwardly projecting rib 312 (shown as two ribs 312 in FIG. 3) that help secure the filter media 102 and the center tube 106 in the U-shaped channel 108.

[0025] The handle 110 extends from the top wall 304 at least partially into the inner space 308. The handle creates an undercut in the inner space 308 defining a handling area. The outer edge 202 of the handle 110 has a length that is shorter than a diameter 204 of the central opening forming the inner space 308. Accordingly, the undercut formed by the handle 110 covers less than half of the area of a circle defined by the diameter 204. In some arrangements, the handle 110 does not extend beyond a plane defined by an upper surface of the top wall 304 with respect to the inner space 308. In such arrangements, the handle 110 is completely contained within the inner space 308. Accordingly, the handle 110 is internal to the boundary profile of the first endplate 104, which helps to maintain the size of the first endplate 104. The handle 110 forms a grip area for a service technician to assist with the removal of the filter element 100 from a filter housing of a filtration system or from a primary filter element in arrangements where the filter element 100 is a safety element. In some arrangements, the handle 110 is shaped to receive a tool used by the technician or a robotic arm used during servicing of the filtration system. The handle 110 may be formed during the injection molding process by an angle lifter or a straight lifter. In some arrangements, the first endplate 104 includes at least one securing cam 206 (shown in FIG. 2), which assists in aligning the filter element 100 within a housing of a filtration system during installation of the filter element 100 into the housing. In some arrangements, the first endplate 104 includes two securing cams 206.

[0026] Referring to FIGS. 4-7, views of a filter element 400 are shown according to another example embodiment. FIG. 4 shows a cross-sectional view of a top portion of the filter element 400 installed in a housing. FIG. 5 shows a perspective view of the filter element 400 installed in

the housing. FIG. 6 is a perspective view of the top portion of the filter element 400. FIG. 7 is a perspective view of a handle insert 408 of the filter element 400. The filter element 400 is similar to the filter element 100. Accordingly, like numbering is used between the description of the filter element 100 and the filter element 400 to designate like parts. The primary difference between the filter element 400 and the filter element 100 is that the handle 410 of the filter element 400 is separate from the first endplate 404, whereas the handle 110 is integrated with the first endplate 104 in the filter element 100.

[0027] The filter element 400 is a cylindrical filter element. In some arrangements, the filter element 400 is a primary filter element. In other arrangements, the filter element 400 is a secondary or safety filter element that is structured to be positioned within a central opening of a primary filter element. The filter element 400 may be any of a fuel filter element, a lubricant filter element, an air filter element, a water filter element, or the like. The filter element 400 comprises filter media 102 arranged in a cylindrical form. The filter media 102 is positioned between a first endplate 404 and a second endplate (not shown). In some arrangements, the filter media 102 is any combination of felt filter media, woven filter media, pleated filter media, fiber filter media, or the like. In some arrangements, the filter media 102 is supported by a center tube 106. In such arrangements, the filter media 102 and the center tube 106 are received in a channel formed between the first endplate 404 and a handle insert 408. In some arrangements, the filter media 102 and the center tube 106 are be bonded to the first endplate 404 with a polyurethane adhesive within the channel.

[0028] The filter element 400 includes a handle insert 408. The first endplate 404 may be formed by an injection molding process. In some arrangements the first endplate 404 is an open endplate (e.g., the first endplate 404 includes a central opening to allow fluid to flow into or out of the central space of the filter element 400). In such arrangements, the handle insert 408 is cylindrical in shape such that it can be fitted into the central opening of the first endplate 404. The first endplate 404 is molded around the handle insert 408 to secure the handle insert 408 within the first endplate 404. In alternate arrangements, the handle insert 408 is secured to the first endplate 404 through a snap-fit connection, a press-fit connection, or with adhesive. The

body of the handle insert 408 defines an inner space 412. The handle insert 408 is open on both a first side and a second side to allow fluid to flow through the handle insert 408. The handle 410 is similar to the handle 110 of FIGS. 1 through 3. The handle insert includes a handle 410 that projects from a top wall of the handle insert 408 and at least partially into the inner space 412. The handle 410 creates an undercut in the inner space 412 defining a handling area. The outer edge 414 of the handle 410 has a length that is shorter than a diameter of the opening that forms the inner space 412. Accordingly, the undercut formed by the handle 410 covers less than half of a circle defined by the diameter in the same manner as described above with the handle 110. In some arrangements, the handle 410 does not extend beyond a plane defined by an upper surface of the top wall with respect to the inner space 412. In such arrangements, the handle 410 is completely contained within the inner space 412. Accordingly, the handle 410 is internal to the boundary profile of the first endplate 404 and the handle insert 408, which helps to maintain the size of the first endplate 404. The handle 410 forms a grip area for a service technician to assist with the removal of the filter element 400 from a filter housing (e.g., along the direction of the arrow shown in FIG. 5) of a filtration system or from a primary filter element in arrangements where the filter element 400 is a safety element. In some arrangements, the handle 410 is shaped to receive a tool used by the technician or a robotic arm used during servicing of the filtration system.

[0029] As described above, the handle insert 408 is a separate piece from the first endplate 404. The first endplate 404 may be molded around the handle insert 408 (e.g., a portion of the first endplate 404 is overmolded around the handle insert 408). Accordingly, the handle insert 408 includes a plurality of supports 414 (as shown in FIG. 7) that are received within the first endplate 404 during the molding manufacturing process. Accordingly, as the material forming the first endplate 404 sets, the material sets around the supports 414, and the handle insert 408 is secured to the first endplate 404. In some arrangements, the handle insert 408 is formed of a material that is more rigid than the material that forms the first endplate 404 thereby adding structural support to the first endplate 404. As shown in FIG. 4, the handle insert 408 may rest on the center tube 106, thereby transmitting axial and radial load to the center tube 106, which

assists in preventing axial bending of the filter media 102 after installation of the filter element 400 into the housing.

[0030] Referring to FIGS. 8 through 14, views of a filter element 800 are shown according to another example embodiment. FIG. 8 shows a cross-sectional view of the filter element 800 installed in a filtration system. FIG. 9 shows a cross-sectional view of a top portion of the filter element 800 installed in a housing. FIG. 10 shows a close-up cross-sectional view of the top portion of the filter element 800 installed in the housing. FIG. 11 and FIG. 12 each show perspective views of the filter element 800 being removed from the housing. FIG. 13 is a perspective view of the top portion of the filter element 800. FIG. 14 is a perspective view of a handle insert 808 of the filter element 800. The filter element 800 is similar to the filter element 400 and the filter element 100. Accordingly, like numbering is used between the description of the filter element 800 and the filter elements 100 and 400 to designate like parts. The primary difference between the filter element 800 and the filter elements 100 and 400 is that the handle 810 of the filter element 800 has a different shape than the handles 110 and 410 of the filter elements 100 and 400.

[0031] The filter element 800 is a cylindrical filter element. In some arrangements, the filter element 800 is a primary filter element. In other arrangements, the filter element 800 is a secondary or safety filter element that is structured to be positioned within a central opening of a primary filter element. The filter element 800 may be any of a fuel filter element, a lubricant filter element, an air filter element, a water filter element, or the like. The filter element 800 comprises filter media 102 arranged in a cylindrical form. The filter media 102 is positioned between a first endplate 802 and a second endplate 804. In some arrangements, the filter media 102 is any combination of felt filter media, woven filter media, pleated filter media, fiber filter media, or the like. In some arrangements, the filter media 102 is supported by a center tube 106. In such arrangements, the filter media 102 and the center tube 106 are received in a channel formed between the first endplate 802 and a handle insert 808. In some arrangements, the filter media 102 and the center tube 106 are be bonded to the first endplate 802 with a polyurethane adhesive within the channel.

[0032] In some arrangements, the filter element 800 includes a handle insert 808. The first endplate 802 may be formed by an injection molding process. In some arrangements the first endplate 802 is an open endplate (e.g., the first endplate 802 includes a central opening to allow fluid to flow into or out of the central space of the filter element 800). In such arrangements, the handle insert 808 is cylindrical in shape such that it can be fitted into the central opening of the first endplate 802. The first endplate 802 is molded around the handle insert 808 to secure the handle insert 808 within the first endplate 802. In alternate arrangements, the handle insert 808 is secured to the first endplate 802 through a snap-fit connection, a press-fit connection, or with adhesive. The body of the handle insert 808 defines an inner space 812. The handle insert 808 is open on both a first side and a second side to allow fluid to flow through the handle insert 808. In other arrangements, the first endplate 802 includes the features of the handle insert 808 as a unitary piece. In such arrangements, the features of the handle insert 808 are included in the first endplate 802 and no additional insert is needed.

[0033] The handle insert includes a handle 810 that extends across the central opening from a first side of an inner side wall of the handle insert 808 and extends across the inner space 812 to a second, opposite side of the inner side wall. Accordingly, the handle 810 forms a cross-brace that spans across the opening of the handle insert 808 (e.g., as shown best in FIGS. 11 through 14). The cross-brace nature of the handle 810 helps to prevent the cylindrical filter element from deformation during installation, removal, and use. In some arrangements, the handle 810 does not extend beyond a plane defined by an upper surface of a top wall of the first endplate 802 with respect to the inner space 812. In such arrangements, the handle 810 is completely contained within the inner space 812. Accordingly, the handle 810 is internal to the boundary profile of the first endplate 802 and the handle insert 808, which helps to maintain the size of the first endplate 802. The handle 810 forms a grip area for a service technician to assist with the removal of the filter element 800 from a filter housing (e.g., along the direction of the arrow shown in FIG. 5) of a filtration system or from a primary filter element in arrangements where the filter element 800 is a safety element. In some arrangements, the handle 810 is shaped to receive a tool used by the technician or a robotic arm used during servicing of the filtration system.

[0034] As described above, the handle insert 808 is a separate piece from the first endplate 802. The first endplate 802 may be molded around the handle insert 808. Accordingly, the handle insert 808 includes a plurality of supports 814 (as shown in FIG. 14) that are received within the first endplate 802 during the molding manufacturing process. Accordingly, as the material forming the first endplate 802 sets, the material sets around the supports 814, and the handle insert 808 is secured to the first endplate 802. In some arrangements, the handle insert 808 is formed of a material that is more rigid than the material that forms the first endplate 802 thereby adding structural support to the first endplate 802. As shown in FIGS. 8 through 10, the handle insert 808 may rest on the center tube 106 thereby transmitting axial and radial load to the center tube 106, which assists in preventing axial bending of the filter media 102 after installation of the filter element 800 into the housing.

[0035] It should be noted that any use of the term "example" herein to describe various embodiments is intended to indicate that such embodiments are possible examples, representations, and/or illustrations of possible embodiments (and such term is not intended to connote that such embodiments are necessarily extraordinary or superlative examples).

[0036] References herein to the positions of elements (e.g., "top," "bottom," etc.) are merely used to describe the orientation of various elements in the FIGURES. It should be noted that the orientation of various elements may differ according to other example embodiments, and that such variations are intended to be encompassed by the present disclosure.

[0037] The terms "coupled" and the like as used herein mean the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another.

[0038] It is important to note that the construction and arrangement of the various example embodiments are illustrative only. Although only a few embodiments have been described in

detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter described herein. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the position of elements may be reversed or otherwise varied, and the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Additionally, features from particular embodiments may be combined with features from other embodiments as would be understood by one of ordinary skill in the art. Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various example embodiments without departing from the scope of the present invention.

WHAT IS CLAIMED IS:

1. A filter element comprising:

a first endplate comprising a top wall having a central opening and an inner projecting wall extending from the top wall so as to define an inner space;

a second endplate;

filter media positioned between the first endplate and the second endplate; and

a handle that extends from the first endplate at least partially into the inner space, thereby creating an undercut in the inner space to define a handling area.

2. The filter element of claim 1, wherein the filter element is a cylindrical filter element.

3. The filter element of claim 1, wherein the first endplate is an open endplate such that fluid can flow through the first endplate by way of the inner space.

4. The filter element of claim 1, wherein the handle does not extend beyond the plane defined by the top wall of the first endplate such that the handle is completely contained within the inner space and is internal to a boundary profile of the first endplate.

5. The filter element of claim 1, wherein the handle is part of a handle insert that is coupled to the first endplate.

6. The filter element of claim 5, wherein the handle insert is coupled to the first endplate through a snap-fit connection or adhesive.

7. The filter element of claim 5, wherein the handle insert is coupled to the first endplate through a molding process in which the first endplate is molded around the handle insert.

8. The filter element of claim 5, wherein the handle insert is formed of a first material that is harder than a second material, and wherein the first endplate is formed of the second material.

9. The filter element of claim 1, wherein a length of an outer edge of the handle is shorter than a diameter of the central opening.

10. The filter element of claim 1, wherein the handle covers less than half of an area of a circle defined by a diameter of the central opening.

11. A filter element comprising:

a first endplate comprising a central opening defined by an inner projecting wall extending that defines an inner space;

a second endplate;

filter media positioned between the first endplate and the second endplate; and

a handle that extends across the central opening from a first side of the inner projecting wall to a second side of the inner projecting wall.

12. The filter element of claim 11, wherein the handle forms a cross-brace extending across the central opening.

13. The filter element of claim 11, wherein the filter element is a cylindrical filter element.

14. The filter element of claim 11, wherein the first endplate is an open endplate such that fluid can flow through the first endplate by way of the inner space.

15. The filter element of claim 11, wherein the handle is part of a handle insert that is coupled to the first endplate.

16. The filter element of claim 15, wherein the handle insert is coupled to the first endplate through a snap-fit connection or adhesive.

17. The filter element of claim 15, wherein the handle insert is coupled to the first endplate through a molding process in which the first endplate is molded around the handle insert.

18. The filter element of claim 15, wherein the handle insert is formed of a first material that is harder than a second material, the first endplate is formed of the second material.

19. An endplate for a filter element, the endplate comprising:

a top wall having a central opening and an inner projecting wall extending from the top wall so as to define an inner space; and

a handle that extends from the top wall at least partially into the inner space, thereby creating an undercut in the inner space to define a handling area.

20. The endplate of claim 19, wherein the endplate is an open endplate such that fluid can flow through the endplate by way of the inner space.

21. The endplate of claim 19, wherein the handle does not extend beyond the plane defined by the top wall such that the handle is completely contained within the inner space and is internal to a boundary profile of the endplate.

22. The endplate of claim 19, wherein the handle is part of a handle insert that is coupled to the endplate.

23. The endplate of claim 19, wherein a length of an outer edge of the handle is shorter than a diameter of the central opening.

24. The filter element of claim 19, wherein the handle covers less than half of an area of a circle defined by a diameter of the central opening.

25. An endplate for a filter element, the endplate comprising:

an endplate body having an inner projecting wall that defines a central opening and an inner space; and

a handle that extends across the central opening from a first side of the inner projecting wall to a second side of the inner projecting wall.

26. The endplate of claim 25, wherein the handle forms a cross-brace extending across the central opening.

27. The endplate of claim 25, wherein the endplate is an open endplate such that fluid can flow through the endplate by way of the inner space.

28. The endplate of claim 25, wherein the handle is part of a handle insert that is coupled to the endplate.

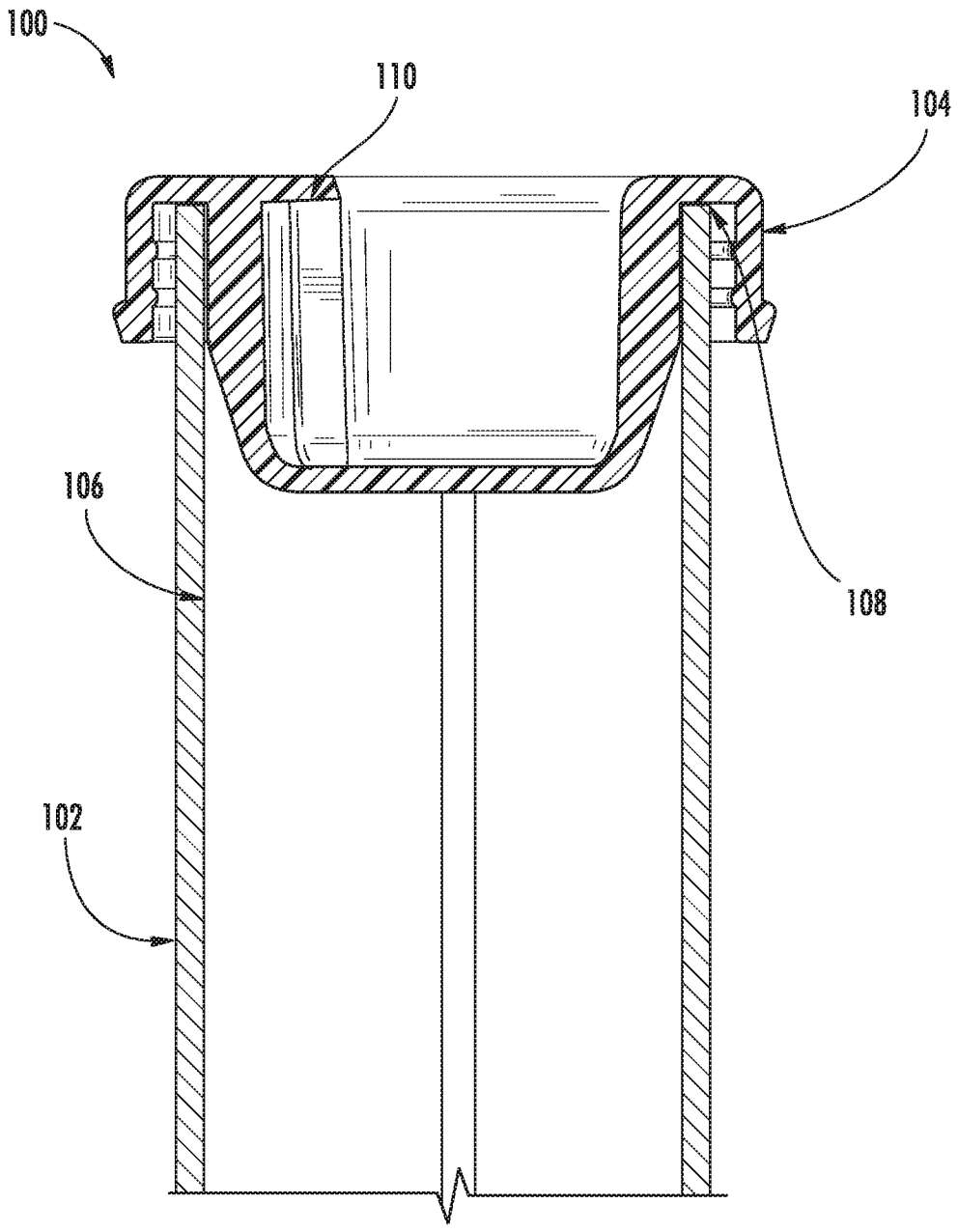


FIG. 1

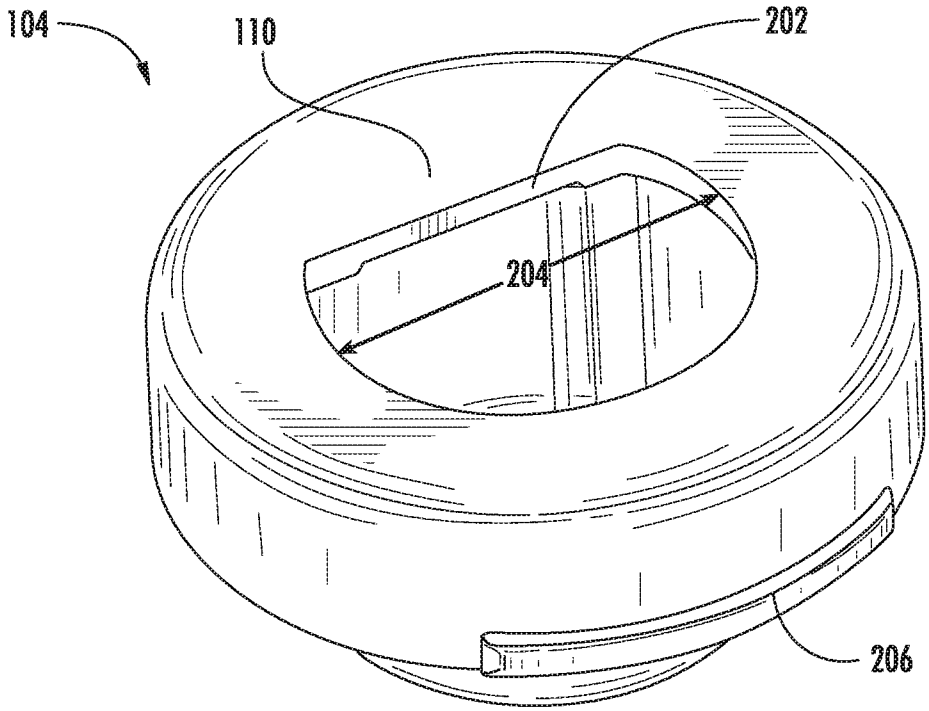


FIG. 2

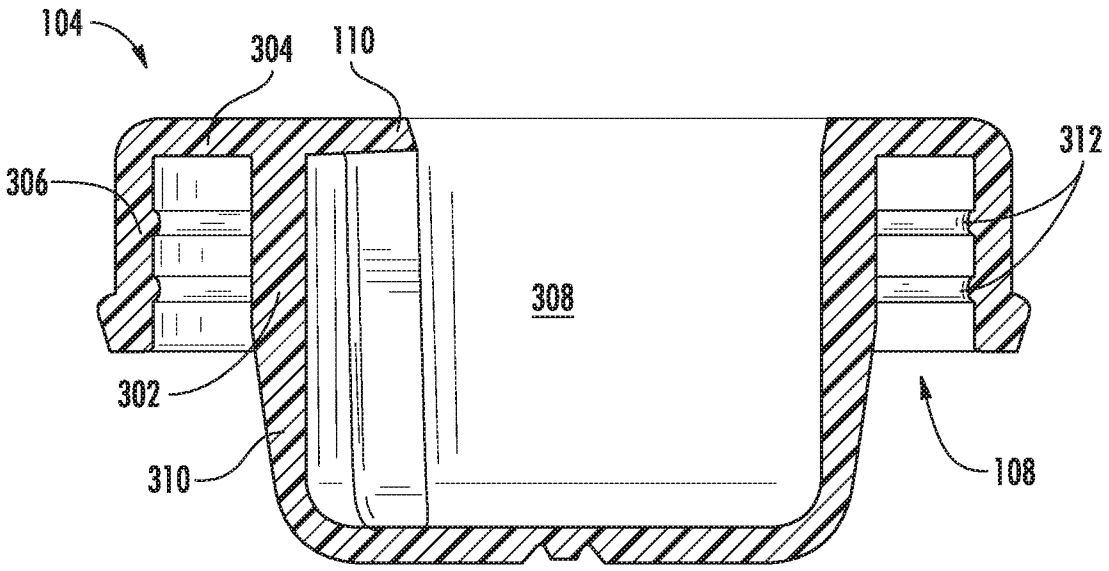


FIG. 3

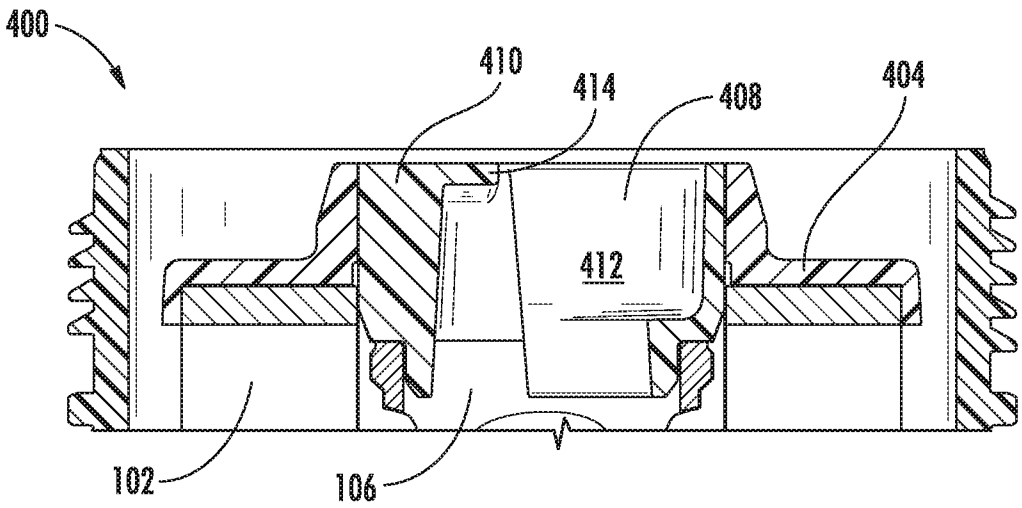


FIG. 4

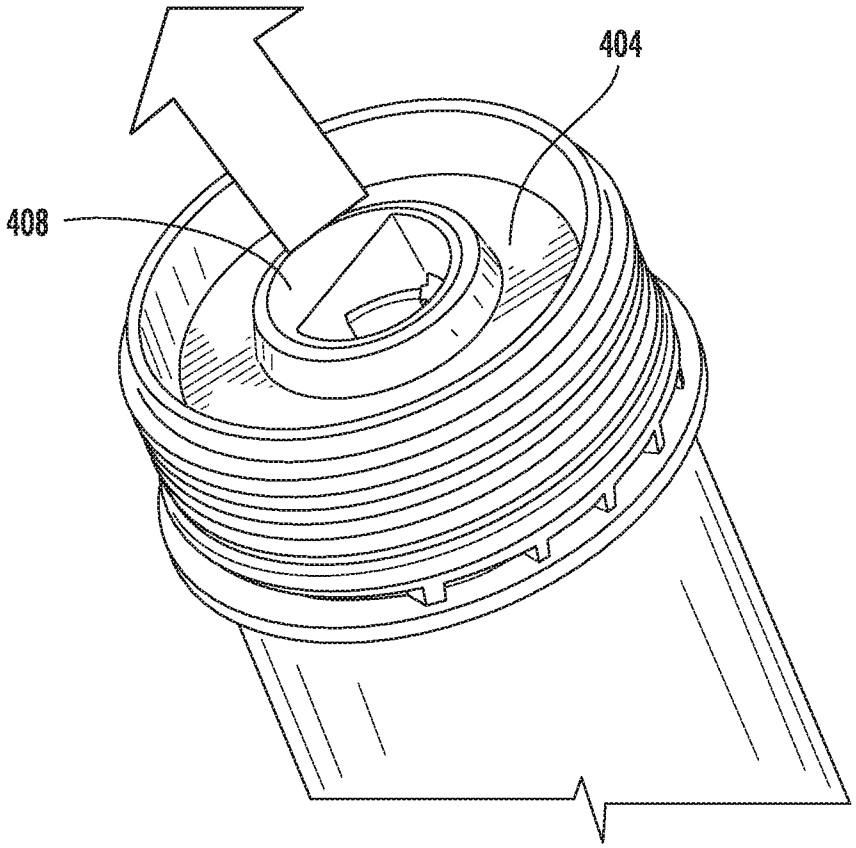


FIG. 5

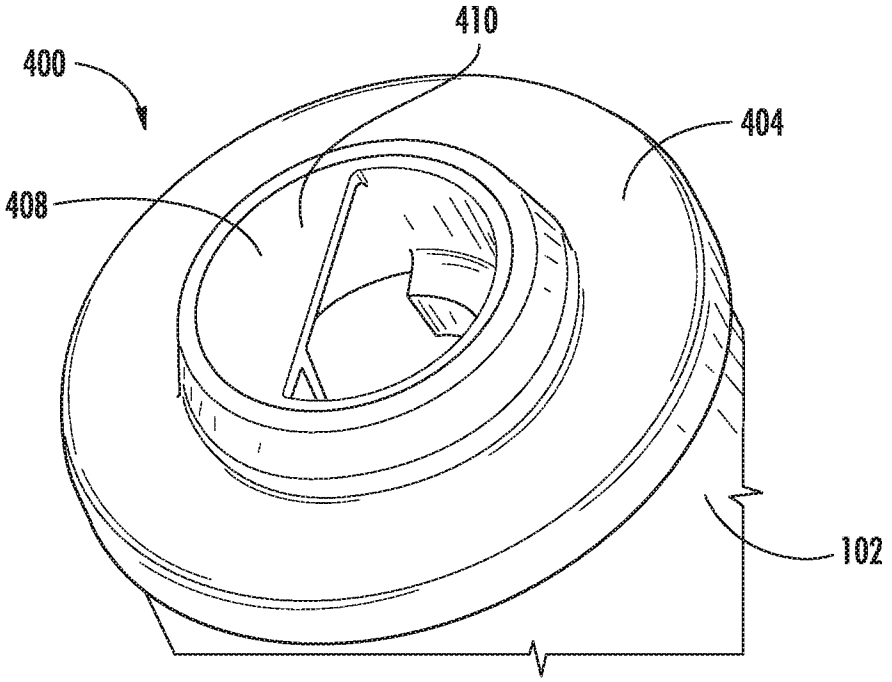


FIG. 6

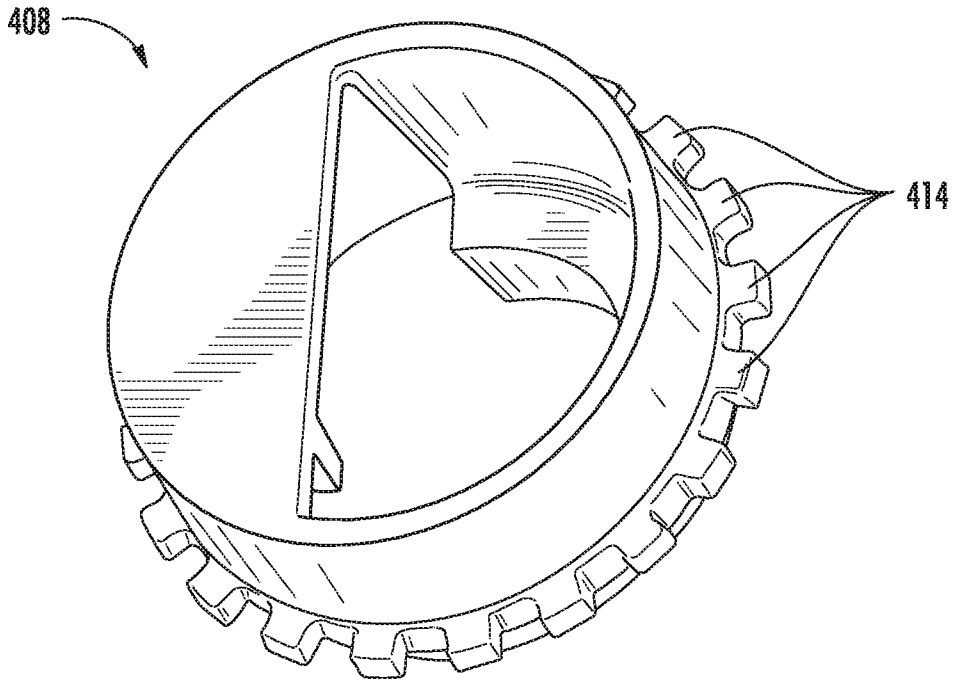


FIG. 7

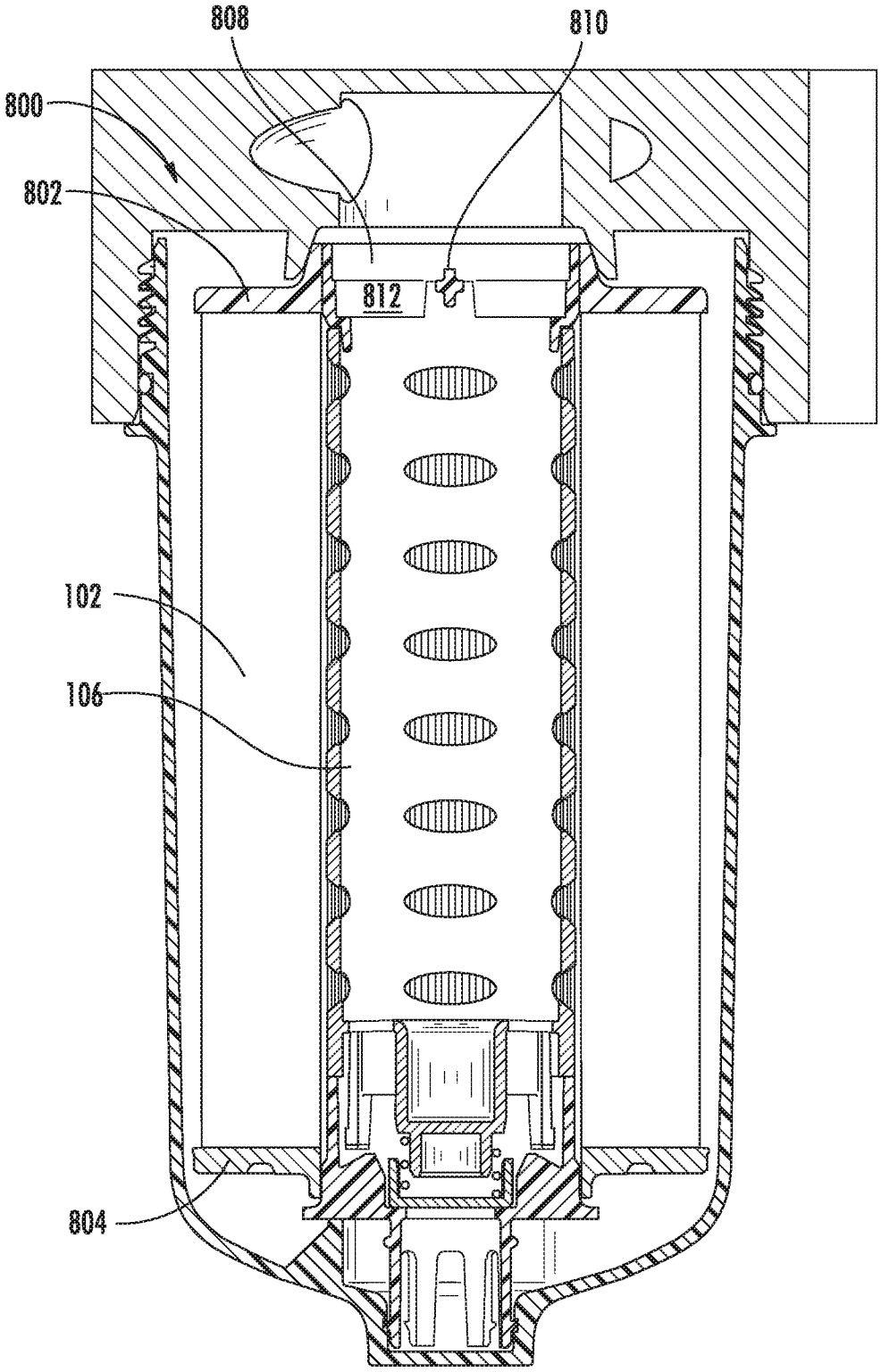


FIG. 8

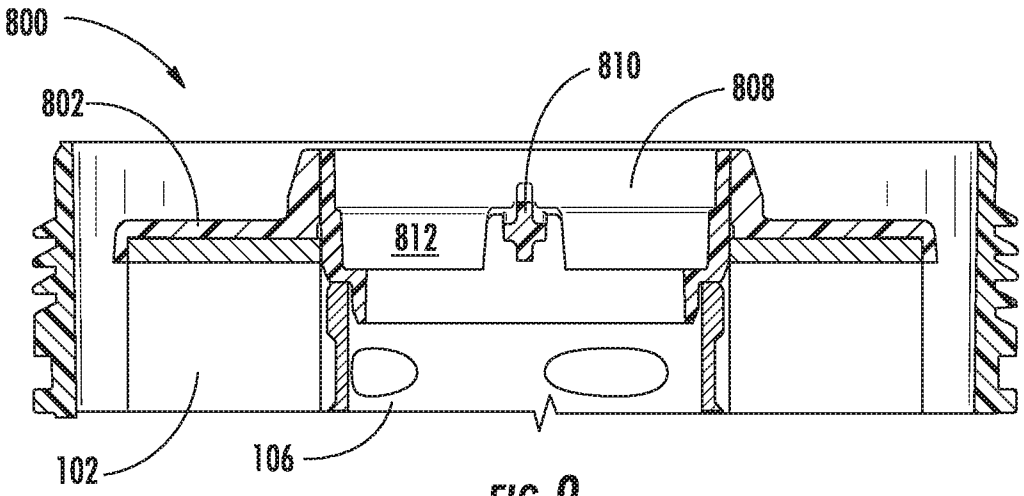


FIG. 9

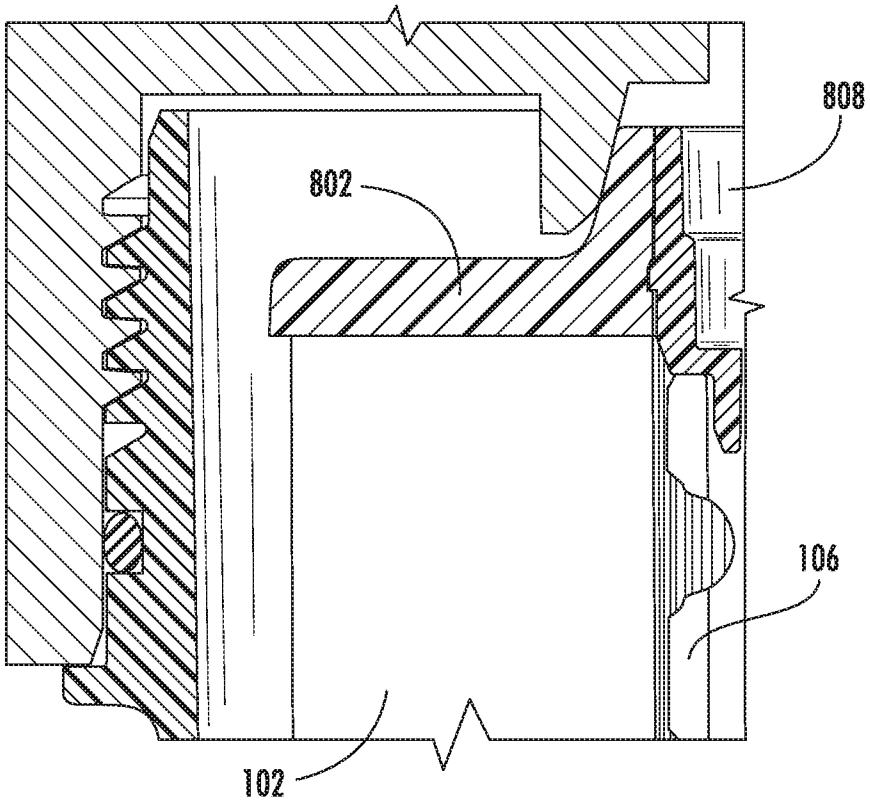


FIG. 10

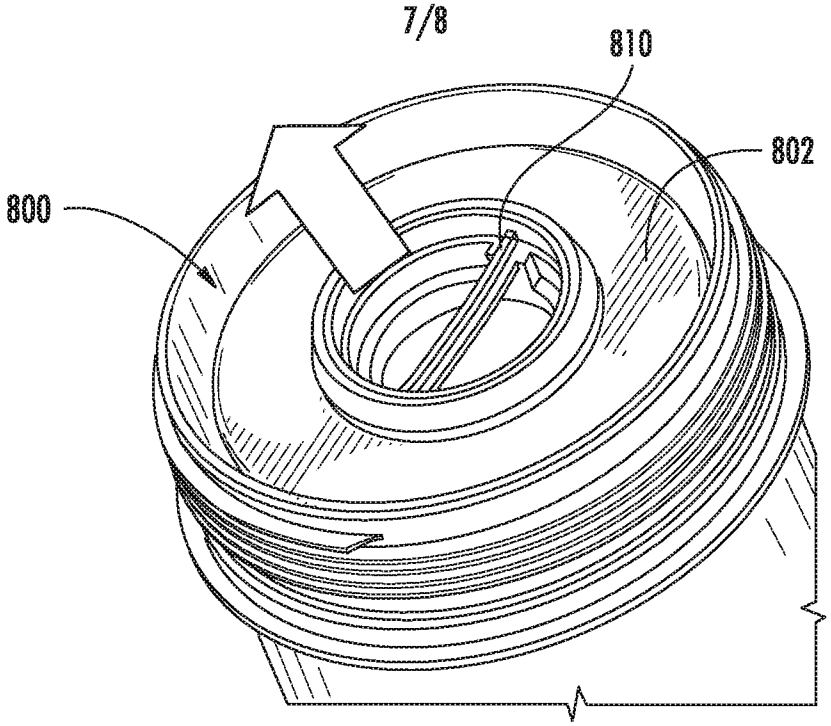


FIG. 11

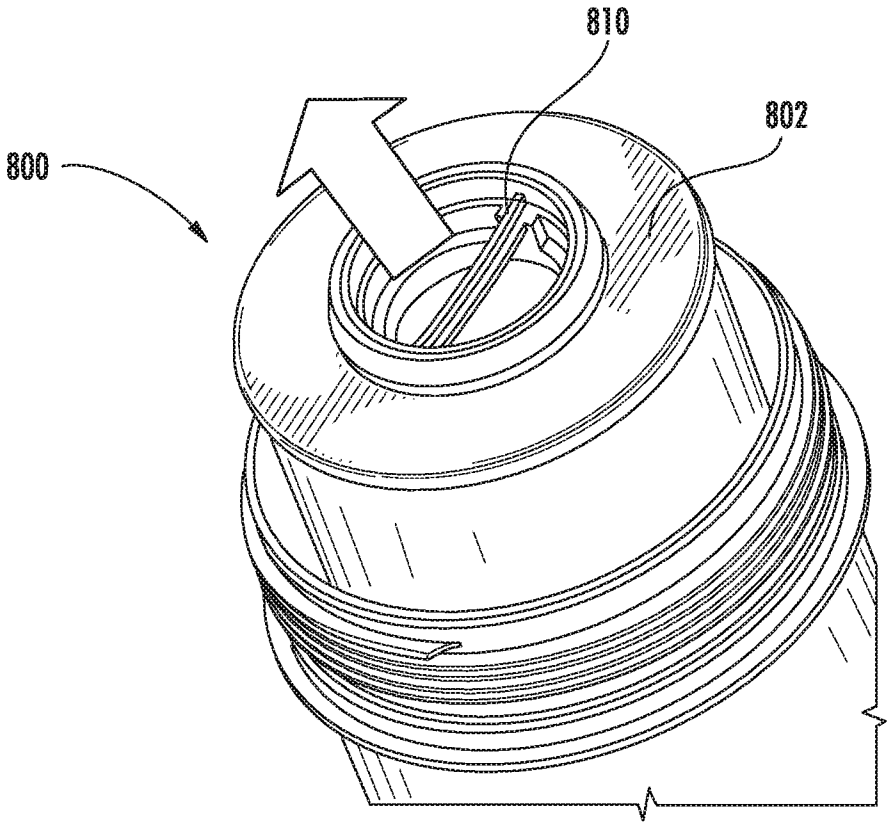


FIG. 12

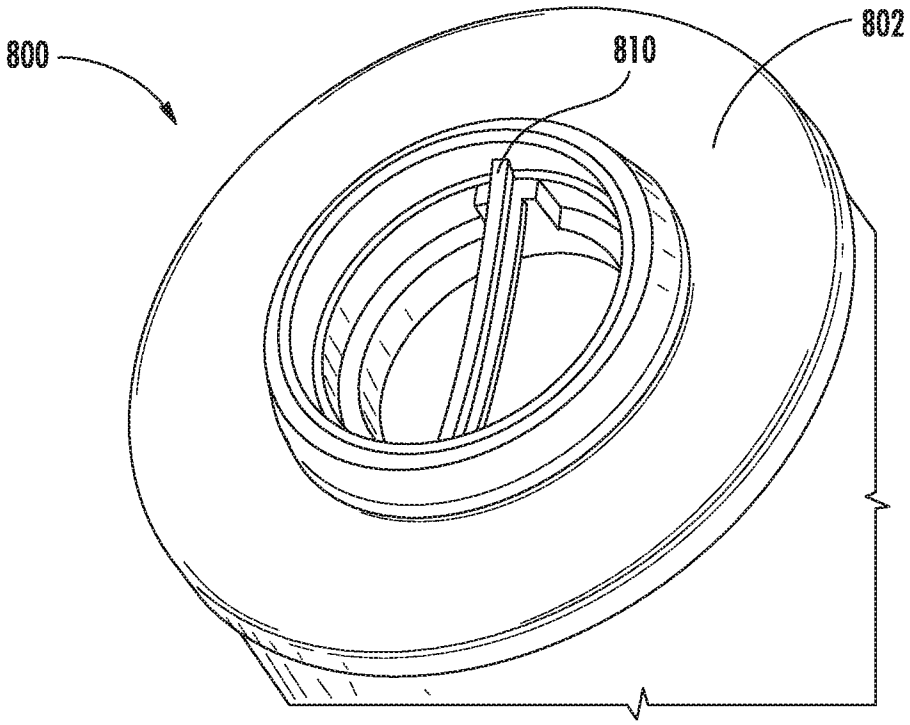


FIG. 13

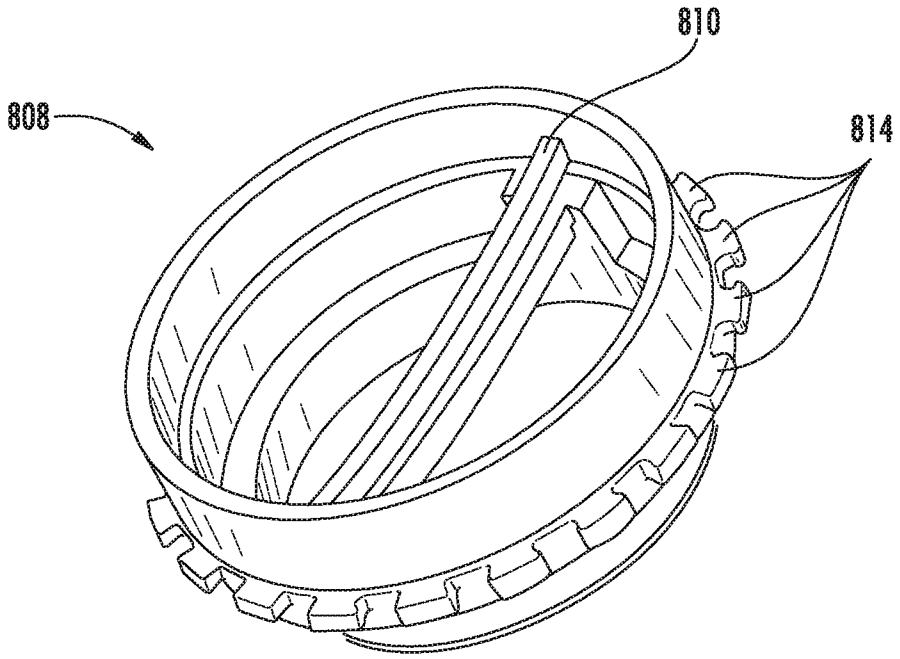


FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/49882

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B01D 29/96; 27/08, 46/42 (2016.01)
CPC - B01D 46/4227, 46/0004, 29/96
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): B01D 29/96; 27/08, 46/00, 46/42 (2016.01)
CPC: B01D 29/96, 27/08, 46/00, 46/42, 46/4227, 46/0004

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)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google Patent; Google; Google Scholar; EBSCO; filter, endplate, handle, grip, tab, inner wall, undercut, space, chamber, cylinder, cavity, recess, beneath, below, edge, surface, engine

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/0249754 A1 (AMIRKHANIAN, H et al.) 08 October 2009; title; figures 1-2; paragraphs [0003], [0029], [0031], [0035]-[0037], [0042]	1-28
A	US 6,627,078 B1 (WAGNER, BK et al.) 30 September 2003; entire document	1-28
A	US 2015/0013282 A1 (MANN+HUMMEL GMBH) 15 January 2015; entire document	1-28
A	US 2004/0134171 A1 (SCOTT, JR et al.) 15 July 2004; entire document	1-28

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 October 2016 (24.10.2016)	07 NOV 2016
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. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)