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(54) Title: CARTRIDGE ENDPLATE WITH INTEGRATED SEALING AND REMOVAL FEATURE

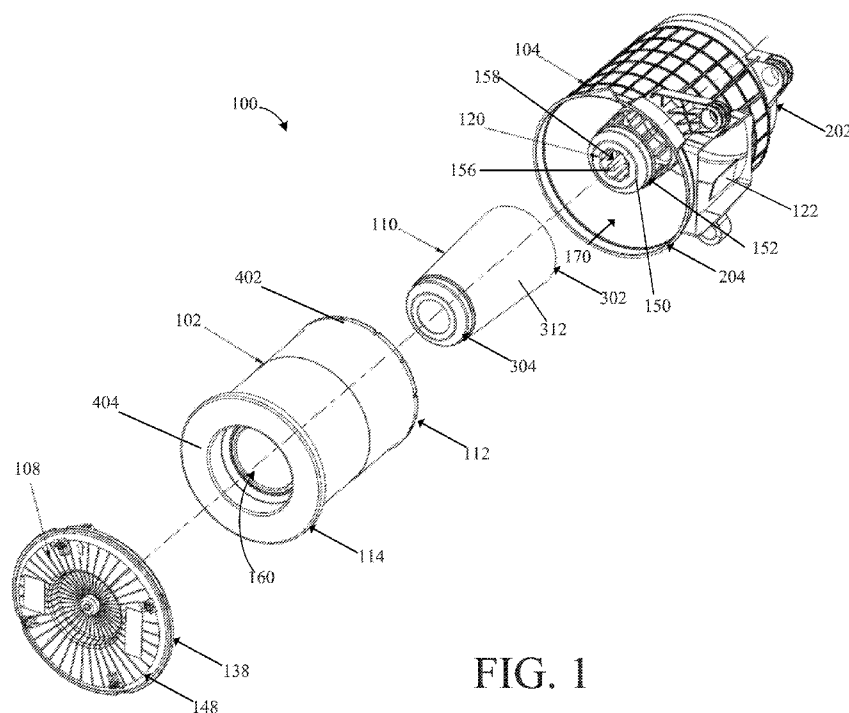


FIG. 1

(57) Abstract: Various embodiments provide for a filtration system that includes a housing defining an internal volume. A secondary filter element is positioned within the internal volume of the housing. A primary filter element is positioned within the internal volume of the housing. The filter media includes filter media positioned between a primary filter element first endplate and a primary filter element second endplate. The primary filter element first endplate includes an external surface and an internal surface. The internal surface abuts the filter media. A raised wall extends from the internal surface away from the external surface. The raised wall forms a radial seal with an external surface of the secondary filter element.



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# Cartridge Endplate with Integrated Sealing and Removal Feature

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority to U.S. Provisional Patent Application No. 62/913,993, filed on October 11, 2019, which is herein incorporated by reference in its entirety.

## TECHNICAL FIELD

**[0002]** The present application relates generally to fluid/air filtration systems.

## BACKGROUND

**[0003]** Internal combustion engines generally combust a mixture of fuel (e.g., diesel, gasoline, natural gas, etc.) and air. Prior to entering the engine, the fuel is typically passed through a filter cartridge to remove particulate matter (e.g., dust, metal particles, debris, etc.) from the fuel prior to combustion. Similarly, lubricant or lube (e.g., engine oil) provided to the engine may also be passed through a filter cartridge so as to remove particulate matter from the lube before communicating to the engine. The fuel or oil may include water, which may accumulate in the filter and may have to be removed.

**[0004]** Filter elements (e.g., filter cartridges) often include a seal member that is compressed against a component of the filtration system housing or another portion of the filtration system. The seal member forms a seal between the filtration system housing and the filter element, thereby preventing fluid/air from bypassing the filter elements (e.g., for air to bypass an air filter element or liquid to bypass a liquid filter element). If an improper filter element (i.e., a non-authorized or non-genuine filter element) is installed in a filtration system, or if the proper filter element is installed incorrectly, the seal member of the filter element may not form a proper seal, and fluid/air may bypass the filter element, causing damage to downstream components or a drop in operating pressure. Accordingly, the installation of an improper filter element, or the improper installation of a filter element, can harm critical components in the filtration system, cause improper sealing, diminish emission compliance mechanisms, cause subpar performance, and the like.

## SUMMARY

**[0005]** Various embodiments provide for a filtration system that includes a housing defining an internal volume. A secondary filter element is positioned within the internal volume of the housing. A primary filter element is positioned within the internal volume of the housing. The filter media includes filter media positioned between a primary filter element first endplate and a primary filter element second endplate. The primary filter element first endplate includes an external surface and an internal surface. The internal surface abuts the filter media. A raised wall extends from the internal surface away from the external surface. The raised wall forms a radial seal with an external surface of the secondary filter element.

**[0006]** Various embodiments provide for a filter element that includes filter media positioned between a first endplate and a second endplate. The filter media defines an internal volume. The first endplate includes a first external surface and a first internal surface. The first internal surface abuts the filter media. A raised wall extends from the first internal surface away from the first external surface. The raised wall forms a radial seal with a second external surface of a secondary filter element. The secondary filter element is disposed within the internal volume.

**[0007]** Various embodiments further provide for a method of securing a filter element within a filter housing that includes positioning a secondary filter element within a filter housing, the secondary filter element defining an internal volume that receives a standpipe of the filter housing such that the standpipe is positioned within the secondary filter element. The method further comprises positioning a primary filter element within the filter housing such that the secondary filter element is within the primary filter element. The primary filter element includes a primary filter second endplate and a primary filter element first endplate. The primary filter element first endplate includes a seal surface. The seal surface contacts the annular portion such that a first radial seal is formed between the seal surface and the annular portion.

**[0008]** 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 DRAWINGS

**[0009]** FIG. 1 shows a perspective view of a filtration system in an unassembled state, according to an example embodiment.

**[0010]** FIG. 2A shows a cross-sectional side view of the filtration system of FIG. 1 when in an assembled state.

**[0011]** FIG. 2B shows a cross-sectional side view of a portion of the filtration system of FIG. 2A.

**[0012]** FIG. 3A shows a top perspective view of a secondary filter element for the filtration system of FIG. 1, according to an example embodiment.

**[0013]** FIG. 3B shows a cross-sectional side view of the secondary filter element of FIG. 3A.

**[0014]** FIG. 4 shows a perspective view of an unassembled primary filter element of the filtration system of FIG. 1, according to an example embodiment.

**[0015]** FIG. 5A shows a top perspective view of the filter element of FIG. 4 in an assembled state.

**[0016]** FIG. 5B shows a bottom perspective view of the filter element of FIG. 5A.

**[0017]** FIG. 5C shows a top view of the filter element of FIG. 5A.

**[0018]** FIG. 6A shows a top perspective view of a primary filter endplate with sealing features of the filter element of FIG. 4, according to an example embodiment.

**[0019]** FIG. 6B shows a bottom perspective view of the primary filter endplate of FIG. 6A.

**[0020]** FIG. 6C shows a top plan view of the primary filter endplate of FIG. 6A.

**[0021]** FIG. 6D shows a bottom plan view of the primary filter endplate of FIG. 6A.

**[0022]** FIG. 6E shows a side view of the primary filter endplate of FIG. 6A.

**[0023]** FIG. 7 shows a cross-sectional side view of the primary filter element of FIG. 4 in an assembled state.

**[0024]** FIG. 8 shows a portion of the primary filter element of FIG. 7.

**[0025]** FIGS. 9A and 9B show views of the radial seal formed between the primary filter endplate of the primary filter element and secondary filter element in the assembled filtration system of FIG. 1.

#### DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

**[0026]** Embodiments described herein relate generally to a system and method for securing a filter element within a filter housing. In some embodiments, the primary filter element includes a primary filter endplate with a raised wall that is configured to hold the filter media and secondary filter element in place within the filter housing. The primary filter endplate may be configured to form a radial seal with the secondary filter element such that the endplate forms a seal between the filter media (e.g., primary filter media) and the secondary filter element. In some embodiments, the primary filter endplate includes a rectangular (e.g., “u-shaped) groove that provides a touch surface for a user (e.g., end user, service personnel, etc.) to contact and grip for ease of serviceability (e.g., removal of one or more elements of the filter element from the housing). Additionally, the primary filter endplate may include a flat bottom side that provides structural support to the primary filter endplate and filter media (e.g., the filter element) within the housing.

**[0027]** FIG. 1 shows a perspective view of a filtration system 100 in an unassembled state, according to an example embodiment. FIG. 2A depicts the filtration system 100 of FIG. 1 in the assembled configuration. The filtration system 100 includes a filter housing 104, a primary filter element 102, a secondary filter element 110, and a cover 108 (e.g., housing endcap, housing cover, etc.). The filter housing 104 includes a first housing end 202 (e.g., top end) and

a second housing end 204 disposed axially away from the first housing end 202. An inlet 122 is formed along wall of the filter housing 104 between the first housing end 202 and the second housing end 204. As shown in FIG. 2A, an outlet 124 is formed along the first housing end 202 through an outlet wall 206 that extends from the first housing end 202 away from the second housing end 204. The second housing end 204 is substantially opened and configured to receive the cover 108. In some embodiments, an internal surface 138 of the cover 108 is configured to couple to the second housing end 204. For example, the cover 108 may threadedly engage a threaded member along the second housing end 204 and may include one or more clip elements that lock with complementary elements in the second housing end 204.

**[0028]** Referring back to FIG. 1, an interior space 170 is defined within the filter housing 104. A standpipe 120 (e.g., protruding member) is disposed within the interior space 170 and extends from the first housing end 202 towards the second housing end 204. In some embodiments, the standpipe 120 is formed with (e.g., molded on) the filter housing 104. The standpipe 120 is configured to receive the secondary filter element 110, such that the cylindrical wall 312 of the secondary filter element 110 is disposed around the standpipe 120. A secondary filter element first end 302 is configured to be adjacent to the first housing end 202 such that the secondary filter element 110 is disposed on and tightly wrapped around the outer surface of the standpipe 120. The standpipe 120 includes a cage portion 150 with a plurality of openings 154 and a top portion 152 extending from the cage portion 150 away from the first housing end 202. The top portion 152 of the standpipe 120 is configured to receive an internal surface of the secondary filter element second end 304. The top portion 152 has a cavity 158 formed therewithin and a protrusion 156 that extends from the base of the cavity 158 (e.g., approximately one-fourth the length of the standpipe 120) towards the second housing end 204.

**[0029]** As shown in FIG. 2A, when the secondary filter element 110 is installed within the filter housing 104, the secondary filter element first end 302 engages (e.g., is disposed within) a housing slot 208 disposed on an end of the centrally located outlet wall 206. In some embodiments, the secondary filter element first end 302 is press-fit within the housing slot 208. Once installed, the standpipe 120 is disposed within an internal volume 330—as shown in FIG.

3B—of the secondary filter element 110. As shown in FIGS. 3A and 3B, an annular portion 314 extends from the cylindrical wall 312 of the secondary filter element 110 toward the secondary filter element second end 304. A lip portion 320 is disposed between the annular portion 314 and the cylindrical wall 312. A top portion 308 of the secondary filter element 110 extends from the lip portion 320 toward a rim portion 318 along the secondary filter element second end 304. As shown in FIG. 2A, the rim portion 318 has a substantially centrally located opening 310 formed therewithin that receives a portion of the protrusion 156 when the secondary filter element 110 is installed over the standpipe 120. Once installed, the cylindrical wall 312, the lip portion 320, the annular portion 314, the top portion 308, and the rim portion 318 are fit against the outer surface of the standpipe 120.

**[0030]** The interior space 170 defined within the filter housing 104 is configured to receive the primary filter element 102. Specifically, a primary filter element second endplate 402 along the first filter end 112 is adjacent to the first housing end 202 and a primary filter element first endplate 404 along the second filter end 114 is adjacent the second housing end 204 when the primary filter element 102 is installed within the interior space 170 of the filter housing 104. As shown in FIG. 2B in a portion 200 of the filtration system 100, the primary filter element second endplate 402 forms a radial seal 290 with the outlet wall 206 when the primary filter element 102 is installed within the filter housing 104. As shown in FIG. 2A, the primary filter element first endplate 404 is configured to abut the internal surface 138 of the cover 108 when the primary filter element 102 is installed within the filter housing 104. An internal volume 160 is defined within and extends through the primary filter element 102 such that the standpipe 120 and the secondary filter element 110 are disposed within the internal volume 160 when the primary filter element 102 is installed within the filter housing 104. Once the primary filter element 102 is disposed within the filter housing 104 and the cover 108 is attached, the protrusion 156 is disposed within an opening 128 defined by a sleeve 118 that extends from an internal surface 138 away from the external surface 148 of the cover 108. As described in greater detail below, the primary filter element first endplate 404 is configured to position the primary filter element 102 within the filter housing 104 and provides more stability after assembling the primary filter element 102 within the filter housing 104.



**[0031]** Referring to FIG. 4, the primary filter element 102 in an unassembled state is shown. FIGS. 5A-5C show the primary filter element 102 in an assembled state. A filter media 410 is disposed between the primary filter element first endplate 404 and the primary filter element second endplate 402. The first media end 420 is affixed to an internal surface 432 of the primary filter element second endplate 402 and the second media end 430 is affixed to an internal surface 424 of the primary filter element first endplate 404. When the primary filter element 102 is in an assembled state, the opening 470 of the primary filter element second endplate 402, the internal volume 440 of the filter media 410, and the opening 460 of the primary filter element first endplate 404 are substantially aligned. The primary filter element second endplate 402 includes a plurality of notches 450 disposed along a perimeter of the surface between the external surface 422 and the internal surface 432 of the primary filter element second endplate 402. The plurality of notches 450 may be configured to assist the installation and positioning of the primary filter element second endplate 402 within the filter housing 104 and may impede rotation of the primary filter element 102 within the filter housing 104. As shown in FIGS. 6A-6E, the primary filter element first endplate 404 includes an endplate channel 806, a groove channel 802, and a raised circular wall 480. The endplate channel 806 is formed between the groove channel 802 and the raised circular wall 480 and is configured to receive the second media end 430. The groove channel 802 includes a plurality of ribs 804 that extend radially from an inner groove wall 502 toward the outer groove wall 504, which defines the diameter of the primary filter element first endplate 404. As shown in FIG. 5C, the diameter of the primary filter element first endplate 404 is greater than the diameter of the primary filter element second endplate 402.

**[0032]** Turning to FIGS. 6A-6E, the external surface 434 includes a substantially flat surface 830 that provides additional structural support and stability when the primary filter element 102 is installed within the filter housing 104. The plurality of ribs 804 and the groove channel 802 form a touch surface that provides a filter element removal feature for a user to grab and remove the primary filter element 102 from the filter housing 104. For example, a user may hold the primary filter element 102 by inserting the user's fingers within the groove channel 802 and pulling, thereby providing ease of serviceability. As shown in FIG. 6E, the inner groove wall 502 extends in the transverse direction to have a height that is greater than the

height of the outer groove wall 504. Each rib in the plurality of ribs 804 extend from the top, outer edge of the inner groove wall 502 radially outward and downward toward the top inner edge of the outer groove wall 504. Each rib in the plurality of ribs 804 may be configured to provide a touch surface for a user (e.g., end user, service user, etc.) to contact and grip for ease of serviceability of the primary filter element 102 and/or filtration system 100 (e.g., removal of one or more elements of the filter element from the housing).

**[0033]** Referring to FIGS. 7 and 8, the raised circular wall 480 extends from the internal surface 424 away from the external surface 434 and is configured to extend into the internal volume 440 of the filter media 410 when the primary filter element 102 is assembled. The circular wall 480 includes an axial wall 818 that extends from an internal surface 424 away from the external surface 434. The axial wall 818 and the inner groove wall 502 form the endplate channel 806. An angled surface 820 extends from the axial wall 818 inwardly (e.g., away from inner groove wall 502 in the lateral direction) toward a ring portion 822. The ring portion 822 extends radially inward. As shown in the portion 800 of the circular wall 480, the ring portion 822 includes a seal surface 824 disposed around an internal perimeter of the ring portion 822. The ring portion 822 (e.g., protrusion) and the seal surface 824 are configured to press against the secondary filter element 110 to form a radial seal 902. In other words, the primary filter element first endplate 404 is configured to form a seal between the filter media 410 and the secondary filter element 110.

**[0034]** As shown in the portion 900 of the filtration system 100 in FIGS. 9A and 9B, when the secondary filter element 110 and primary filter element 102 are installed within the filter housing 104, the seal surface 824 of the ring portion 822 presses against the annular portion 314 of the secondary filter element 110. A radial seal 902 is formed between the ring portion 822 pressing against the annular portion 314 of the secondary filter element 110. The formation of the radial seal 902 and the radial seal 290 (formed between the primary filter element second endplate 402 and the outlet wall 206) seal the primary filter element 102 within the filter housing 104 such that dirty fluid/air enters the inlet 122, travels through and is filtered by the filter media 410 and the secondary filter element 110, and exits the filtration system 100 through the outlet 124 by way of the standpipe 120. The radial seal 902 formed between the

ring portion 822 pressing against the annular portion 314 of the secondary filter element 110 prevent fluid/air from entering the area 950 between the primary filter element 102 and the cover 108.

**[0035]** Various exemplary embodiments provide for a method of installing a filter element (e.g., primary filter element 102 and secondary filter element 110) within a filter housing 104. The method includes positioning the secondary filter element 110 within the filter housing 104. The internal volume 330 of the secondary filter element 110 receives the standpipe 120 of the filter housing 104. The method also includes positioning the primary filter element 102 within the filter housing 104 such that the secondary filter element 102 is positioned within the internal volume 440 of the filter media 410 in FIG. 2A. When the primary filter element 102 is positioned within the filter housing 104 a first radial seal (e.g., radial seal 902) is formed between the seal surface 824 and the annular portion 314 as shown in FIG. 9B. The primary filter second endplate 402 may form a second radial seal (e.g., radial seal 290 as shown in FIG 2B) with an outlet wall of the filter housing when the primary filter element is positioned within the filter housing. The positioning of the secondary filter element within the housing comprises fitting the annular portion 314 around the standpipe 120. The method may also include coupling the cover 108 to the filter housing 104 such that the primary filter element first endplate 404 abuts an internal surface 138 of the cover 108 such that the first radial seal (e.g., radial seal 902) prevents a fluid from entering the area 905 shown in FIG. 9B.

**[0036]** It should be noted that the term “example” as used 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).

**[0037]** The term “coupled,” “connected,” 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]** References herein to the positions of elements (e.g., “top,” “bottom,” “above,” “below,” 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 exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

**[0039]** 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, various 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. 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 concepts presented herein.

**[0040]** While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any inventions or of what may be claimed, but rather as descriptions of features specific to particular implementations of particular inventions. Certain features described in this specification in the context of separate implementations can also be implemented in combination in a single implementation. Conversely, various features described in the context of a single implementation can also be implemented in multiple implementations separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the

combination, and the claimed combination may be directed to a subcombination or variation of a subcombination.

**WHAT IS CLAIMED IS:**

1. A filtration system, comprising:
  - a housing defining an internal volume;
  - a secondary filter element positioned within the internal volume of the housing; and
  - a primary filter element positioned within the internal volume of the housing, the secondary filter element positioned within the primary filter element, the primary filter element comprising:
    - a primary filter element first endplate;
    - a primary filter element second endplate; and
    - filter media positioned between the primary filter element first endplate and the primary filter element second endplate;
    - the primary filter element first endplate comprising:
      - an external surface;
      - an internal surface, the internal surface abutting the filter media; and
      - a raised wall extending from the internal surface away from the external surface, the raised wall forming a radial seal with an external surface of the secondary filter element.
2. The filtration system of claim 1, wherein the primary filter element first endplate further comprises a groove channel, the groove channel comprising an outer groove wall, an inner groove wall, and a plurality of ribs, the outer groove wall disposed around a perimeter of the internal surface of the primary filter element first endplate, the inner groove wall disposed radially inward from the outer groove wall, each rib in the plurality of ribs extending radially outward from the inner groove wall toward the outer groove wall.
3. The filtration system of claim 2, wherein an endplate channel is formed on the internal surface between the raised wall and the groove channel, the endplate channel configured to receive an end of the filter media.

4. The filtration system of claim 2, wherein a first outer diameter of the primary filter element first endplate is greater than a second outer diameter of the primary filter element second endplate, the first outer diameter defined by the outer groove wall.

5. The filtration system of claim 2, wherein the plurality of ribs and the groove channel define a touch surface, the touch surface configured to be selectively operable by a user such that when the user operates the touch surface, the primary filter element is removed from the housing.

6. The filtration system of claim 1, wherein the primary filter element second endplate comprises a plurality of notches configured to facilitate installing the primary filter element second endplate within the housing.

7. The filtration system of claim 1, wherein the raised wall further comprises an axial wall extending from the internal surface away from the external surface and a ring portion extending from the axial wall away from the internal surface, the ring portion comprising an internal seal surface, the ring portion configured to contact the external surface of the secondary filter element and form the radial seal between the external surface of the secondary filter element and the internal seal surface of the ring portion.

8. The filtration system of claim 1, wherein the filter media defines an internal media volume, a portion of the raised wall extends into the internal media volume, and wherein the secondary filter element is disposed within the internal media volume.

9. The filtration system of claim 1, wherein the housing comprises:  
a housing first end;  
a housing second end opposite the housing first end;  
a standpipe disposed within the internal volume and extending from the housing first end to the housing second end; and

a cover disposed at the housing second end, the cover comprising a cover internal surface configured to couple to the housing second end.

10. The filtration system of claim 9, wherein the standpipe comprises:

a cage portion having a plurality of openings; and

a top portion extending from the cage portion and away from the housing first end, the top portion defining a cavity formed therewithin, the top portion comprising protrusion that extends from the cavity towards the housing second end, the protrusion disposed within an opening of the cover.

11. The filtration system of claim 10, wherein the top portion is configured to receive a secondary filter element internal surface.

12. A filter element, comprising:

a first endplate;

a second endplate; and

filter media positioned between the first endplate and the second endplate, the filter media defining an internal volume;

the first endplate comprising:

a first external surface;

a first internal surface, the first internal surface abutting the filter media; and

a raised wall extending from the first internal surface away from the first external surface, the raised wall forming a radial seal with a second external surface of a secondary filter element, the secondary filter element disposed within the internal volume.

13. The filter element of claim 12, wherein the first endplate further comprises:

a groove channel defined by an inner groove wall and an outer groove wall;

a plurality of ribs disposed in the groove channel and extending from the inner groove wall to the outer groove wall;



an angled surface extending from the raised wall radially inwardly and away from the inner groove wall; and

a ring portion disposed at the angled surface, the ring portion comprising a seal surface disposed about an internal perimeter of the ring portion and configured to press against the secondary filter element so as to form the radial seal.

14. The filter element of claim 12, wherein the second endplate comprises:
  - a second internal surface;
  - a plurality of notches around a perimeter of the second endplate; and
  - a second opening.
15. The filter element of claim 14, wherein the filter media comprises:
  - a first media end coupled to the second internal surface;
  - a second media end opposite the first media end, the second media end coupled to the first internal surface.
16. The filter element of claim 14, wherein the first endplate comprises a first opening, the first opening axially aligning with the second opening and the internal volume.
17. A method of installing a filter element, comprising:
  - positioning a secondary filter element within a filter housing, the secondary filter element defining an internal volume that receives a standpipe of the filter housing such that the standpipe is positioned within the secondary filter element; and
  - positioning a primary filter element within the filter housing, the primary filter element comprising:
    - a primary filter second endplate;
    - a primary filter element first endplate comprising a seal surface, the seal surface contacting an annular portion of the secondary filter element such that a first radial seal is formed between the seal surface and the annular portion; and

a filter media disposed between the primary filter first endplate and the primary filter second endplate, the filter media defining an internal volume that receives the secondary filter element as the primary filter element is positioned within the filter housing.

18. The method of claim 17, wherein during positioning of the primary filter element within the filter housing, the primary filter second endplate forms a second radial seal with an outlet wall of the filter housing.

19. The method of claim 17, wherein positioning the secondary filter element within the housing further comprises fitting the annular portion around the standpipe.

20. The method of claim 17, further comprising coupling a cover to the filter housing such that the primary filter element first endplate abuts an internal surface of the cover such that the first radial seal prevents a fluid from entering an area between the primary filter element and the cover.



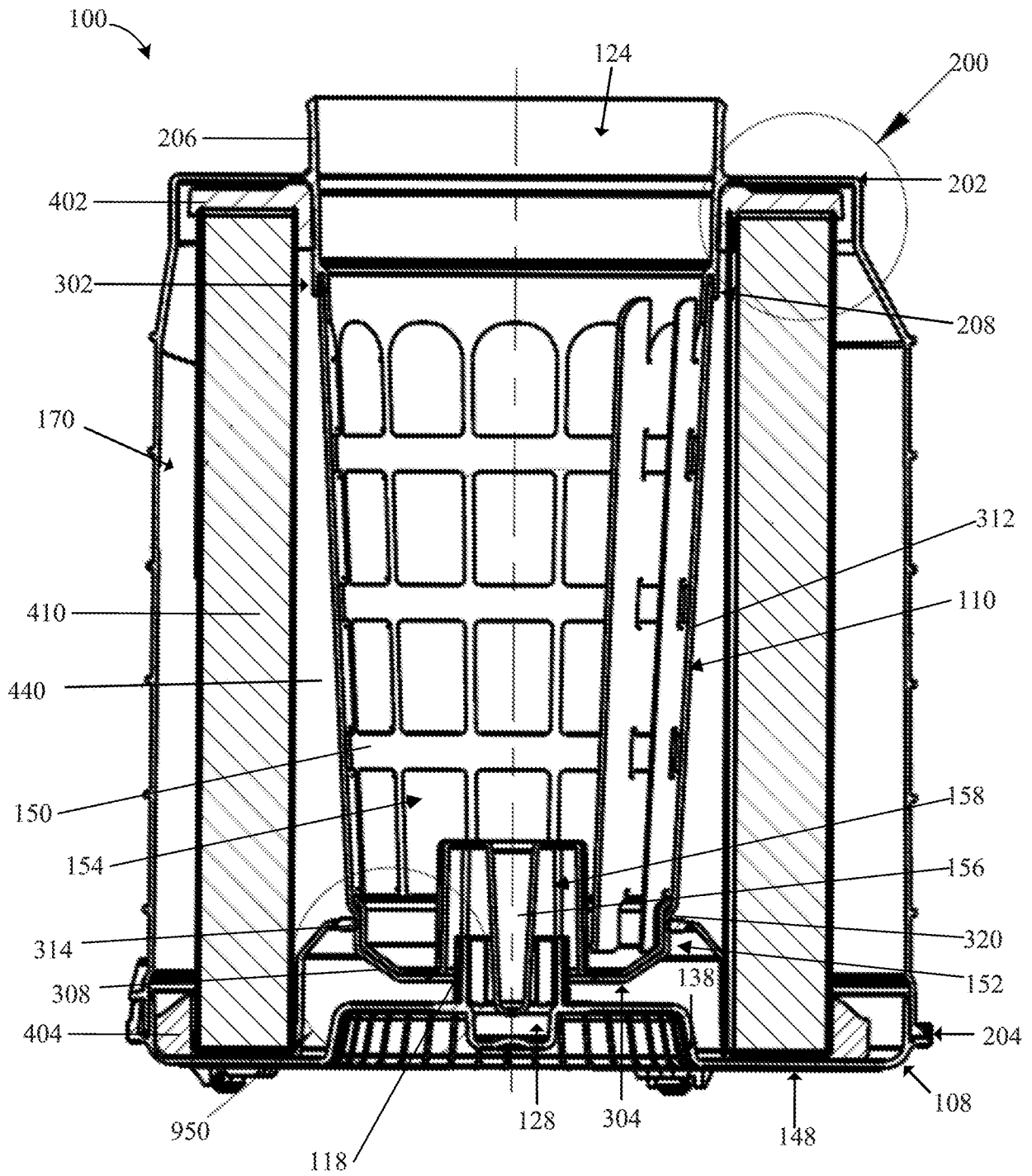


FIG. 2A

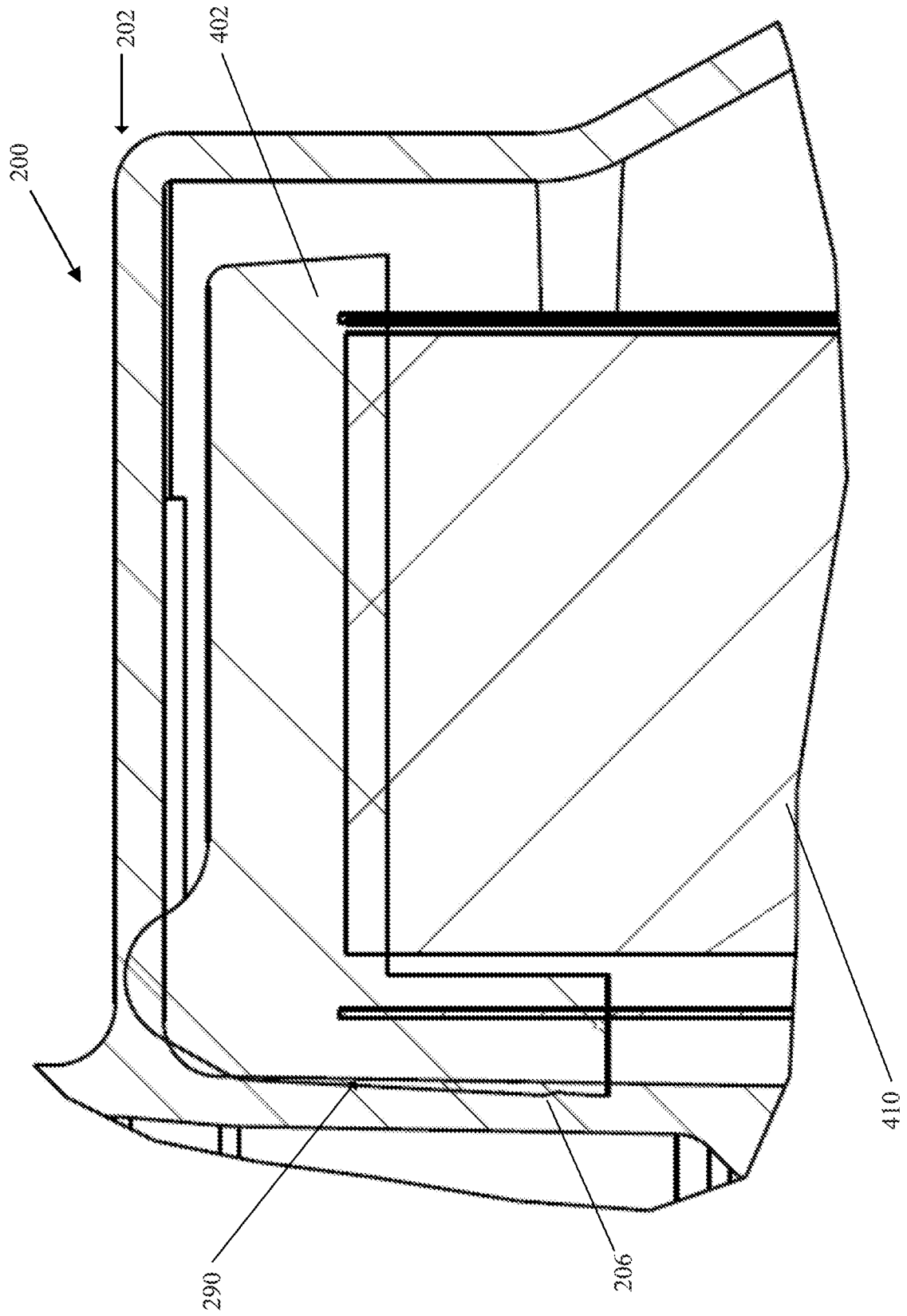


FIG. 2B

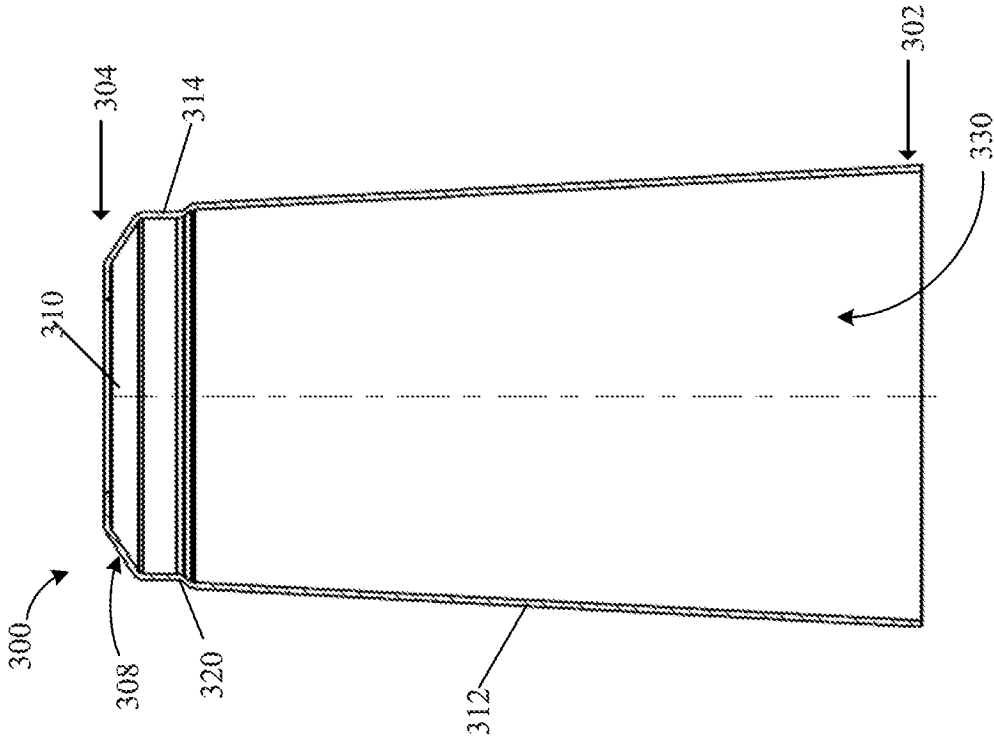


FIG. 3A

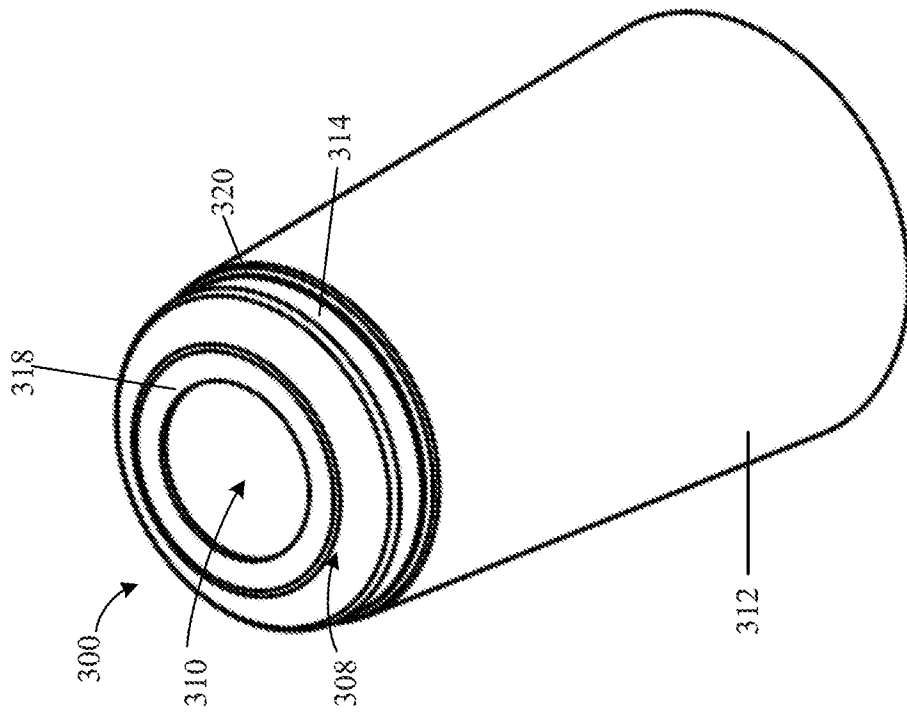


FIG. 3B

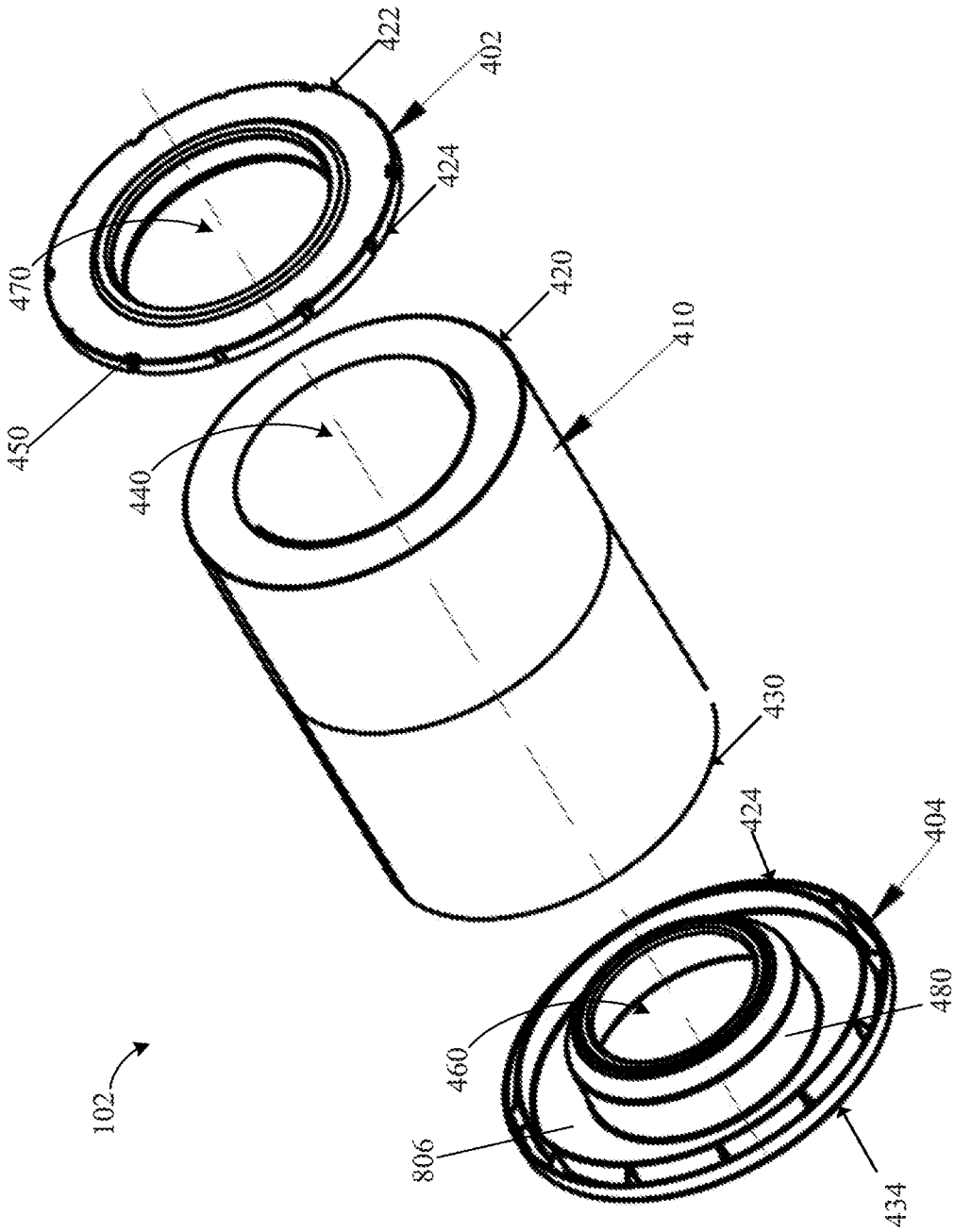


FIG. 4

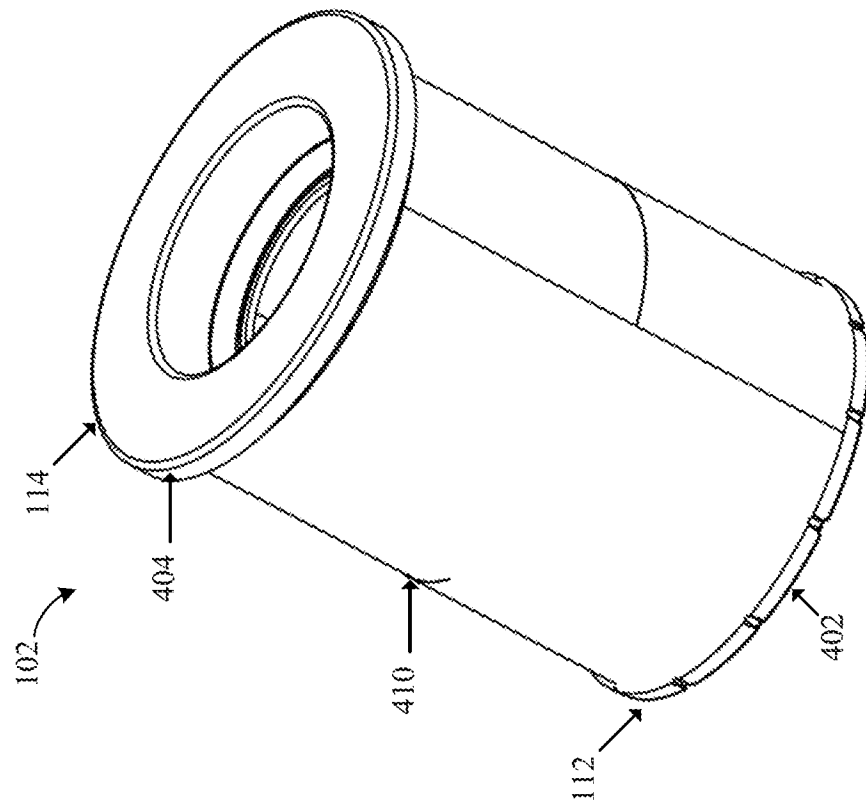


FIG. 5B

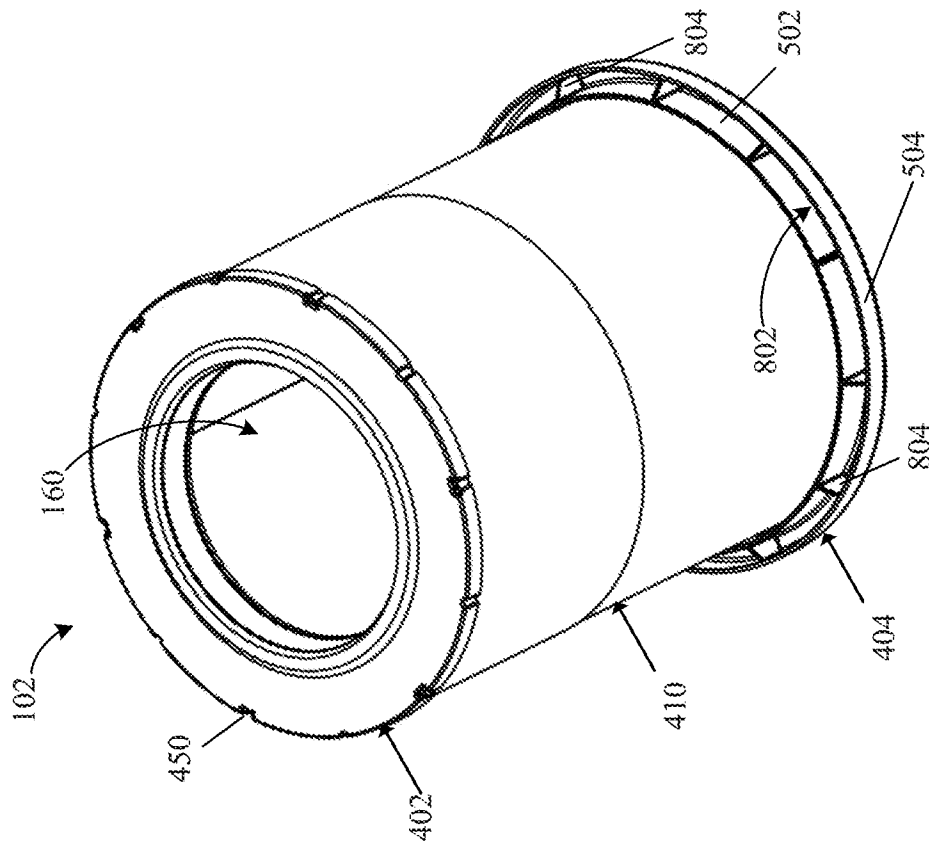


FIG. 5A



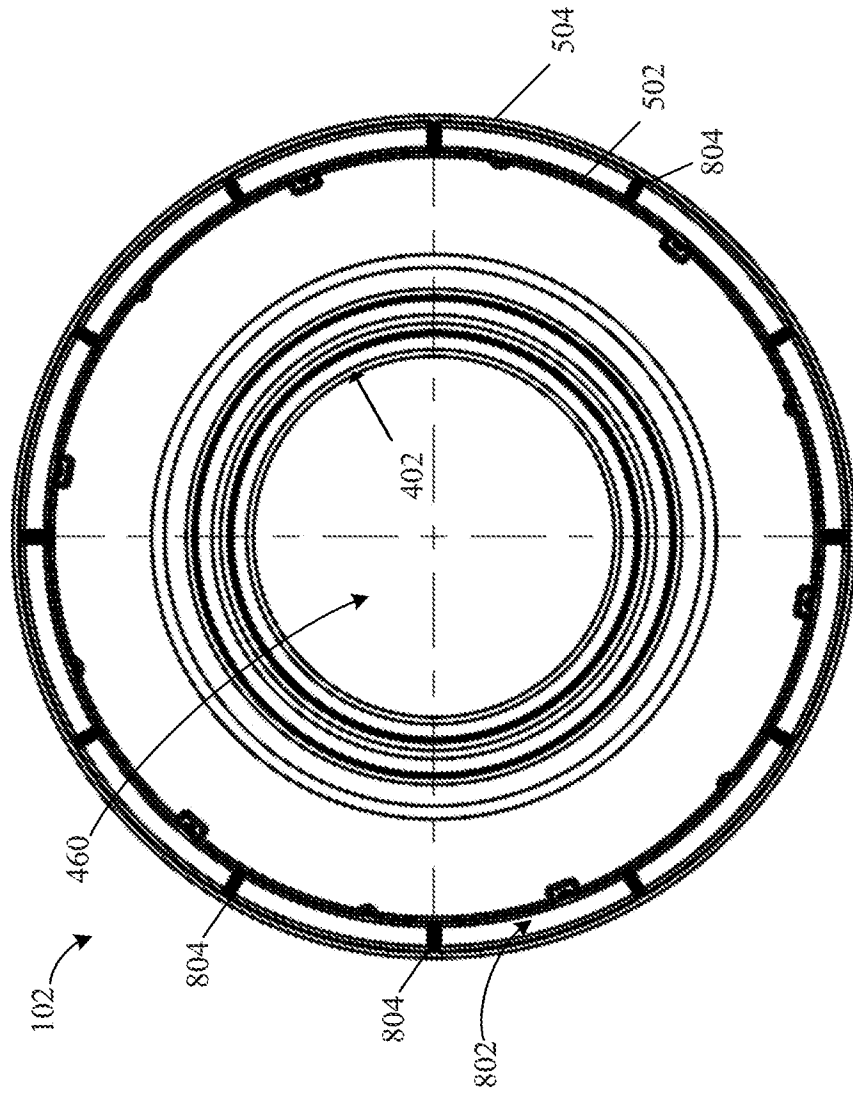


FIG. 5C

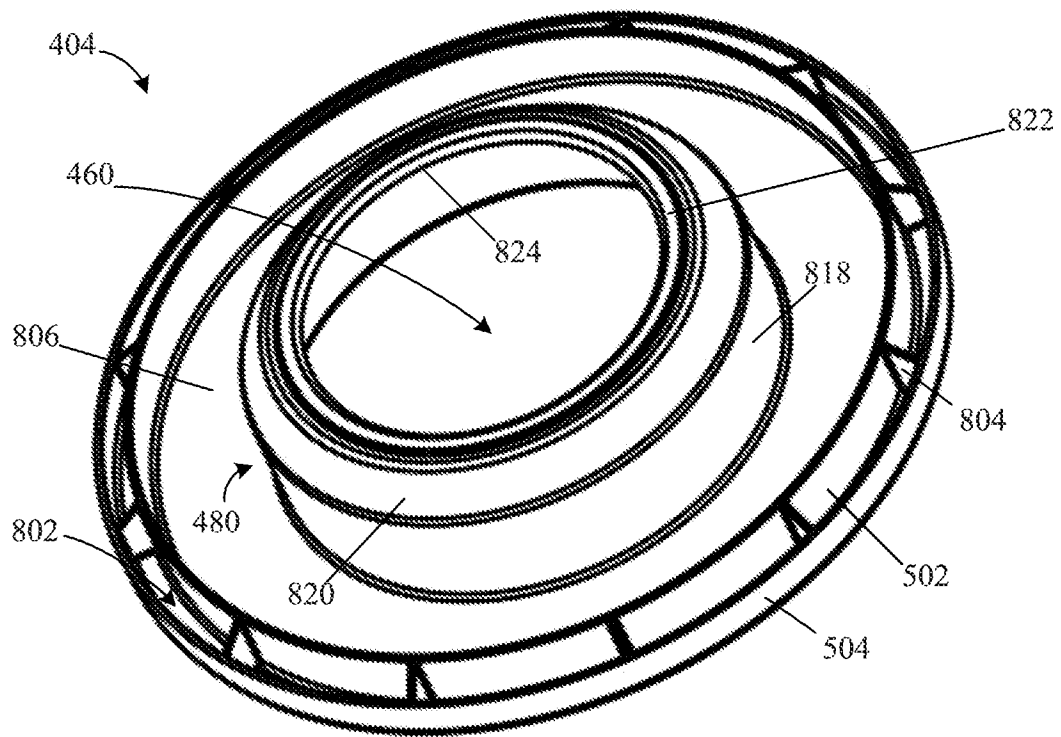


FIG. 6A

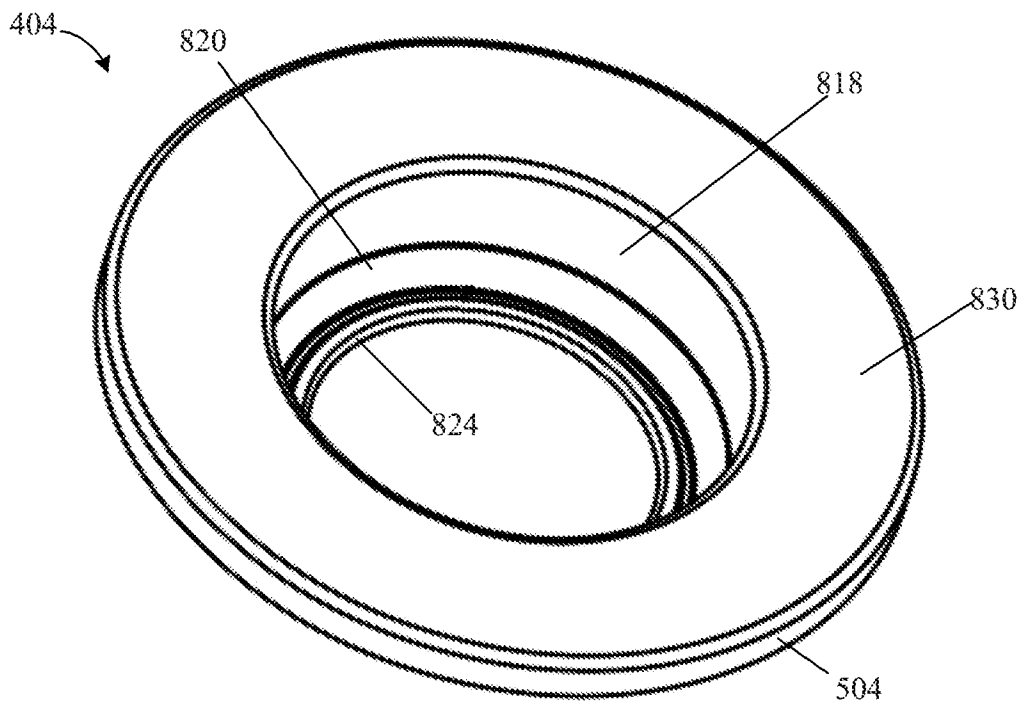


FIG. 6B

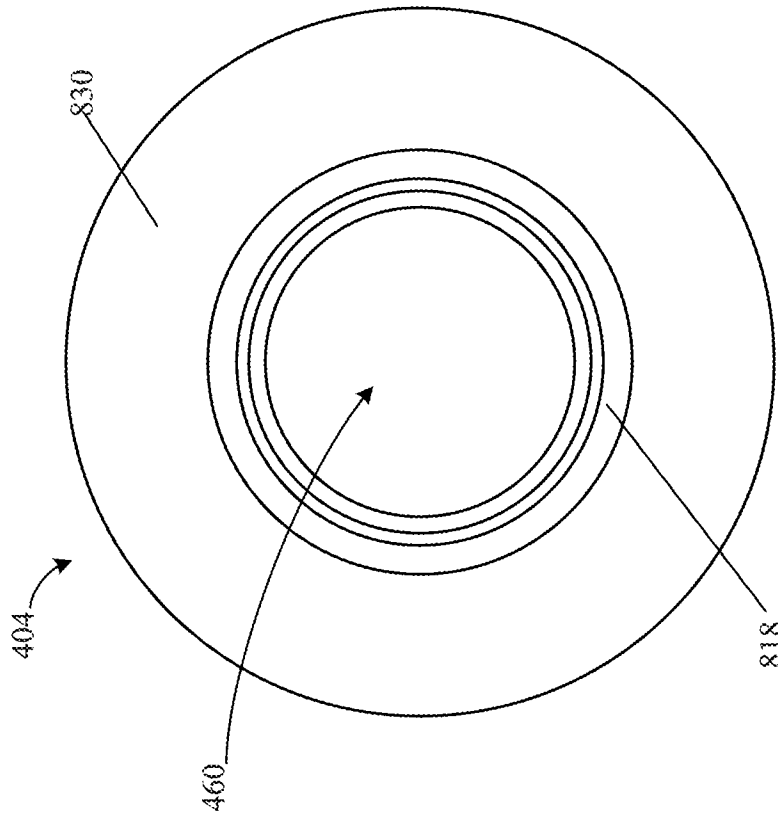


FIG. 6D

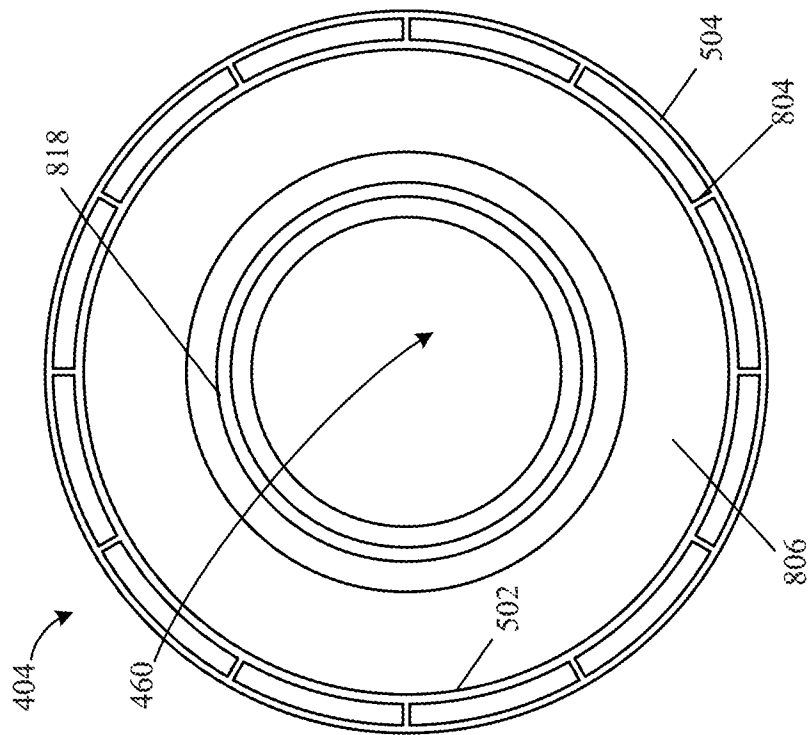


FIG. 6C

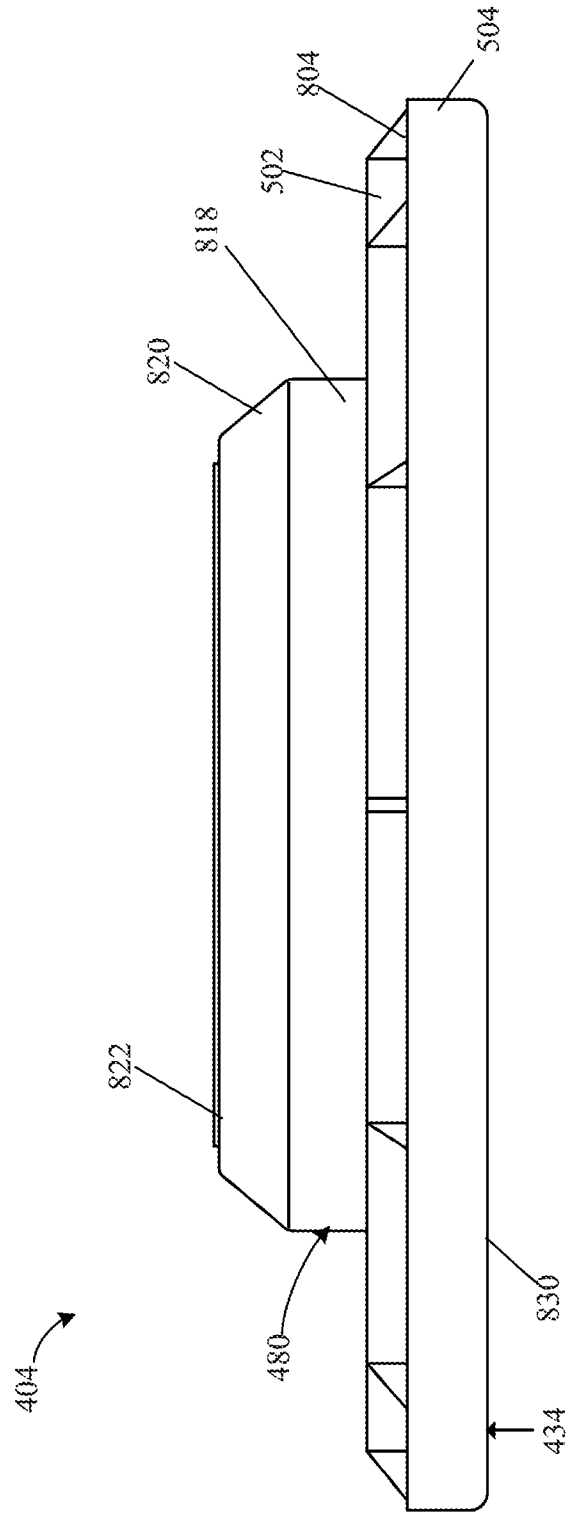


FIG. 6E



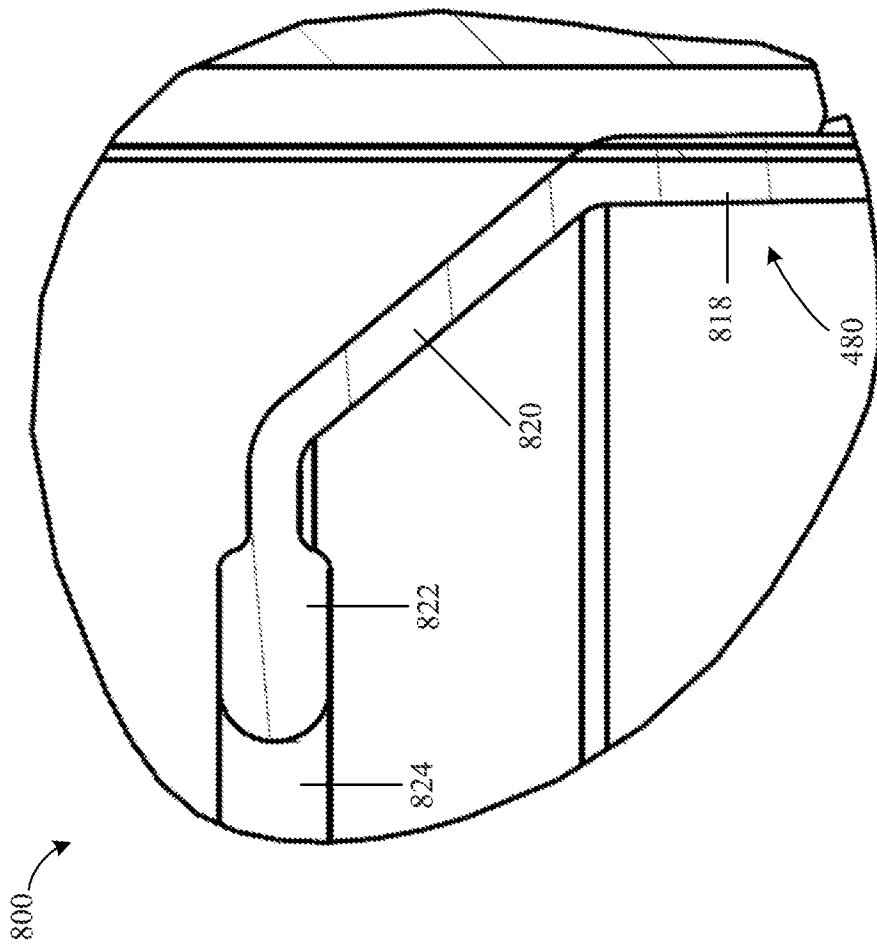


FIG. 8

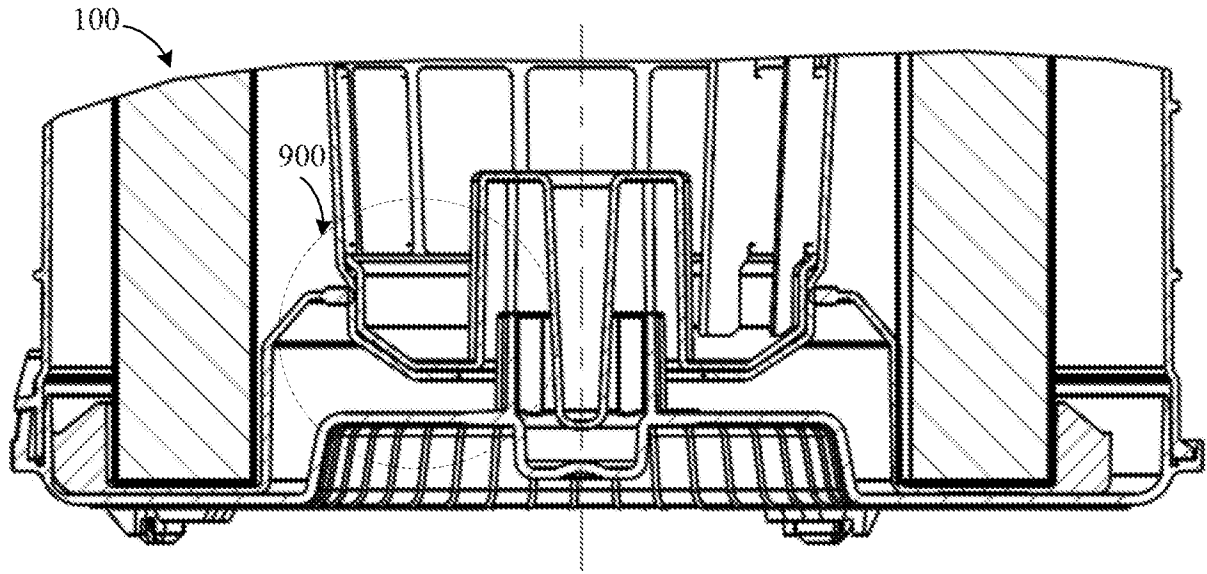


FIG. 9A

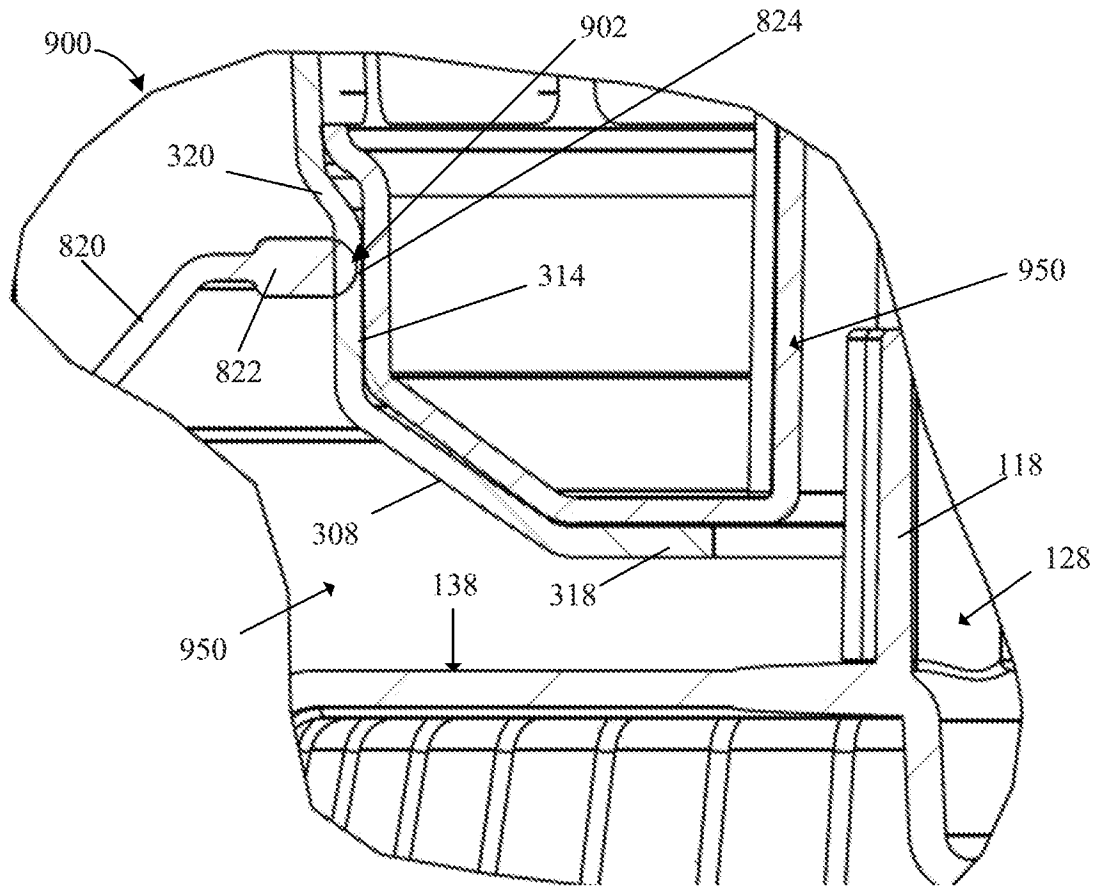


FIG. 9B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 20/54381

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC - B01D 29/21; B01D 35/147; B01D 35/153 (2021.01)  
 CPC - B01D 29/21; B01D 35/147; B01D 35/153; B01D 35/30

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)  
 See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- A	US 2013/0087497 A1 (Wells et al.) 11 April 2013 (11.04.2013) Abstract, para [0054], [0058], [0060]-[0064], [0068], Figure 1; Figure 3; Figure 5; Figure 7; Figure 8; Figure 10; Figure 13; Figure 14; Figure 15; Figure 18; Figure 21; Figure 24.	1, 7-8, 12 ----- 2-6, 9-11, 13-16
A	EP 2,765,298 A1 (Mann and Hummel GmbH) 13 August 2014 (13.08.2014) para [0001], [0035], [0047], Figure 1; Figure 7.	2-5, 13
A	US 2009/0026124 A1 (Schmitz et al.) 29 January 2009 (29.01.2009) Abstract, para [0042], [0044]-[0046], Figure 1.	6, 14-16
A	US 2005/0247617 A1 (Harms et al.) 10 November 2005 (10.11.2005) Abstract, para [0015]-[0016], [0018], Figure 1; Figure 3; Figure 6; Figure 7.	9-11
A	US 2010/0294712 A1 (Abdalla et al.) 25 November 2020 (25.11.2010) Entire Document.	1-16
A	US 5,484,466 A (Brown et al.) 16 January 1996 (16.01.1996) Entire Document.	1-16
A	US 6,626,299 B1 (Brown et al.) 30 September 2003 (30.09.2003) Entire Document.	1-16

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"D" document cited by the applicant in the international application	"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
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"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)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"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 19 January 2021	Date of mailing of the international search report <b>MAR 10 2021</b>
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 Lee Young  Telephone No. PCT Helpdesk: 571-272-4300



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 20/54381

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:  
(See Supplemental Page)

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-16

**Remark on Protest**

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

Lack of Unity Box III:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-16, directed to a filter element.

Group II: Claims 17-20, directed to a method of installing a filter element.

The group of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special Technical Features:

Group I requires the special technical feature of the primary filter element first endplate comprising: an external surface; an internal surface, the internal surface abutting the filter media; and a raised wall extending from the internal surface away from the external surface, the raised wall forming a radial seal, not required by group II.

Group II requires the specific technical feature of a method of installing a filter element, comprising: positioning a secondary filter element within a filter housing, the secondary filter element defining an internal volume that receives a standpipe of the filter housing such that the standpipe is positioned within the secondary filter element; and positioning a primary filter element within the filter housing, the primary filter element comprising: a primary filter second endplate; a primary filter element first endplate comprising a seal surface, the seal surface contacting an annular portion of the secondary filter element such that a first radial seal is formed between the seal surface and the annular portion; and a filter media disposed between the primary filter first endplate and the primary filter second endplate, the filter media defining an internal volume that receives the secondary filter element as the primary filter element is positioned within the filter housing, not required by group I.

Common technical features:

Groups I-II share the technical feature of a filtration system comprising: a housing defining an internal volume; a secondary filter element positioned within the internal volume of the housing; and a primary filter element positioned within the internal volume of the housing, the secondary filter element positioned within the primary filter element; the primary filter element comprising: a primary filter element first endplate; a primary filter element second endplate; and filter media positioned between the primary filter element first endplate and the primary filter element second endplate; and the filter media defining an internal volume that receives the secondary filter element as the primary filter element is positioned within the filter housing; and the primary filter element first endplate comprising a radial seal with an external surface of the secondary filter element.

These shared technical features, however, do not provide a contribution over the prior art, as being anticipated by US 2013/0087497 A1 to Wells et al. (hereinafter Wells). Wells teaches a filtration system comprising: a housing defining an internal volume (Figure 1, 10 and 20; and Figure 3, 10 and 20; and Abstract, A filter within a filter cartridge design is described; and para [0054], FIGS. 1-4 illustrate one embodiment of the filter cartridge 20 assembled together with the housing 10. The housing 10 has a generally open end that the filter cartridge 20 can be inserted into); a secondary filter element positioned within the internal volume of the housing; and a primary filter element positioned within the internal volume of the housing, the secondary filter element positioned within the primary filter element (Figure 1, 10 and 20; and Figure 3, 10 and 20; and Figure 8, 20 and 30 and 40; and Figure 10, 20 and 30 and 40; and para [0054], FIGS. 1-4 illustrate one embodiment of the filter cartridge 20 assembled together with the housing 10. The housing 10 has a generally open end that the filter cartridge 20 can be inserted into; and para [0060], With particular reference to the filter cartridge 20, FIGS. 8-10 show the filter cartridge 20 with an outer filter element 30 and an inner filter element 40; Note that outer filter element 30 is interpreted to be the primary filter element, with inner filter element 40 interpreted to be the secondary filter element); the primary filter element comprising: a primary filter element first endplate; a primary filter element second endplate; and filter media positioned between the primary filter element first endplate and the primary filter element second endplate (Figure 8, 30 and 32 and 34; and Figure 10; and Figure 13, 30 and 32 and 34 and 36; and para [0060]-[0061], With particular reference to the filter cartridge 20, FIGS. 8-10 show the filter cartridge 20 with an outer filter element 30 and an inner filter element 40. In one embodiment, the outer and inner filter elements 30, 40 have respective filtering media 36, 46... see FIGS. 13 and 22 respectively; and para [0062], The outer filter element 30 has a first endplate 32 connected at one end and a second endplate 34 connected at an opposing end... In some embodiments, the endplates 32, 34, 42, 44 of the outer and inner filter elements 30, 40 are embedded, bonded or otherwise fixed to the filter media 36, 46 to create fluid tight seals at the ends which they are connected); and the filter media defining an internal volume that receives the secondary filter element as the primary filter element is positioned within the filter housing; and the primary filter element first endplate comprising a radial seal with an external surface of the secondary filter element (Figure 1; and Figure 8, 30 and 40; and Figure 10, 30 and 40 and 32 and 42; and Figure 13, 30 and 32 and 36 and 56; and Figure 24, 42 and 66; and para [0060]-[0061], With particular reference to the filter cartridge 20, FIGS. 8-10 show the filter cartridge 20 with an outer filter element 30 and an inner filter element 40. In one embodiment, the outer and inner filter elements 30, 40 have respective filtering media 36, 46; and para [0062]-[0063], As shown in FIG. 10, for example, the media of the outer filter element 30 is arranged around the media of the inner filter element 40, such that a space 38 is defined therebetween... The outer filter element 30 has a first endplate 32 connected at one end and a second endplate 34 connected at an opposing end. The inner filter element 40 has a first endplate 42 connected at one end and a second endplate 44 connected at an opposing end. In some embodiments, the endplates 32, 34, 42, 44 of the outer and inner filter elements 30, 40 are embedded, bonded or otherwise fixed to the filter media 36, 46 to create fluid tight seals at the ends which they are connected. The first endplate 32 of the outer filter element 30 and the first endplate 42 of the inner filter element 40 are connected in a fluid tight seal and define an outlet flow passage... e.g. outlet 24; and para [0068], An inner annular flange 56 extends partially into the area surrounded by the media 36 and defines an opening through the first endplate 32. The flange 56 connects with a flange 66 of the first endplate 42... of the inner filter element 40 to create the outlet flow passage... e.g. outlet 24... In one preferred example, the flange 56 is connected to the flange 66 of the first endplate 42 in a fluid tight seal; With reference to Figures 8, 10, 13, and 24, the primary filter element 30 is equipped to receive the secondary filter element 40. Specifically, the endplates 32 and 42 of the primary and secondary filter elements respectfully form a radially shaped seal with each other. This radially shaped seal is formed by the flange 56 of the endplate 32 connected to the flange 66 of the endplate 42. The flange 66 and/or the endplate 42 may be interpreted as the external surface of the secondary filter element 40).

\*\*\*Continued on Supplemental Page\*\*\*

**INTERNATIONAL SEARCH REPORT**

International application No.

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**Lack of Unity Continuation:**

As the technical features were known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups.

Groups I-II therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.