US 20250256292A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2025/0256292 A1
(43) Pub. Date: Aug. 14, 2025
Erickson et al.

(54) VENT ASSEMBLIES

(71) Applicant: **3M INNOVATIVE PROPERTIES COMPANY**, St. Paul, MN (US)

(72) Inventors: **Ryan D. Erickson**, Roseville, MN (US); **Anna M. Hegdahl**, Maple Grove, MN (US); **Stephen C.P. Joseph**, Woodbury, MN (US); **Steven J. Tarnowski**, Mahtomedi, MN (US); **Ryan P. Birringer**, Minneapolis, MN (US)

(21) Appl. No.: **19/169,963**

(22) Filed: **Apr. 3, 2025**

Related U.S. Application Data

(62) Division of application No. 17/775,740, filed on May 10, 2022, filed as application No. PCT/IB2020/060589 on Nov. 10, 2020.

(60) Provisional application No. 62/933,628, filed on Nov. 11, 2019.

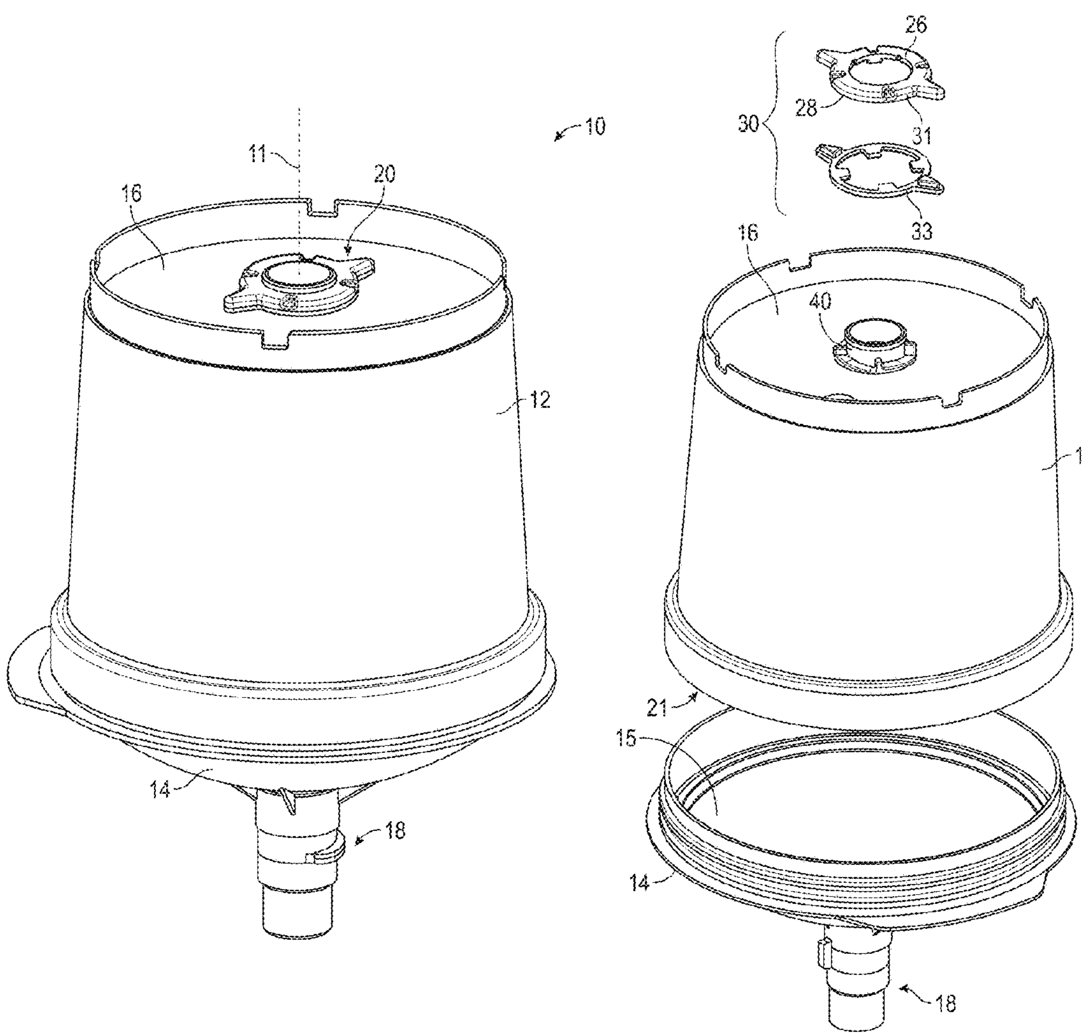
Publication Classification

(51) **Int. Cl.**
B05B 7/24 (2006.01)
B05B 11/00 (2023.01)

(52) **U.S. Cl.**
CPC ***B05B 7/2408*** (2013.01); ***B05B 7/2478*** (2013.01); ***B05B 11/0039*** (2018.08)

(57) **ABSTRACT**

Vent assemblies for reservoirs and other closed systems. The vent assemblies include one or more apertures in a wall of the reservoir. A closure member is retained on the external surface of the reservoir by a closure member retainer and includes a first component and a second component, the second component is relatively conformable compared to the first component. The second component is positioned between the first component and the wall of the reservoir. A sealing surface is located on either the first component or the second component, where the sealing surface closes the aperture when the closure member is in an unvented position, and the sealing surface does not close the aperture when the closure member is in a vented position.



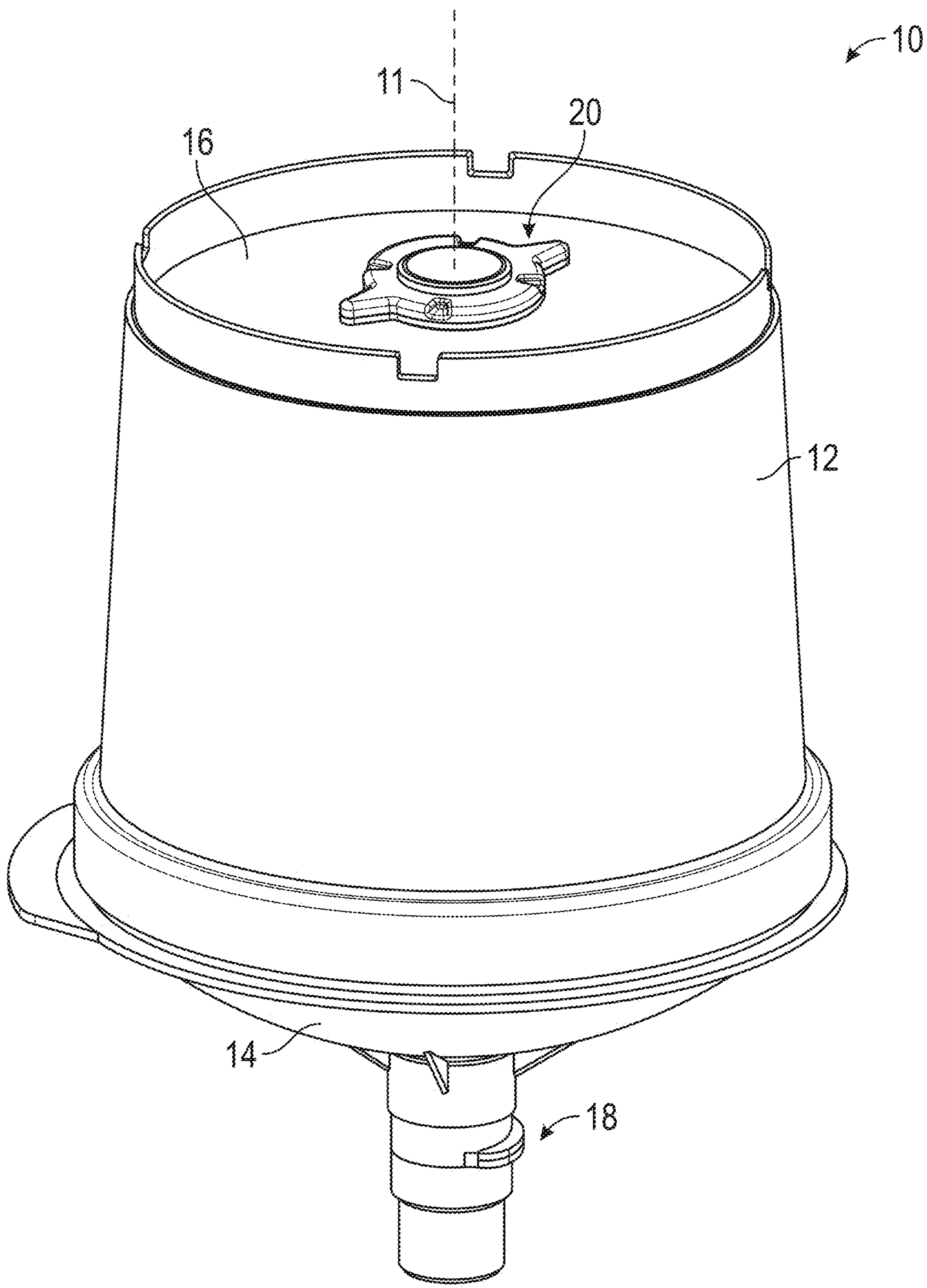


FIG. 1A

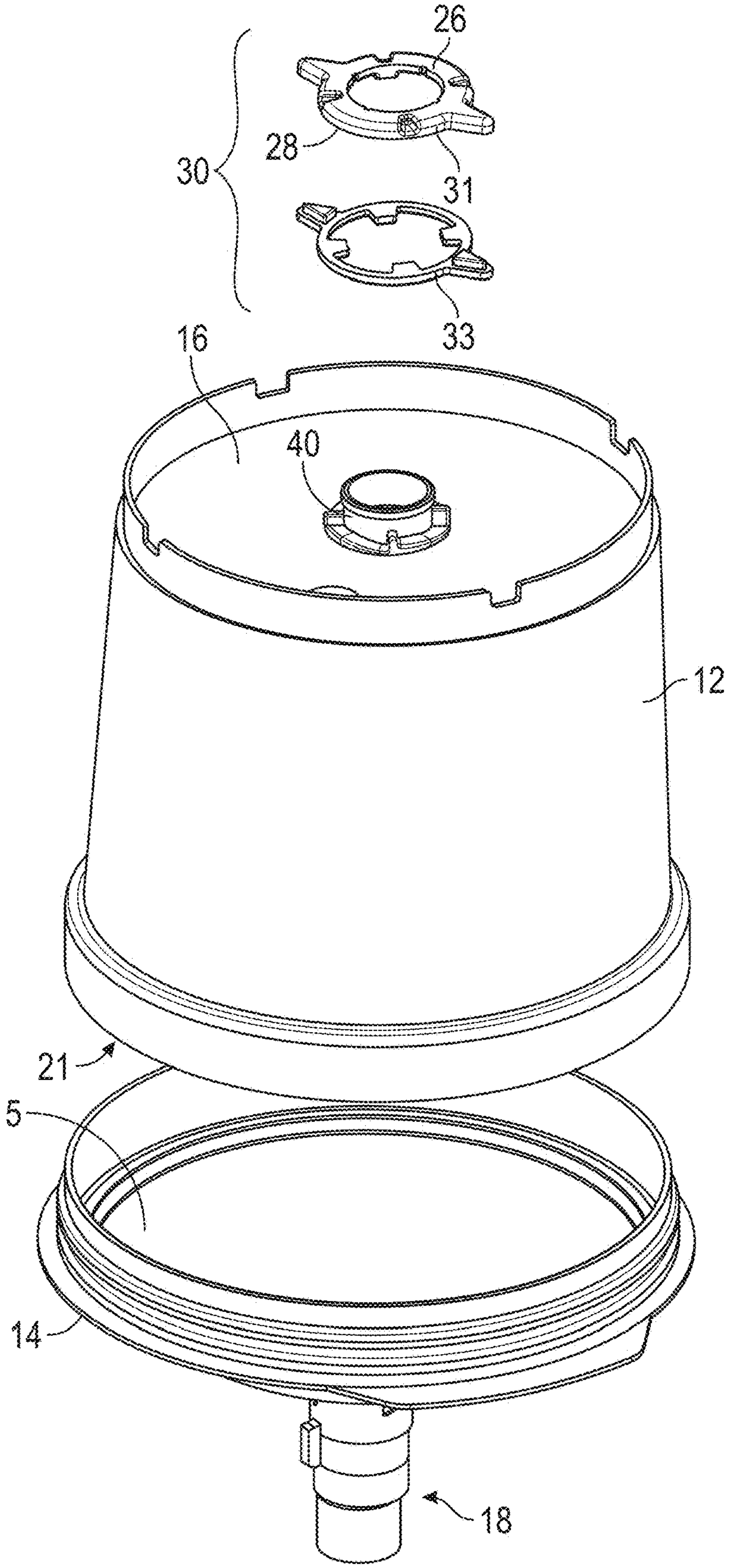


FIG. 1B

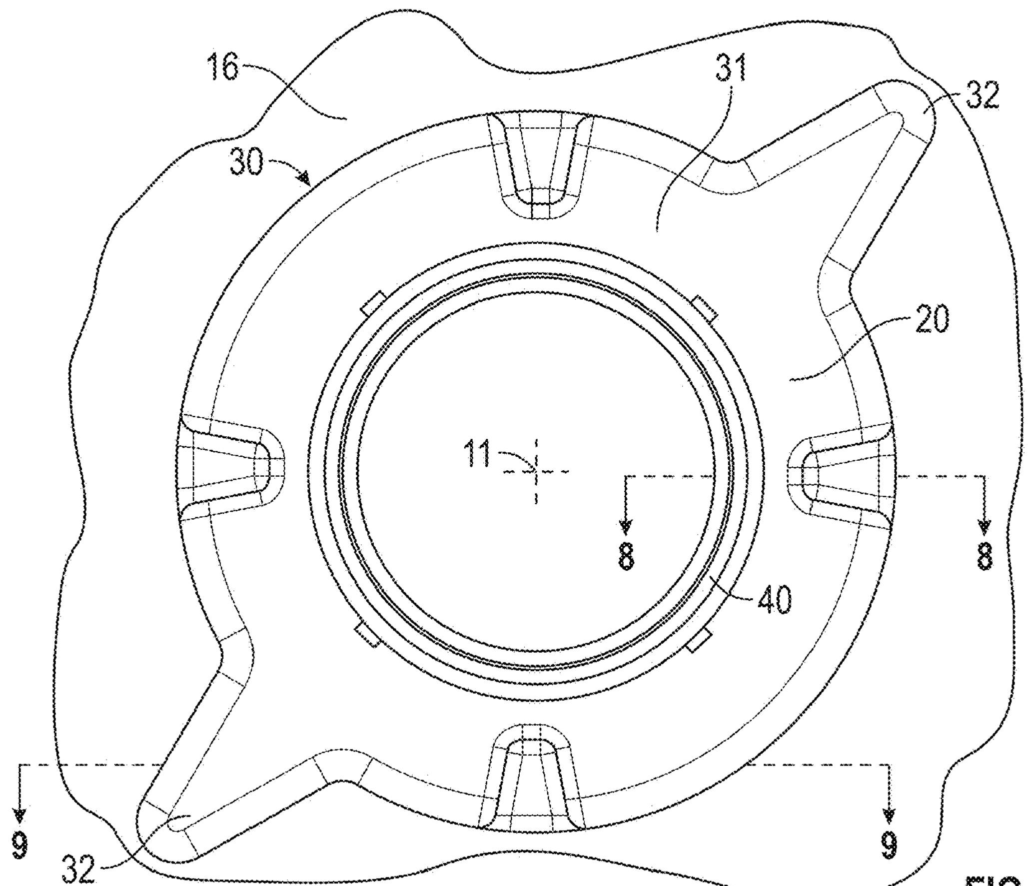

16
31
32
30
20
11
8
8
40
9
9
32

FIG. 2

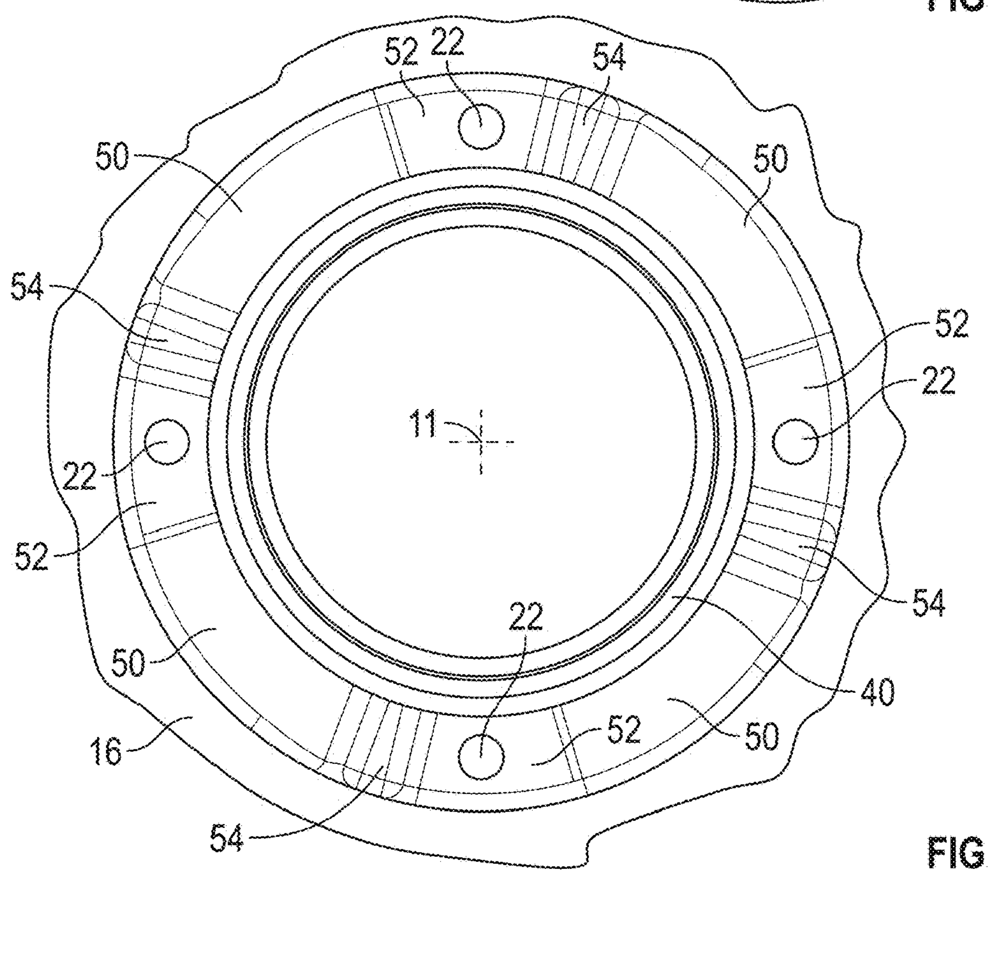

52
22
54
50
50
54
52
22
11
22
52
54
22
50
40
16
52
50
54

FIG. 3

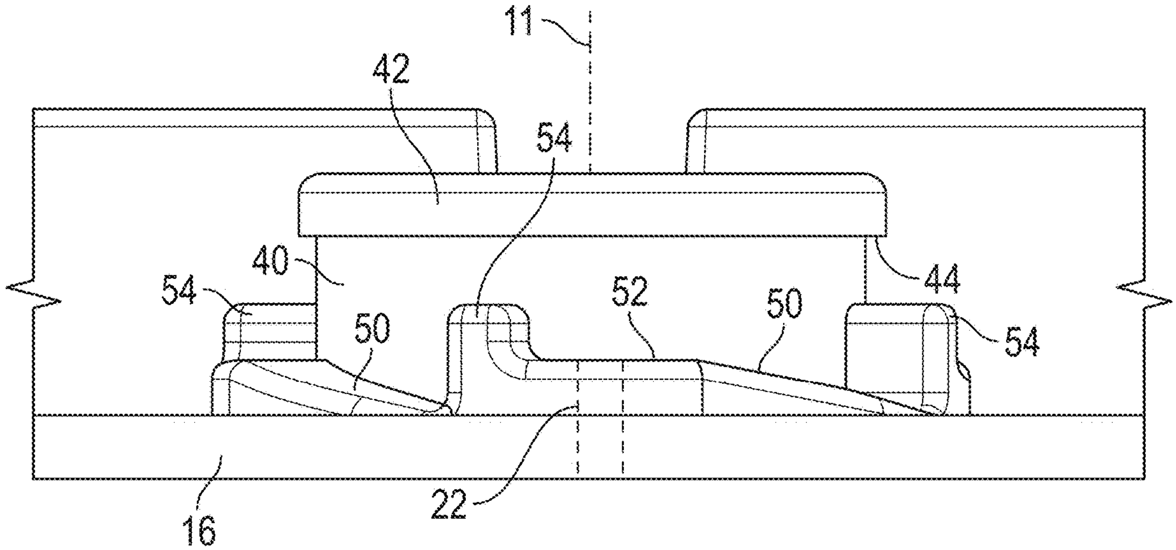

11
42
54
40
44
54
52
50
50
54
22
16

FIG. 4

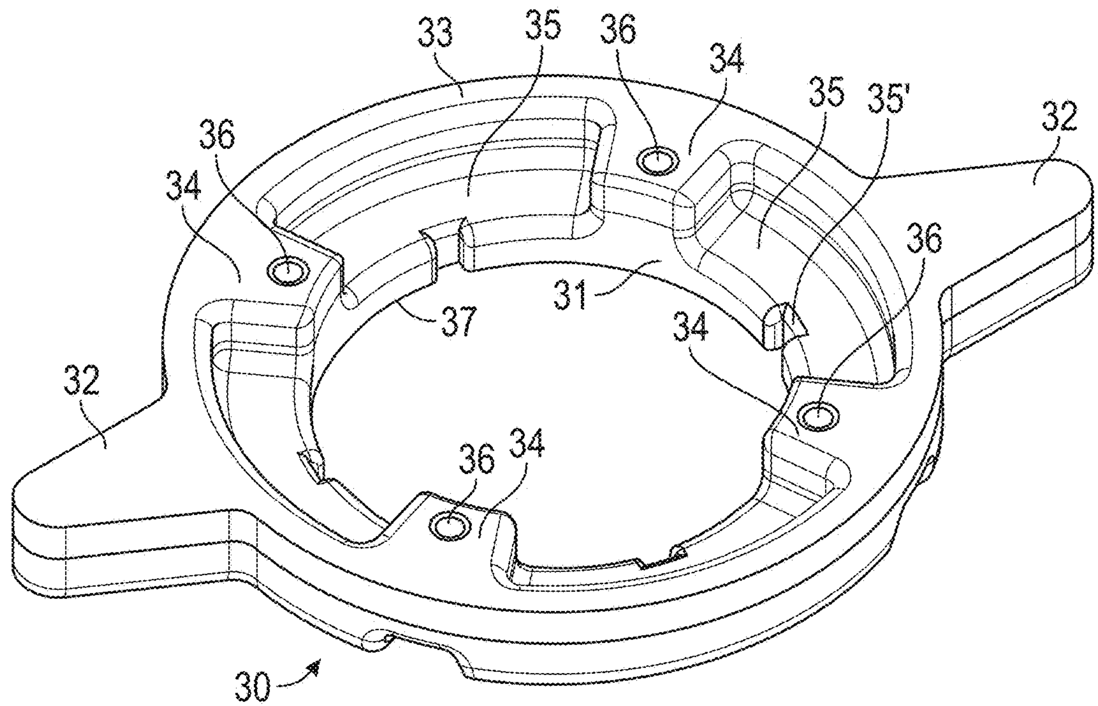

33
35
36
34
35
35'
32
36
34
36
31
37
34
32
36
34
36
34
30

FIG. 5

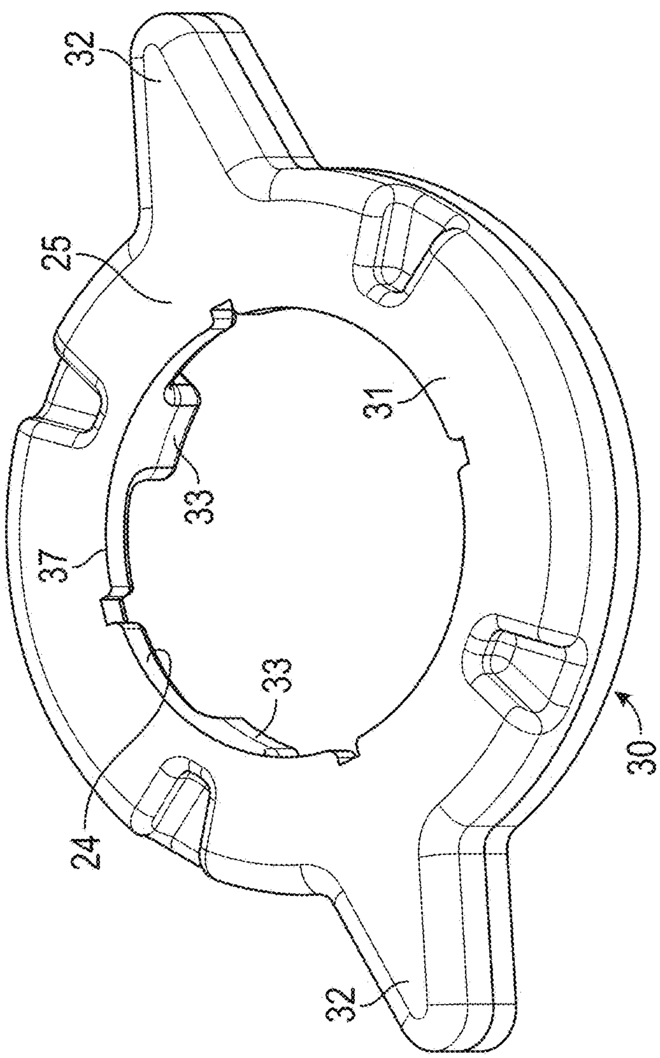


FIG. 6

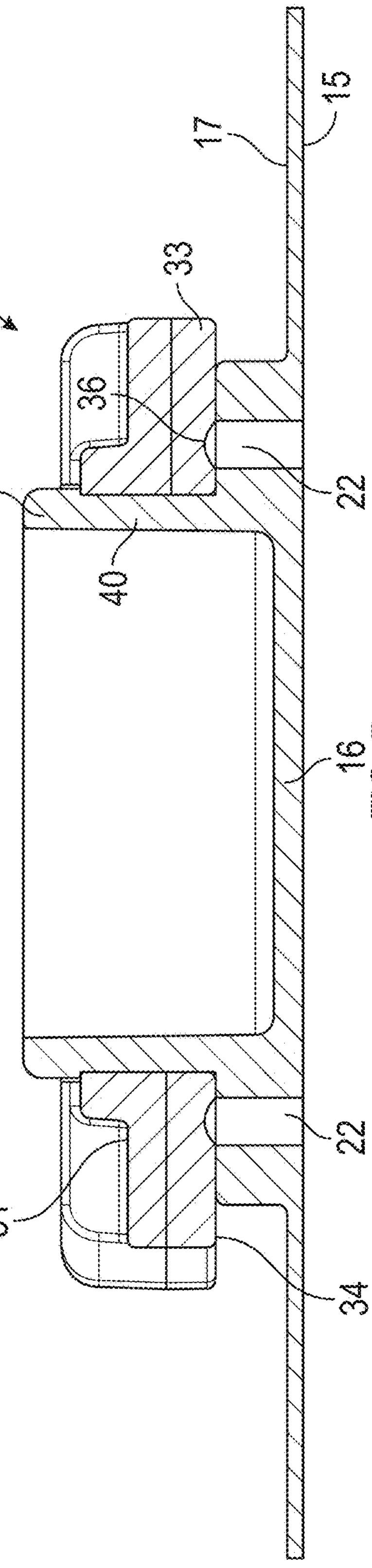


FIG. 7

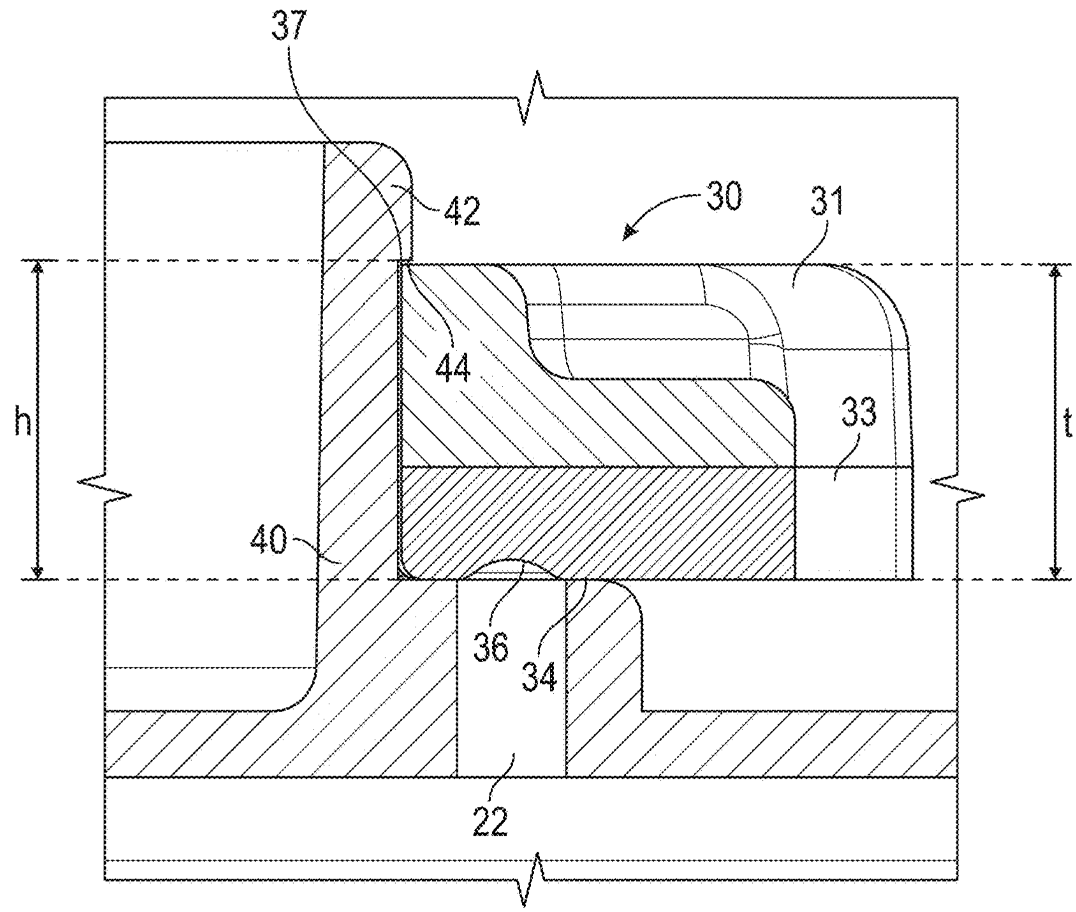


FIG. 8

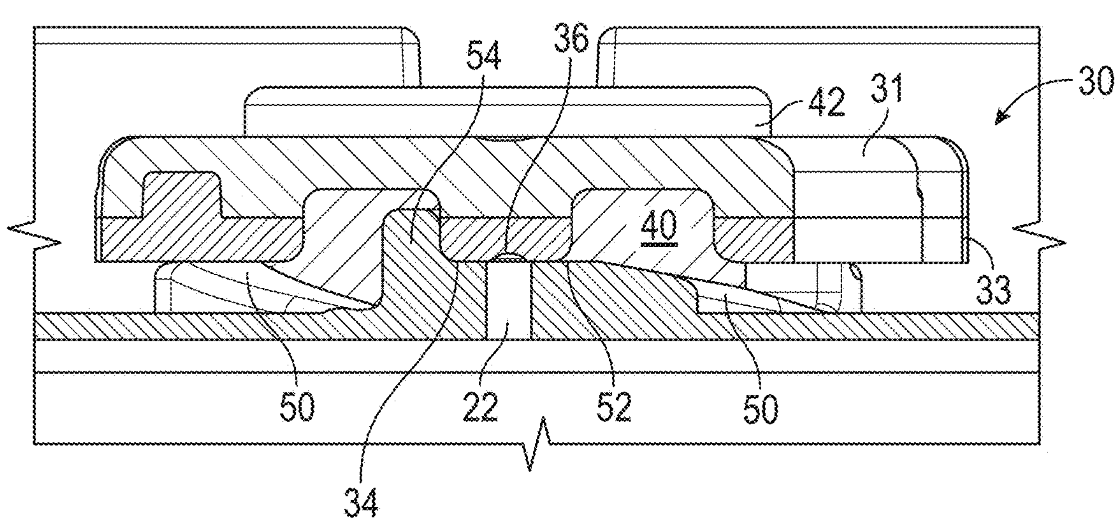


FIG. 9

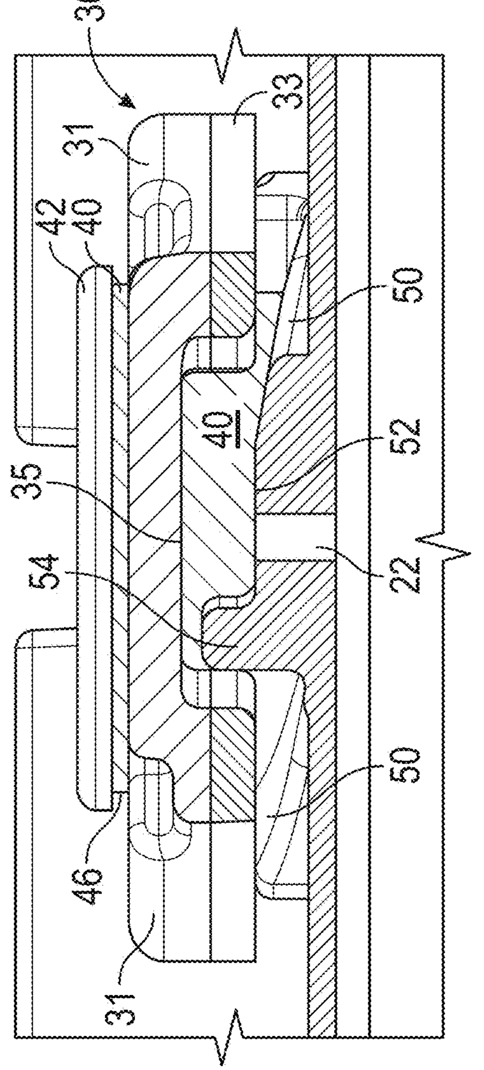

30
31
33
42
40
50
40
35
52
54
22
50
46
31

FIG. 10

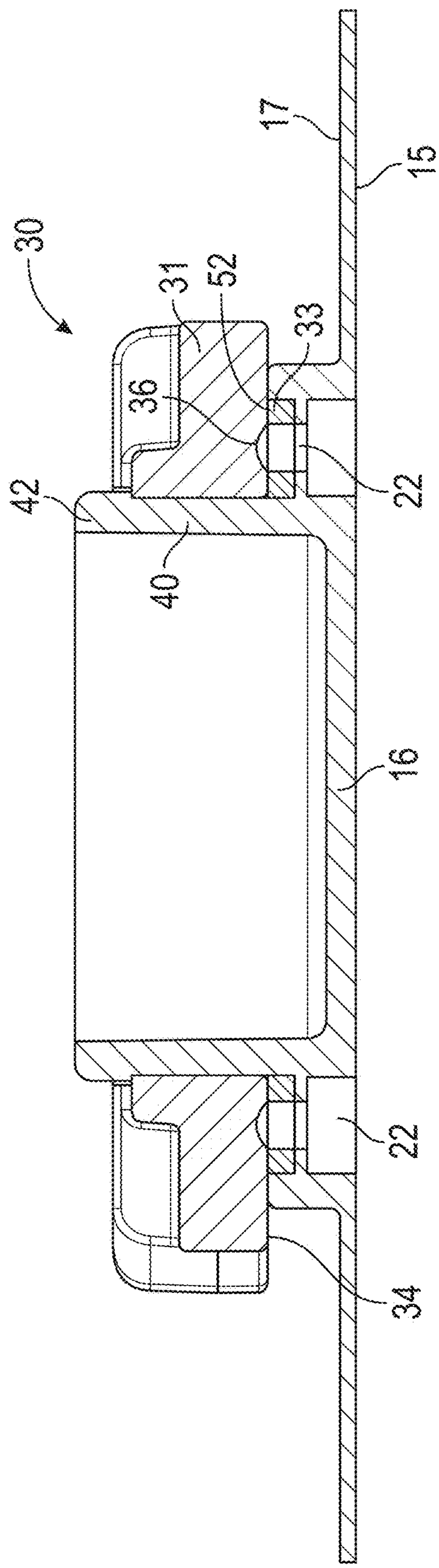

17
15
30
31
52
33
36
42
22
40
16
22
34

FIG. 11

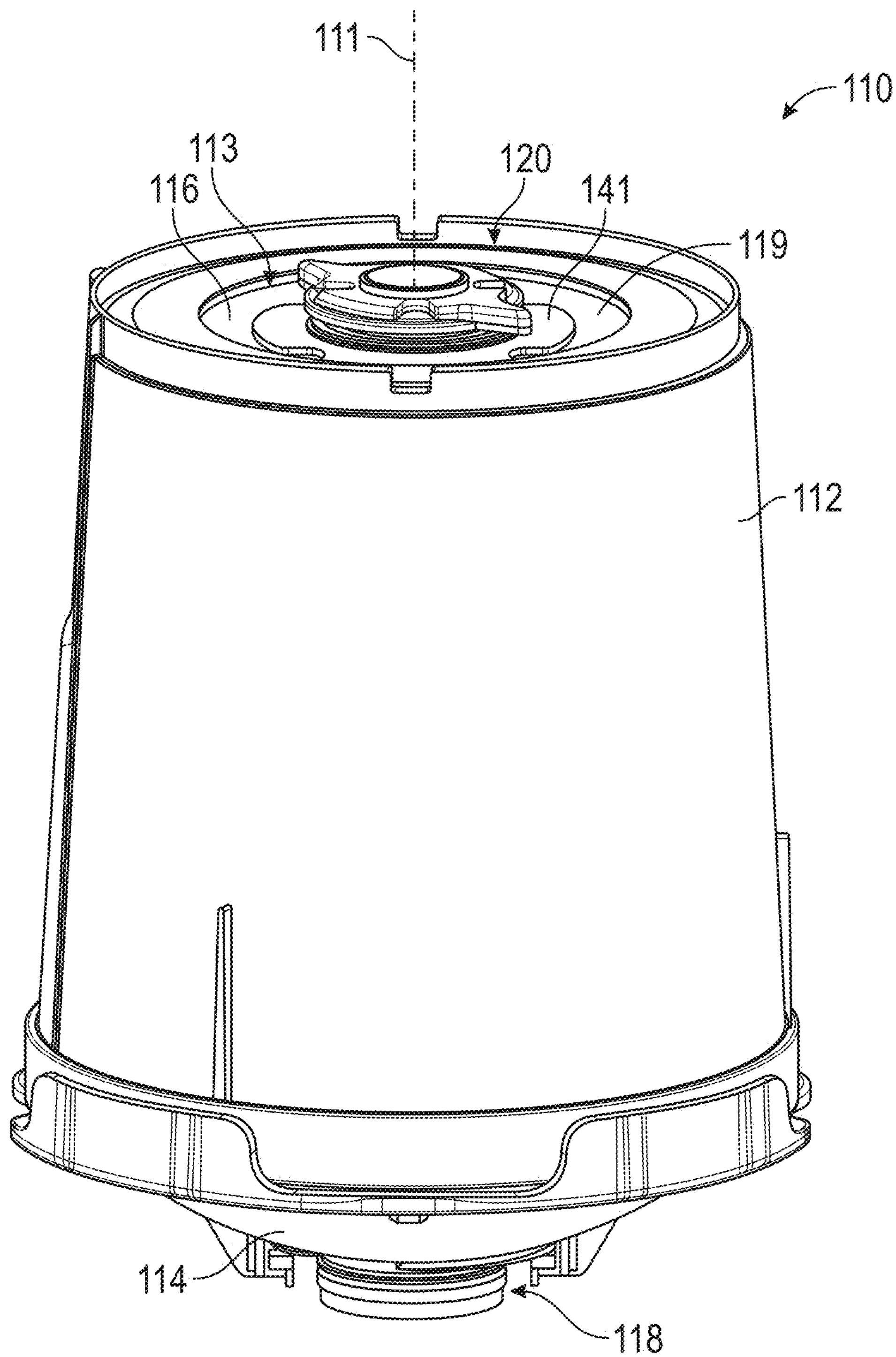


FIG. 12

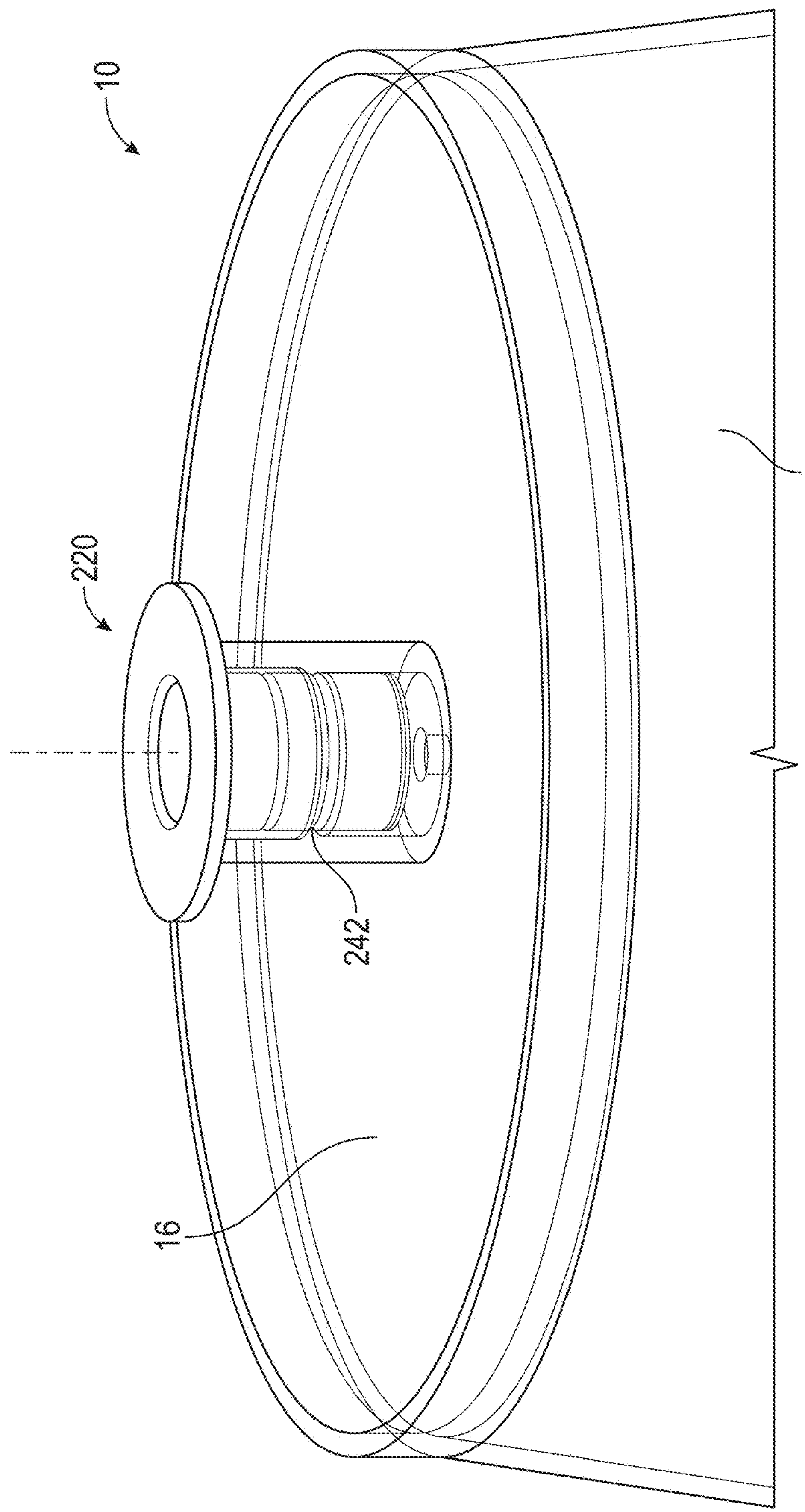


FIG. 13

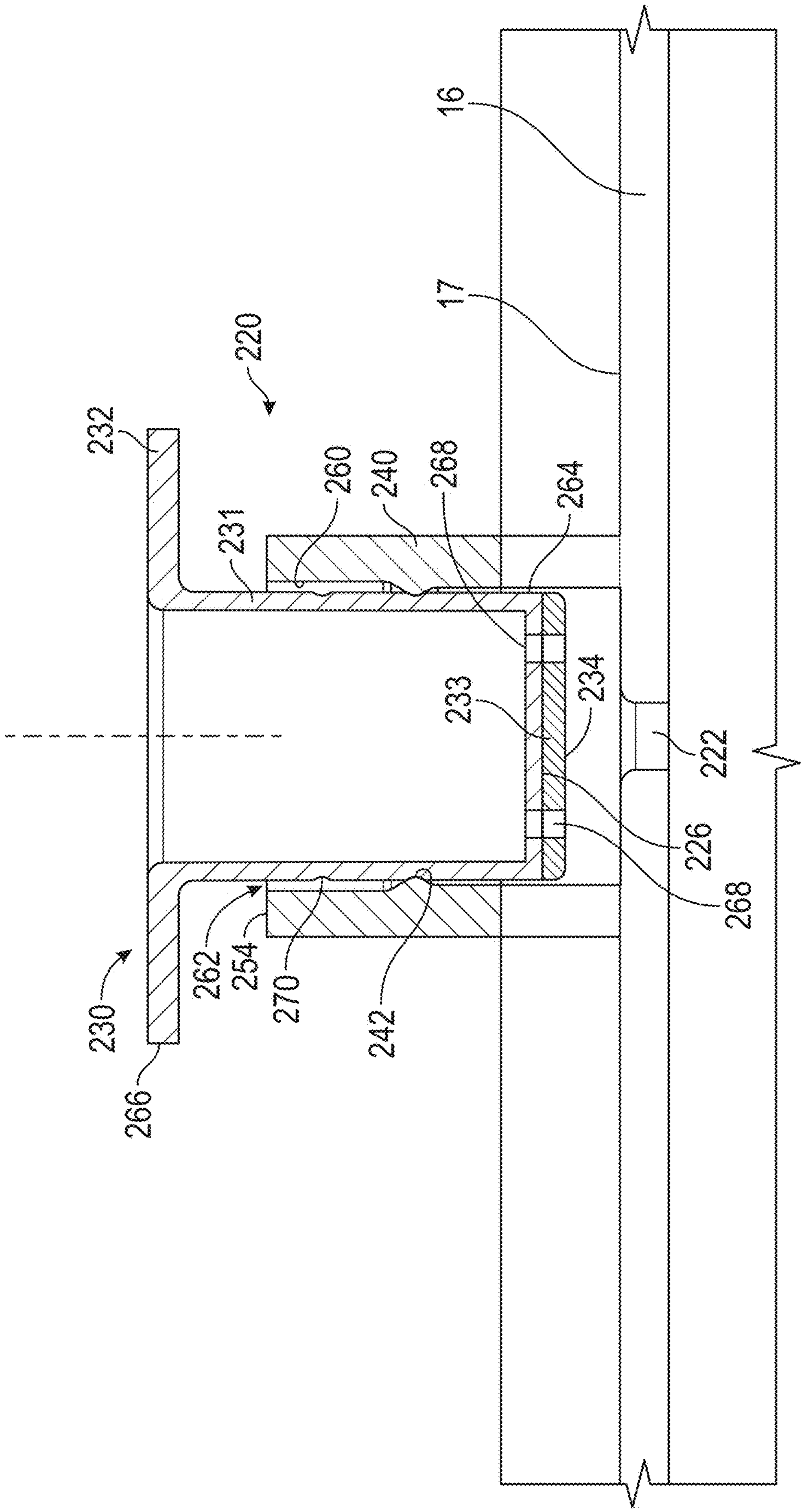

16
17
220
232
231
260
240
268
264
233
234
222
226
268
230
262
254
270
242
266

FIG. 14

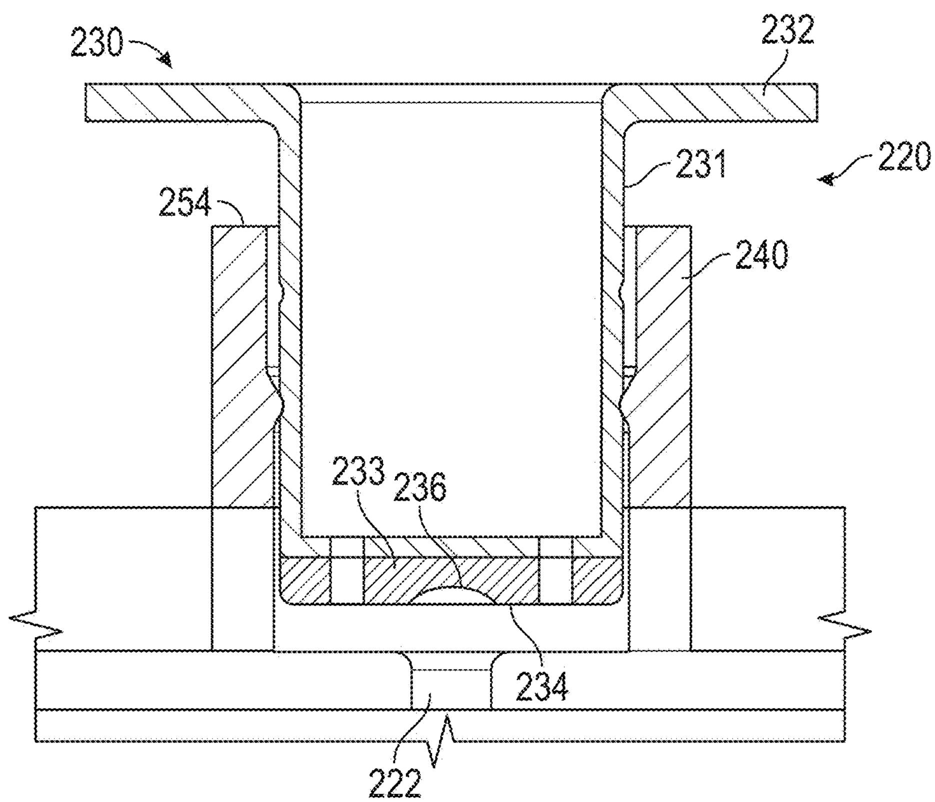

230
232
220
231
254
240
233
236
234
222

FIG. 15

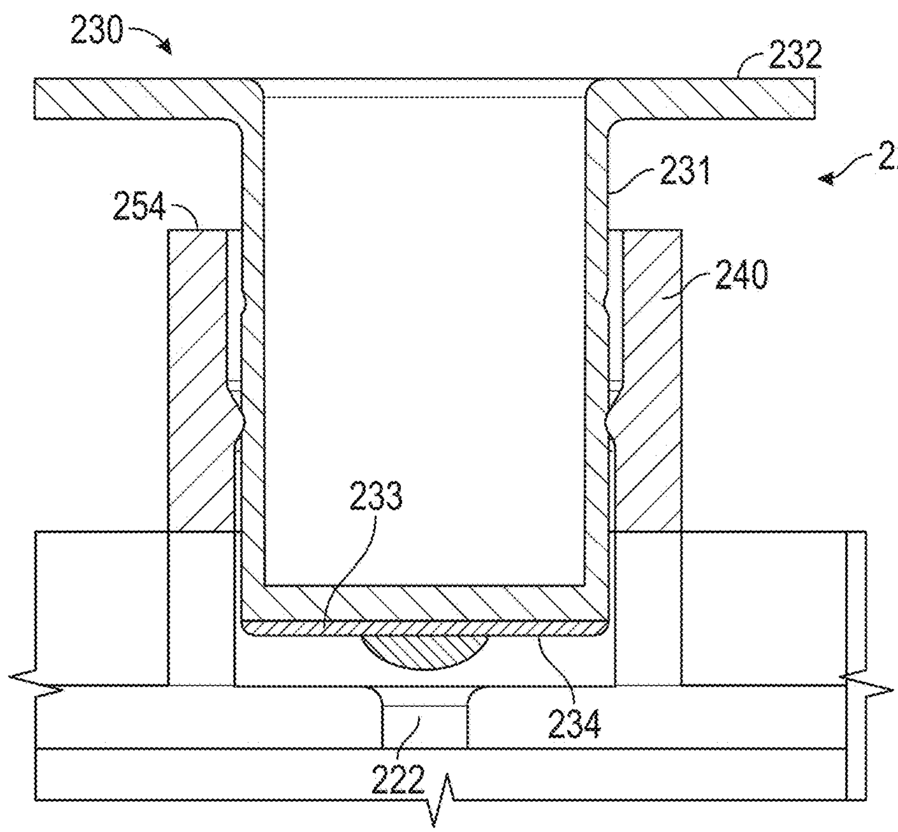

230
232
220
231
254
240
233
234
222

FIG. 16

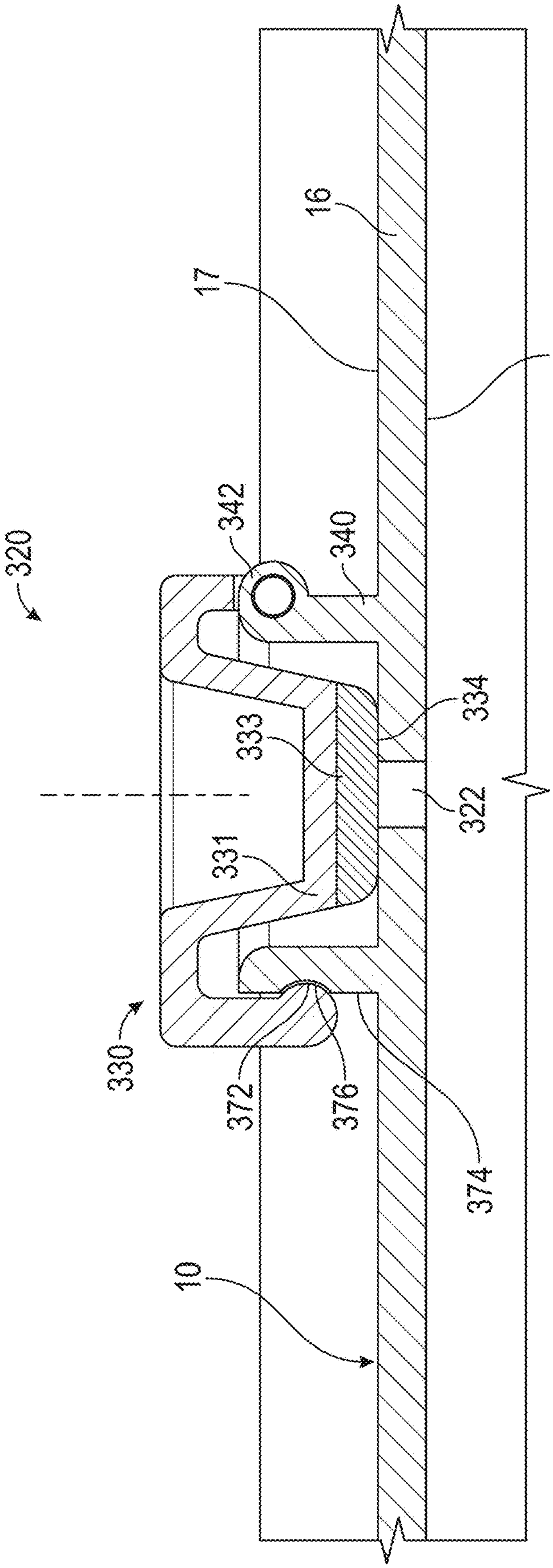


FIG. 17

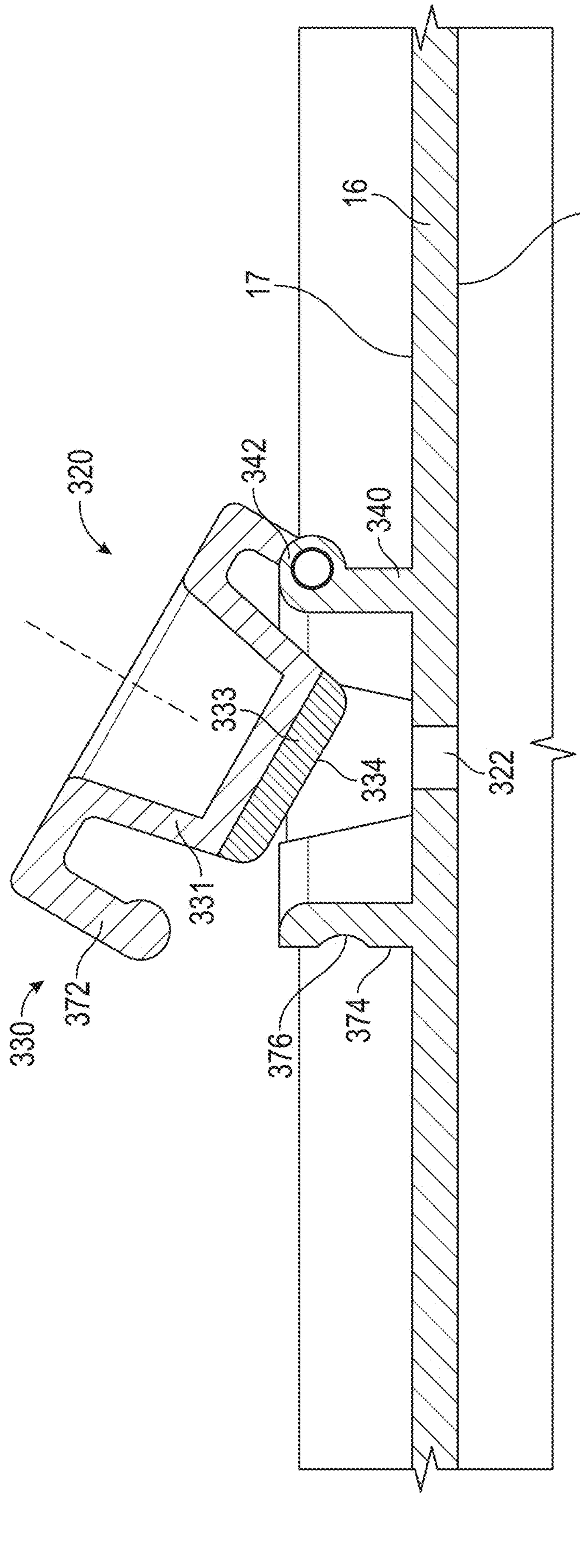


FIG. 18

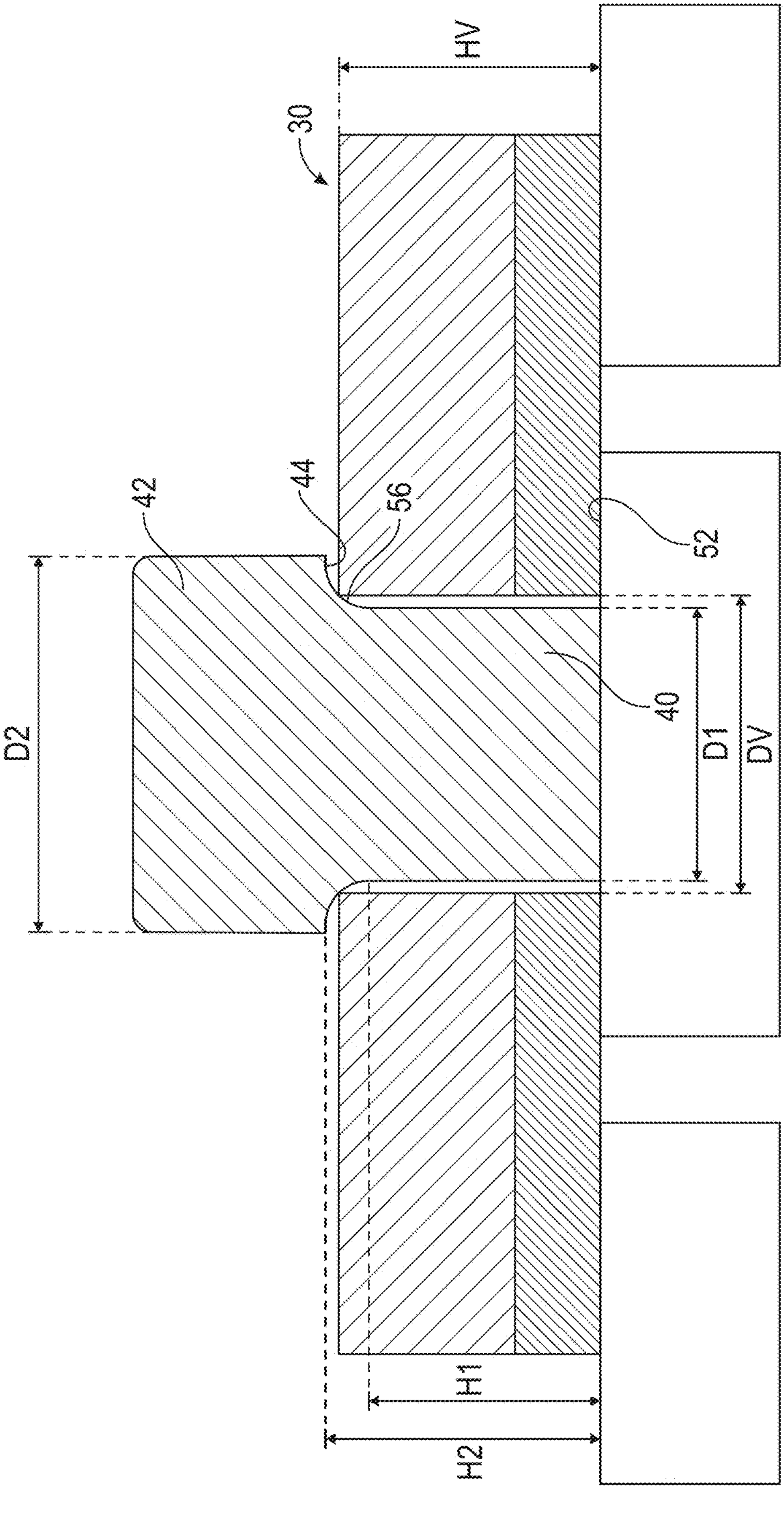


FIG. 19

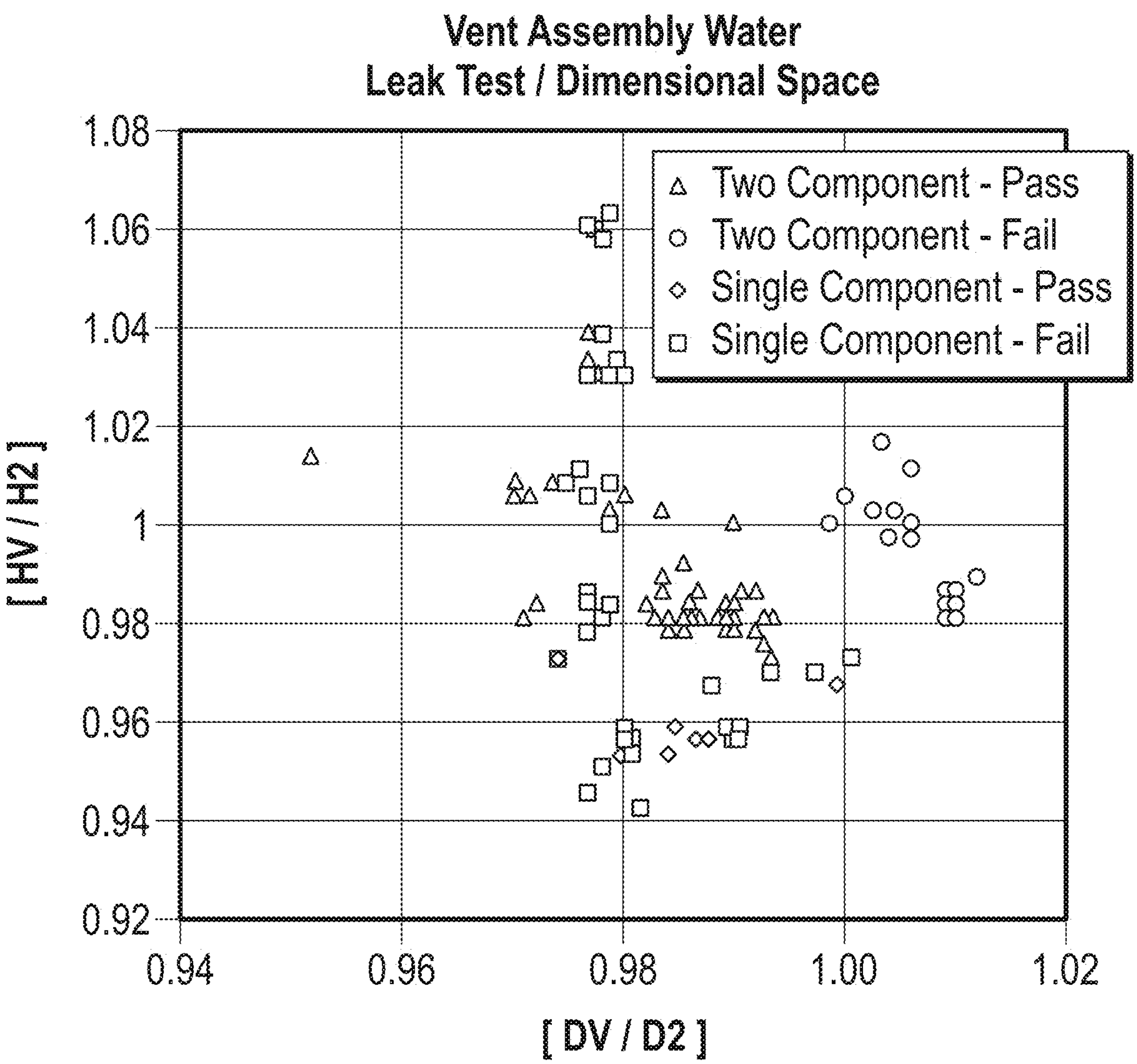

Vent Assembly Water
Leak Test / Dimensional Space
1.08
1.06
1.04
1.02
1
0.98
0.96
0.94
0.92
[HV / H2]
0.94
0.96
0.98
1.00
1.02
[DV / D2]
Two Component - Pass
Two Component - Fail
Single Component - Pass
Single Component - Fail

FIG. 20

VENT ASSEMBLIES

FIELD OF INVENTION

[0001] The present invention relates to vent assemblies and articles containing the vent assemblies. Vent assemblies provide a means for venting or exposing the contents of a reservoir or other closed system to the atmosphere. Vent assemblies can be used in a number of applications, including facilitating the delivery of liquid from reservoirs to fluid spray guns.

BACKGROUND

[0002] Reservoirs and other similarly constructed closed systems used in the dispensing of liquids often require venting so that air can enter the reservoir as liquid is removed therefrom. One example of reservoirs that may require venting are those used to deliver contents to liquid spray guns. Spray guns are widely used, for example, in vehicle body repair shops to spray a vehicle with liquid coating such as primer, paint and/or clearcoat. Typically, the spray gun includes a body, nozzle and trigger. The liquid coating is typically supplied to the spray gun by a reservoir attached to the spray gun.

[0003] The use of disposable reservoirs for the preparation and spraying of liquid materials in, e.g., vehicle body repair shops, has become an accepted practice that contributes to quick turnaround and high throughput. Reservoirs are used for paint mixing and dispensing applications in the automotive refinishing industry, as well as tangential markets such as marine, aerospace, and general industrial/manufacturing.

[0004] The disposable reservoirs typically include a container having an opening at one end and a lid to cover the opening. The lid includes a structure that attaches either directly or indirectly to a spray gun and through which liquid is delivered from the reservoir to the spray gun. During use, the reservoir is typically placed in an orientation such that the liquid contained therein flows to the spray gun by the force of gravity. In such reservoirs, a vent is typically used to prevent the formation of a vacuum in the reservoir as liquid is delivered to the spray gun, thus facilitating a consistent liquid flow to the spray gun. Vented reservoirs are described, for example, in U.S. Pat. No. 7,090,148 B2 (Petrie et al.); EP U.S. Pat. No. 954,381 B2 (Joseph et al.); and U.S. Publication No. 2015/0203259 (Mulvaney, et al.).

SUMMARY

[0005] A potential problem with current vented reservoirs is leakage of liquid through the vent assemblies during, for example, filling, storage and/or transport of the reservoir. The contact surfaces of vent assemblies and reservoirs are typically made of rigid materials that may not be pliable enough to provide a leakproof seal under all conditions. Moreover, vent assemblies comprise components that are often made from plastic materials. Plastic materials can absorb certain types of liquids (e.g., solvents) that over time can lead to swelling and/or distortion of the components, potentially compromising the vent assembly. Nylon-6, in particular, will absorb water on hot, humid days, increasing the chance for a leak. Therefore, there is a need for vent assemblies that work effectively in a variety of conditions and with a variety of liquids.

[0006] The vent assemblies of the present disclosure address the above-identified problems. The disclosed vent assemblies are typically made from materials that resist solvent effects and include a rigid component and conformable component that together improve the liquid seal between contact surfaces of the vent assembly, thus reducing or eliminating leakage of the reservoir at the site of the vent assembly.

[0007] In one embodiment, the present disclosure provides a vent assembly comprising: an aperture formed in a wall of a reservoir, the reservoir having an internal surface defining the volume of the reservoir and an external surface; a closure member retained on the external surface of the reservoir, the closure member comprising a first component made of a material having a Shore A Hardness value greater than 100 as measured by ASTM D2240; a second component made of a material having a Shore A Hardness up to 100 as measured by ASTM D2240, the second component positioned between the first component and the wall of the reservoir; a sealing surface on the first component or the second component, where the sealing surface closes the aperture when the closure member is in an unvented position and the sealing surface does not close the aperture when the closure member is in a vented position; a closure member retainer configured to retain the closure member on the reservoir; and a cam surface between the closure member and the wall of the reservoir, the cam surface configured to generate a compressive force on the sealing surface when the closure member is moved into the unvented position.

[0008] In another embodiment, the present disclosure provides a vent assembly comprising: an aperture formed in a wall of a reservoir, the reservoir having an internal surface defining the volume of the reservoir and an external surface; a closure member retained on the external surface of the reservoir, the closure member comprising a first component made of a material having a Shore A Hardness value greater than 100 as measured by ASTM D2240; a second component made of a material having a Shore A Hardness up to 100 as measured by ASTM D2240, the second component positioned between the first component and the wall of the reservoir; a sealing surface on the first component or the second component, where the sealing surface closes the aperture when the closure member is in an unvented position and the sealing surface does not close the aperture when the closure member is in a vented position; a closure member retainer configured to retain the closure member on the reservoir, wherein the closure member is displaced from the wall of the reservoir when moving from the unvented position to the vented position.

[0009] As used herein:

[0010] The term "comprises" and variations thereof do not have a limiting meaning where these terms appear in the description and claims. Such terms will be understood to imply the inclusion of a stated step or element or group of steps or elements but not the exclusion of any other step or element or group of steps or elements. By "consisting of" is meant including, and limited to, whatever follows the phrase "consisting of." Thus, the phrase "consisting of" indicates that the listed elements are required or mandatory, and that no other elements may be present. By "consisting essentially of" is meant including any elements listed after the phrase, and limited to other elements that do not interfere with or contribute to the activity or action specified in the disclosure for the listed elements. Thus, the phrase "consisting essentially of" indicates that the listed elements are required or mandatory, but that other elements are optional and may or may not be present depending upon whether or not they materially affect the activity or action of the listed elements.

[0011] In this application, terms such as "a," "an," and "the" are not intended to refer to only a singular entity, but include the general class of which a specific example may be used for illustration. The terms "a." "an," and "the" are used interchangeably with the phrases "at least one" and "one or more." The phrases "at least one of" and "comprises at least one of" followed by a list refers to any one of the items in the list and any combination of two or more items in the list.

[0012] The term "or" is generally employed in its usual sense including "and/or" unless the content clearly dictates otherwise.

[0013] The term "and/or" means one or all of the listed elements or a combination of any two or more of the listed elements.

[0014] Also herein, all numbers are assumed to be modified by the term "about" and in certain embodiments, by the term "exactly." As used herein in connection with a measured quantity, the term "about" refers to that variation in the measured quantity as would be expected by the skilled artisan making the measurement and exercising a level of care commensurate with the objective of the measurement and the precision of the measuring equipment used. Herein, "up to" a number (e.g., up to 50) includes the number (e.g., 50).

[0015] Also herein, the recitations of numerical ranges by endpoints include all numbers subsumed within that range as well as the endpoints (e.g., 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, 5, etc.).

[0016] Reference throughout this specification to "some embodiments" means that a particular feature, configuration, composition, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. Thus, the appearances of such phrases in various places throughout this specification are not necessarily referring to the same embodiment of the disclosure. Furthermore, the particular features, configurations, compositions, or characteristics may be combined in any suitable manner in one or more embodiments.

[0017] The term "cam surface" means a surface that will facilitate linear displacement of an object that is rotated along the surface. For example, rotating an object along a cam surface surrounding a post will lead to linear displacement of that object up or down the post, depending upon the direction of rotation.

[0018] The term "overlie" means to extend over so as to at least partially cover another layer or element. Overlying layers can be in direct or indirect contact (e.g., separated by one or more additional layers).

[0019] The above summary of the present disclosure is not intended to describe each disclosed embodiment or every implementation of the present disclosure. The description that follows more particularly exemplifies illustrative embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. **1**A is a perspective view of a reservoir containing one embodiment of a vent assembly of the present disclosure;

[0021] FIG. **1**B is an expanded perspective view of the reservoir and vent assembly in FIG. **1**A;

[0022] FIG. **2** is a plan view of the vent assembly of FIGS. **1** and **2**;

[0023] FIG. **3** is a plan view of the vent assembly of FIGS. **1** and **2** with the closure member removed to expose the cam surface and apertures of the vent assembly;

[0024] FIG. **4** is a side view of FIG. **3**;

[0025] FIG. **5** is a bottom perspective view of the closure member used in the vent assemblies of FIGS. **1** and **2**;

[0026] FIG. **6** is a top perspective view of the closure member used in the vent assemblies of FIGS. **1** and **2**;

[0027] FIG. **7** is a cross-sectional view of the vent assembly of FIGS. **1** and **2**;

[0028] FIG. **8** is an enlarge cross-sectional view of the closure member of the vent assembly in FIGS. **1** and **2** taken along **8-8** in FIG. **2** showing the interaction between the closure member sealing surface and aperture and the interaction between the closure member retainer and the post;

[0029] FIG. **9** is a cross-sectional view of the vent assembly of FIGS. **1** and **2** in the non-vented position taken along line **9-9** in FIG. **2**;

[0030] FIG. **10** is a cross-sectional view of the vent assembly of FIG. **9** after rotation of the closure member to the vented position;

[0031] FIG. **11** is a cross-sectional view of an alternative vent assembly of the present disclosure;

[0032] FIG. **12** is a perspective view of another reservoir containing a vent assembly of the present disclosure;

[0033] FIG. **13** is a perspective view of a reservoir containing a second embodiment of a vent assembly of the present disclosure;

[0034] FIG. **14** is a cross-sectional view of the vent assembly in FIG. **13**;

[0035] FIG. **15** is a cross-section view of an alternative closure member for the vent assembly in FIG. **13**;

[0036] FIG. **16** is a cross-sectional view of yet another alternative closure member for the vent assembly in FIG. **13**;

[0037] FIG. **17** is a cross-section view of another reservoir containing a third embodiment of a vent assembly of the present disclosure in an unvented position;

[0038] FIG. **18** is a cross-section view of the vent assembly in FIG. **17** in a vented position;

[0039] FIG. **19** is a schematic cross-sectional view of a vent assembly of the present disclosure; and

[0040] FIG. **20** is a plot of [HV/H2] versus [DV\D2] based upon data from Table 1 in the Examples section.

[0041] With reference to the figures, like reference numbers offset by multiples of 100 (e.g., **31**, **231**, **331**) indicate like elements. Unless otherwise indicated, all figures and drawings in this document are not to scale and are chosen for the purpose of illustrating different embodiments of the invention. In particular, the dimensions of the various components are depicted in illustrative terms only, and no relationship between the dimensions of the various components should be inferred from the drawings, unless so indicated.

DETAILED DESCRIPTION

[0042] In the following description of illustrative embodiments, reference is made to the accompanying figures of the drawing which form a part hereof, and in which are shown, by way of illustration, specific embodiments. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

[0043] The vent assemblies and reservoirs described herein may be used to prevent the formation of a vacuum in closed systems during dispensing of liquids. Venting eliminates the vacuum and provides for a more uniform, consistent delivery of liquid. The vented assemblies disclosed herein can be used in a variety of applications. One exemplary application includes a liquid spray delivery system in which liquid is dispensed from a reservoir to a liquid spray gun. The reservoirs may be attached directly to the spray gun or delivered to the spray gun through a supply line (e.g., hose, tubing, etc.) that extends from the reservoir to the spray gun. Liquid spray guns are preferably sized for use as hand-held spray guns and may be used in methods that involve the spraying of one or more selected liquids.

[0044] One illustrative embodiment of a vent assembly as described herein is depicted in connection with FIGS. **1**-**10**. Referring to FIGS. **1** and **7**, the vent assembly **20** is located in a wall of a reservoir **10** having an internal surface **15** defining the volume of the reservoir and an external surface **17**. The reservoir **10** includes a container **12** having an opening **21** defined by the container and a detachable lid **14** configured to close the opening. The reservoir **10** also includes a base **16** located on an opposite end of the container **12** from the opening **21**. The detachable lid **14** (which can be removed from the opening of the container so that, e.g., the reservoir can be filled with a liquid through the opening) closes the opening **21** in the container **12** when the lid **14** is attached to the container **12**. As further depicted in FIG. **1**, the lid **14** (or any other suitable portion of the reservoir **10**) may, in one or more embodiments, include structure **18**, such as ports, etc., that may facilitate connection of the reservoir **10** to, e.g., a spray gun for dispensing a liquid contained therein. The container **12** and lid **14** may each be constructed of inexpensive polymeric materials such as, e.g., polypropylene, low density polyethylene (LDPE) and high density polyethylene (HDPE), although each may be constructed of any material that is suitable for containing the liquid to be housed in the reservoir **10**. The container **12** and lid **14** may or may not be constructed of the same materials.

[0045] Although the depicted embodiment of container **12** is generally cylindrical such that it includes a cylindrical wall and a base **16** (which is also a wall as the term "wall" is used herein), other reservoirs with which the vent assemblies described herein may be used may, for example, not include a base, may have only one wall, may have two, three or more walls, etc. Essentially, the reservoirs with which the vent assemblies described herein may be used can take any suitable shape that includes at least one wall that defines a volume in which liquid can be contained and in which a vent assembly as described herein can be located.

[0046] In the illustrative embodiment depicted in FIG. **1**, the vent assembly **20** is located in the base **16** of the reservoir **10**. However, the vent assemblies described herein could be located in any wall of the reservoir **10** with the base **16** being only one example of a wall in which the vent assembly **20** could be located. For example, in one or more embodiments, the vent assembly **20** could be located in any wall forming a part of the container **12** or the lid **14**. The vent assembly **20** is typically positioned above the liquid in the reservoir **10** (relative to the force of gravity) when the reservoir **10** is being used to dispense the liquid contained therein. Furthermore, although the reservoir **10** includes only one vent assembly **20**, in one or more embodiments, the reservoir **10** could include two or more vent assemblies and those vent assemblies could be located in the same wall or in different walls of the reservoir **10**.

[0047] As described herein, the vent assembly **20** is movable between a vented position and an unvented position. The vent assembly **20** is typically placed in the unvented position when the reservoir **10** is being filled with a liquid through, e.g., the opening in the container **12**. By placing the vent assembly **20** in the unvented position, leakage of the liquid used to fill the reservoir **10** through the vent assembly **20** is typically prevented when the liquid is located above the vent assembly **20**.

[0048] The reservoir **10** may be inverted during use (when, e.g., attached to a spray gun) such that the base **16** is located above the lid **14**. That change in orientation places the vent assembly **20** above the liquid in the reservoir **10**. Movement of the vent assembly **20** from the unvented position to the vented position when the vent assembly **20** is located above the liquid in the reservoir **10** allows for entry of air into the volume of the reservoir **10** without allowing the liquid to leak through the vent assembly **20**.

[0049] FIGS. **1**-**10** depicted various components and features of one illustrative embodiment of a vent assembly **20** that may be used in connection with the reservoirs **10** as described herein. Referring to FIGS. **1** and **2**, the vent assembly **20** includes a closure member **30** mounted on a post **40** that, in the illustrative embodiment, extends from the base **16** of the reservoir **10** (although, as discussed herein, the vent assembly could be located in any wall of the reservoir). The closure member **30** is configured for rotation on the post **40** about an axis **11** that extends through the post **40** and the base **16** of the reservoir **10**. The post **40** can be solid or hollow.

[0050] The closure member **30** may include two or more extensions **32** to assist the user in rotating the closure member **30** by hand. It should, however, be understood that the closure member **30** may be designed for rotation using a tool designed for that function. Further, extensions **32** represent only one example of many different structures that could be used to facilitate manual rotation of the closure member **30** about the post **40**.

[0051] FIGS. **3** and **4** depict the vent assembly **20** with the closure member **30** removed. Referring to FIG. **3**, the post **40**, through which axis **11** extends, is surrounded by features that cooperate with the closure member **30** to provide both the vented position and the unvented position of the vent assembly **20**. Those features include cam surfaces **50** which terminate in aperture surface portions **52**. In the illustrative embodiment, each of the aperture surface portions **52** includes an aperture **22** located therein such that the aperture **22** extends through the aperture surface portion **52** of the cam surface **50**. The aperture **22** extends through the base **16** and allows air to enter the container **12** when the aperture **22** is not blocked or otherwise closed by features on the closure member **30** as will be described herein. Although the illustrative embodiment includes four apertures, it should be understood that vent assemblies **20** as used in the reservoirs **10** described herein may include as few as one aperture or any other number of apertures selected based on many different factors that relate to the venting performance required. The features depicted in FIGS. **3** and **4** further include stops **54** that are provided to limit rotation of the closure member **30** about the post **40** when the vent assembly **20** is in the unvented position.

[0052] Also depicted in FIG. **4** is a closure member retainer **42** located on the post **40** above the cam surfaces **50** and aperture surface portions **52**. The closure member retainer **42** includes a shoulder **44** that extends outwardly from the post **40** (where outwardly is radially away from the axis **11**). The shoulder **44** faces the base **16** and the cam surfaces **50** and the aperture surface portions **52**. The closure member retainer **42** preferably interacts with the closure member **30** on the post **40** to retain the closure member **30** on the post **40** when the vent assembly **20** is in the vented position. That function is, in the illustrative embodiment of FIGS. **1-10**, provided by a mechanical interference between the closure member **30** and the closure member retainer **42**. The closure member retainer **42** also preferably interacts with the closure member **30** to provide a compressive force that assists in closing or sealing of the apertures **22** in the aperture surface portions **52** as is described herein.

[0053] The cam surfaces **50** preferably rise gradually from the base **16** to the aperture surface portions **52** so that relatively smooth operation of the closure member **30** is achieved as closure member **30** is rotated from the vented position to the unvented position and vice versa. Rotation of the sealing surfaces of the closure member **30** past aperture surface portions **52** is, in the illustrative embodiment, prevented by stops **54** positioned adjacent the aperture surface portions **52**. The stops **54** are only one embodiment of many different structures that could be used to limit rotation of the closure member **30** about the post **40**. For example, in one or more embodiments, stops may be located on the base **16** for interaction with extensions **32** (see, e.g., extensions **32** in FIG. **2**) to limit rotation of the closure member **30** about the axis **11** extending through post **40**.

[0054] Although not necessarily required, it may be advantageous to provide cam surfaces **50** having aperture surface portions **52** that are relatively flat and that are located in a plane that is perpendicular to axis **11** about which closure member **30** rotates. That orientation may provide improved closure of the apertures **22** by the closure member **30**, as discussed herein.

[0055] In one or more embodiments, it may be preferred that all of the features depicted in FIGS. **3** and **4** be molded of the same material, e.g., a thermoplastic such as polypropylene. Such a construction is not, however, required and one or more of the different features may be constructed of different materials that are joined or connected together by any suitable technique or combination of techniques. In one or more embodiments, the additional material used to construct the cam surfaces **50**, aperture surface portions **52**, and stops **54** may, along with post **40**, provide additional rigidity to the base **16** that facilitates proper operation and closure of the apertures **22**.

[0056] FIG. **5** is a view of the underside or bottom surface of the closure member **30**, i.e., the surface of the closure member **30** that faces the base **16** of the reservoir assembly **10**. The extensions **32** are depicted in FIG. **5** along with sealing surfaces **34** and relief surfaces **35** that are positioned between the sealing surfaces **34**. Rotation of the closure member **30** about a post **40** as described herein moves the sealing surfaces **34** and relief surfaces **35** such that, when the closure member **30** is in the vented position, the relief surfaces **35** are located over the apertures **22**. Because the relief surfaces **35** do not close the apertures **22**, air is allowed to pass through the apertures **22** into the container **12** of the reservoir assembly **10**. As depicted, the relief surfaces **35** may optionally include one or more supplemental notches **35'** that may further enhance the movement of air through the vent assembly. When the closure member **30** is in the unvented position, the sealing surfaces **34** are positioned over the apertures **22** such that air is prevented or at least severely restricted from passing through the apertures **22**. Another characterization of the effect of locating sealing surfaces **34** over apertures **22** is that sealing surfaces **34** preferably form a liquid-tight seal over the apertures **22** such that liquid within the container **22** does not pass through the apertures **22**.

[0057] Although the closure members **30** used in vent assemblies **20** as described herein will typically include a number of sealing surfaces **34** that match the number of apertures **22**, such a relationship is not necessarily required. For example, in one or more embodiments, the closure member **30** may include a single sealing surface that extends completely or nearly completely about the circumference of the closure member **30** if, when the closure member **30** is in the vented position, the sealing surface **34** is not in a position to close the apertures **22**. For example, the closure member **30** may be only loosely retained on the post such that air can pass between the sealing surface **34** into the apertures **22** even when the closure member **30** does not include relief surfaces **35**.

[0058] The sealing surface **34** may be configured so that it covers but does not protrude into the aperture **22** when the closure member **30** is in the unvented position. For example, in the embodiment illustrated in FIG. **5**, the sealing surface **34** comprises a recess **36**, at least a portion of which will lie directly over the aperture **22** when the closure member **30** is in the unvented position. Alternatively, the sealing surface **34** may be configured to at least partially protrude into the aperture when the closure member is in the unvented position. In some embodiments, the sealing surface can be made of a conformable material that protrudes into the aperture under the forces applied to the closure member when in the unvented position. In other embodiments, the sealing surface can include projections sized to at least partially enter the aperture when the closure member is in the unvented position.

[0059] In the embodiment illustrated in FIGS. **1-10**, the closure member **30** is retained on the external surface of the reservoir and comprises a first component **31** and second component **33**. The first component **31** is relatively rigid or stiff compared to the second component **33**, whereas the second component is relatively conformable compared to the first component. The first component provides the structural integrity needed to manually adjust the closure member from a vented to unvented position and transfers the forces necessary to seal the aperture when the closure member is in the unvented position. In contrast, the second component is typically adjacent to the wall of the reservoir when the closure member is in the unvented position and is made of a material that conforms to imperfections or deviations in the contact surface of the vent assembly (e.g., tolerance variations due to molding processes and/or swelling due to environmental factors) so that the aperture is properly sealed when the closure member is in the unvented position. In at least one embodiment, the second component is conformable. The two components are typically made of materials that resist swelling or distortion from humidity or exposure to the liquids in the reservoir.

[0060] In at least one embodiment, "relatively rigid" can mean that the first component is stiff. The term "rigid" or "stiff" can be established by a specific range of hardness or modulus of elasticity values as described herein.

[0061] The first component is made of a material having a Shore A Hardness value greater than 100, as measured by ASTM 2240. In some embodiments, the first component is made of a thermoplastic material. Exemplary materials include a polypropylene, high density polyethylene (HDPE), polyamides, polyesters (e.g., polybutylene terephthalate and polyethylene terephthalate), a glass-filled polyamide, an acetal and combinations thereof. The first component typically has a modulus of elasticity greater than that of the second component. In at least one embodiment, the first component has a modulus of elasticity that is at least 0.6 GPa, at least 0.8 GPa, at least 1 GPa, or at least 1.2 GPa.

[0062] In at least one embodiment, "relatively conformable" can mean that the second component is more elastic than the first material. In another embodiment, the term "conformable" can indicate that the second component falls within a specific range of hardness or modulus of elasticity values.

[0063] In at least one embodiment, the second component **33** is made of a material having a Shore A Hardness less than 100 as measure by ASTM D2240. In some embodiments, the Shore A Hardness of the material making up the second component may be less than 90, less than 80, less than 70, less than 60 or even less than 50. In some embodiments, the Shore A Hardness of the material making up the second component may be greater than 20, greater than 30 or even greater 40. In some embodiments, the Shore A Hardness ranges from 20-90. In some embodiments, the second component may have a modulus of elasticity of less than 0.5 GPa (500 MPa), less than 0.1 GPa (100 MPa), less than 0.05 GPa (50 MPa), even less than 0.01 GPa (10 MPa), or even less than 0.006 GPa (6 MPa). In some embodiments, the second component may have a modulus of elasticity of greater than 0.001 GPa. In some embodiments, the modulus of elasticity ranges from 0.001 to 0.5 GPa. The second component is typically made from a thermoplastic elastomer, a thermoplastic vulcanizate, a rubber, and combinations thereof. In at least one embodiment, the modulus of elasticity for both the first component and the second component can be measured according to the Nano Indentation Test Method as described herein.

[0064] Although the second component **33**, as illustrated in FIG. **1**, is relatively co-extensive with the first component **31**, it should be understood that the first and second components **31**, **33** can have the same or different dimensions, e.g., shape, thickness, etc. In some embodiments, the first component **31** has a first major surface **26** and a second major surface **28** and the second component **33** overlies the second major surface **28** of the first component **31**. The second component can overlie the entire second major surface of the first component or, as illustrated in FIG. **1**B, overlie only a portion of the second major surface of the first component, as long as the second component either covers or seals off the aperture when the closure member is in an unvented position.

[0065] In the embodiment illustrated in FIGS. **1-10**, the closure member **30** comprises both the first component **31** and the second component **33**, and the sealing surface **34** is located on the second component **33**. In an alternative embodiment illustrated in FIG. **11**, the second component **33** forms at least part of the cam surface, more particularly at least part of the aperture surface portion **52** of the cam surface, and the sealing surface **34** is located on the first component of the closure member **30**.

[0066] The second component can be molded separately and attached to either the first component or cam surface by any suitable technique or combination of techniques, such as adhesives, mechanical fasteners, dip coating, etc. Preferably, the two component closure member is made by an overmolding process, such as insert molding or two-shot molding.

[0067] FIGS. **6-8** depict other features that may be included in the closure members **30** of the vent assemblies **20** as described herein to provide improved sealing or closure of the apertures **22**. In particular, the closure member **30** may include an inner surface **24** that faces the post **40** when the closure member **30** is mounted on the post **40**. The closure member **30** may also include a top surface **25** that faces away from the base **16** of the reservoir **10**. The closure member **30** may include an edge **37** where the inner surface **24** and the top surface **25** meet. The edge **37** in FIGS. **6-8** is portrayed as squared but may be arcuate (e.g., rounded) or any configuration in-between. The edge **37** mechanically engages with the shoulder **44** of the closure member retainer **42** as the closure member **30** is moved to an unvented position.

[0068] As illustrated in FIGS. **7** and **8**, the wall of the post **40** is relatively perpendicular to the wall of the reservoir. The shoulder **44** of the closure member retainer **42** faces the aperture surface portion **52** (and, therefore, the base **16**) and the shoulder **44** interacts with the edge **37**, preferably in a manner that provides for compression of the sealing surface **34** toward the aperture surface portion **52** around the opening of aperture **22**. The height h of the closure member retainer **42** above the aperture surface portion **52** may preferably be smaller than the thickness/of the closure member **30** located between the shoulder **44** of the closure member retainer **42** and the aperture surface portion **52** (although it should be understood that the opposite relationship is depicted in FIG. **8** only for clarity, i.e., in FIG. **8** h>t for clarity). The difference preferably provides for a compressive force that forces the sealing surface **34** towards the aperture surface portion **52** when the closure member is rotated into the unvented position. That compressive force may preferably provide two functions including a force that improves closure of the aperture **22** and that assists in retaining the closure member **30** in the unvented position due to friction generated between the sealing surface **34** and the aperture surface portion **52**. In one or more embodiments, the compressive force may be generated when the shoulder **44** of the closure member retainer **42** contacts the edge **37** of the inner surface **36** of the closure member **30** when the closure member **30** is in the unvented position.

[0069] In a preferable embodiment, as illustrated in FIG. **19**, the outer diameter of the post increases near the closure member retainer **42**. This increase in diameter creates an arcuate surface **56** between the wall of the post **40** and the closure member retainer **42**. As the closure member **30** is rotated along the cam surface **52** into the unvented position, the closure member **30** moves up the post **40** and engages with the arcuate surface **56**. As the closure member **30** continues upward, the closure member **30** meets with increasing resistance and sufficient downward force on the sealing surface **34** to create a liquid tight seal.

[0070] By increasing the diameter of the post 40 near the closure member retainer 42, as illustrated in FIG. 19, one can allow for variations (e.g., manufacturing tolerances) in the dimensions of the closure member 30 without effecting the sealing properties of the vent assembly. However, at some point, the diameter of the inner surface 24 of the closure member 30 becomes too small to fit around the post or too big to engage the closure member retainer 42 and/or the thickness of the closure member becomes to small or too large to effectively seal or vent the aperture of the vent assembly. In a preferred embodiment, the vent assembly is configured so that:

$$0.9\ D1 \leq DV < D2 \text{ and } H1 < HV < 1.2\ H2$$

[0071] where

[0072] D1 is the outer diameter of the post 40 at its narrowest dimension;

[0073] DV is the diameter of the inner surface 24 of the closure member 30, which encircles the post 40;

[0074] D2 is the outer diameter of the closure member retainer 42;

[0075] HV is the thickness of the closure member 30;

[0076] H1 is the height of the post 40, as measured from the aperture surface portion 52 to the point at which the post diameter begins to increase;

[0077] H2 is the height of the post 40, as measured from the aperture surface portion 52 to the shoulder 44.

[0078] Referring now to FIGS. 9-10, operation of the closure member 30 is depicted with the closure member 30 being located in the unvented position in FIG. 9 and in the vented position in FIG. 10. In the unvented position depicted in FIG. 9, the sealing surface 34 is positioned over the aperture surface portion 52 such that the aperture 22 is blocked by sealing surface 34. In the vented position depicted in FIG. 10, a relief surface 35 is located over the aperture 22 such that air can pass through aperture 22 in into the container as described herein.

[0079] In both FIGS. 9 and 10, interaction between the closure member retainer 42 on post 40 is seen. In FIG. 9, the closure member 30 is depicted as abutting the closure member retainer 42. In FIG. 10, the closure member 30 is in the vented position such that a gap 46 is observed between the closure member retainer 42 on post 40 and the closure member 30. As discussed herein however, closure member retainer 42 is preferably sized and shaped such that, even in the vented position, the closure member 30 is retained on the post 40.

[0080] FIG. 12 is a perspective view of an alternative reservoir 110 of the present application. In this embodiment, the vent assembly 120 is located on a collapsible liner 119 that lines the inside of a self-supporting container 112. The liner 119 has an opening at one end and a base 116 (or wall) at the opposite end. The vent assembly 120 is in the base 116 of the liner 119. The container 112 has a first opening (not shown) and a second opening 113 opposite the first opening. The liner 119 is inserted into the first opening of the container 112 such that the vent assembly 120 projects through the second opening 113 of the container 112. A lid 114 is attached to the container 112 closing off the first opening to the liner 119. The lid 114, as in the above embodiments, comprises a structure 118 that directly or indirectly connects to a liquid spray gun. The vent assembly 120 is constructed similarly to the one embodied in FIGS. 1-10, except that the vent assembly 120 is secured to the collapsible liner 119 through a vent base 141 that is more rigid than the liner 119. Similar fluid delivery assemblies are described in, for example, International Patent Application No. WO 2019/012500.

[0081] The container, lid and vent assembly (including vent base) may be constructed of the same materials described above for the embodiments illustrated in FIGS. 1-10. The collapsible liner may be thermo/vacuum formed from a polymeric material. The liner may be made from, for example, polyethylene (e.g., low density polyethylene or high density polyethylene) or polypropylene. The liner may also be formed from a blend of polymeric materials, for example a blend of polyethylene and polypropylene, or a blend of low density polyethylene and linear low density polyethylene. The liner may optionally be thermo/vacuum formed from a thermoplastic material.

[0082] FIGS. 13 and 14 illustrate the reservoir 10 with a second embodiment of a vent assembly 220. The reservoir 10 was previously described with respect to the illustrate embodiment in FIGS. 1-10. Therefore, reference can be made thereto for a complete description of the various features of the reservoir. For simplicity, only a portion of the reservoir 10 is shown.

[0083] The vent assembly 220 comprises at least one aperture 222 formed in a wall of the reservoir 10. As with the embodiment illustrated in FIGS. 1-10, the vent assembly 220 in FIGS. 13 and 14 is located in the base 16 of the reservoir 10 but could be located in any wall of the reservoir with the base 16 being only one example of a wall in which the vent assembly 220 could be located. Furthermore, the reservoir 10 may include one or more vent assemblies and, in the instance of multiple vent assemblies, the vent assemblies could be located in the same wall or in different walls of the reservoir.

[0084] The vent assembly 220 includes a post 240 extending from the external surface 17 of the reservoir 10. The post 240 has an inner surface 260 that surrounds one or more apertures 222 that extend through the wall of the reservoir 10. The end of the post 240 opposite the wall of the reservoir 10 defines an opening 262. The closure member 230 is inserted into the opening 262 of the post 240. A closure member retainer 242 is located on the inner surface 260 of the post and creates a friction fit with the closure member 230. In some embodiments, as illustrated in FIG. 13, the closure member retainer 242 encircles the inner surface 260 of the post. In alternative embodiments, the closure member retainer may only partially encircle the inner surface. In some embodiments, the closure member retainer comprises one or more protrusions on the inner surface of the post, more preferably two or more protrusions that center the closure member in the post.

[0085] The closure member 230 comprises a first component 231 in the shape of a plug. In some embodiments, the first component is hollow. In other embodiments, the first component is solid throughout. The firsts component 231 is partially inserted into the post 240 so that a first end 264 resides in the post 240 and a second opposite end 266 extends past the opening 262 of the post 240. The second end 266 further comprises a flange that extends radially outward and perpendicular to the post 240. The flange can serve as a closure member extension 232 that allows the user to move the closure member 230 between vented and unvented positions. Although in FIG. 13 the closure member extension 232 completely surrounds the first component

231, in other embodiments the closure member extension does not completely surround the first component **231** (e.g., opposing tabs). Although not shown, the closure member **230** can include multiple flanges to further aid in sealing the post **240**.

[0086] The vent assembly **220** further comprises a second component **233** that overlies a first major surface **226** of the first component **231**. In at least one embodiment, the closure member **230** can be formed from only a conformable material such as the second component **233** and not a rigid material such as the first component **231**.

[0087] As with the embodiment illustrated in FIGS. **1-10**, the second component **233** can overlie all or only a portion of the first major surface **226** of the first component **231**, provided that the second component **233** either covers the aperture **222** or seals off the aperture **222** when the closure member is in an unvented position. In FIG. **14**, the second component **233** overlies the first major surface **226** at the first end **264** of the first component **231**. The first and second components were each described with respect to the illustrate embodiment in FIGS. **1-10**. Therefore, reference can be made thereto for a complete description of the various features of the components.

[0088] In one embodiment, as illustrated in FIG. **14**, the closure member **230** comprises at least two apertures **268** in the closure member **230**. An aperture **268** can be formed within the first component **231** and the second component **233** to form a passageway therein. The passageway can form an air path from the interior of the reservoir **10**, through aperture **222** and at least one of apertures **268** to the atmosphere when in the vented position. The apertures **268** allow for venting to and from the reservoir **10** when the closure member **230** is in the vented position. In at least one embodiment, the aperture **222** can define an aperture axis (not shown) leading to the volume of the reservoir **10**. The apertures **268** can each have their own aperture axis parallel to a sidewall of the closure member **230**. In the unvented position, the aperture **222** forms an air-tight seal with the sealing surface **234**. For example, no part of the aperture **222** is aligned with the aperture **268**. For example, the aperture axis of aperture **222** does not line up with the aperture axis of any of the apertures **268**. Alternatively, or in addition to the apertures **268**, venting can occur between the closure member **230** and the inner surface **260** of the post **240**.

[0089] In practice the vent assembly **220** is closed by pushing the closure member **230** into the post **240** until the first end **264** contacts the wall of the reservoir **10**. The end of the post **240** defining the opening **262** can serve as a stop **254** to indicate when the closure member **230** is properly seated in the unvented position. In some embodiments, a notch **270** in the closure member **230** mechanically engages with the closure member retainer **242** to ensure the closure member **230** does not prematurely disengage from the unvented position. The vent assembly **220** is opened or "vented" by pulling the closure member **230** away from the wall of the reservoir so that venting can occur through the apertures **268** and/or space between the inner surface **260** of the post **240** and closure member **230**. The closure member retainer **242** provides a friction fit that will allow the closure member **230** to remain in the post **240** when in both the vented and unvented positions.

[0090] As with the embodiment in FIGS. **1-10**, the sealing surface **234** may be configure so that it covers but does not protrude into the aperture **222** when the closure member **230** is in the unvented position. For example, in the embodiment illustrated in FIG. **15**, the sealing surface **234** comprises a recess **236**, at least a portion of which will lie directly over the aperture **222** when the closure member **230** is in the unvented position. Alternatively, as illustrated in FIG. **16**, the sealing surface **234** may be configured to at least partially protrude into the aperture **222** when the closure member is in the unvented position.

[0091] As illustrated in FIG. **14**, the second component **233** forms part of the closure member **230**. The sealing surface **234** is then located on the second component **233**. The second component **233** can follow the contours of the first component **231**. The sealing surface **234** can further be configured to contact the external surface. In at least one embodiment, a face of the closure member extension **232** facing the exterior surface **17** can be configured to (i.e., have a dimension from the sealing surface **234** to the closure member extension **232**) contact a distal end of the post **240** when a portion or the majority of the flange sealing surface **234** contacts the exterior surface. In at least one embodiment, the second component **233** can be molded over the sidewalls of the first component **231** (not shown) instead of being disposed on one surface of the closure member **230**. The overmolding of the second component **233** can be any height relative to the flange **232** (including covering a portion of the flange **232**). Alternatively, the second component can form part of the wall of the reservoir around the aperture **222**, in which case the sealing surface is located on the first component. In either case, the second component **233** provides sufficient conformability between the wall of the reservoir and the closure member **230** to seal the vent assembly **220** when adjusted to the unvented position.

[0092] FIGS. **17** and **18** illustrate the reservoir **10** with a third embodiment of a vent assembly **320**. The vent assembly **320** has many of the same features described above with respect to the vent assembly **220**. However, the vent assembly **320** in FIGS. **17** and **18** differs in that the closure member **330** is hinged to the wall of the reservoir **10** through the closure member retainer **342**. The closure member **330** may comprise a first component **331** and a second component **333** with a sealing surface **334** on the second component **333**. Alternately, the second component forms part of the wall of the reservoir and the sealing surface is on the first component. In either case, the vent assembly is closed by rotating the closure member **333** about the closure member retainer **342** so that the sealing surface **334** covers the aperture **322**, as illustrated in FIG. **17**. In some embodiments, the closure member **330** includes a latch **372** that mechanically engages with a notch **376** in the outer surface **374** of the post **340** to insure the closure member **330** does not prematurely disengage from the post **340** when the closure member in in the unvented position. The closure member **330** can be moved to the vented position by unlatching the closure member **330** from the post **340** so that the sealing surface **334** no longer covers the aperture **322**, as illustrated in FIG. **18**.

[0093] The reservoir **10** and first and second components **331**, **332** were previously described with respect to the illustrate embodiment in FIGS. **1-10**. Therefore, reference can be made thereto for a complete description of the various features of the reservoir and components.

Some Embodiments of the Disclosure

[0094] In a first embodiment, the present disclosure provides a vent assembly comprising: an aperture formed in a wall of a reservoir, the reservoir having an internal surface defining the volume of the reservoir and an external surface; a closure member retained on the external surface of the reservoir, the closure member comprising a first component and a second component, the second component is relatively conformable compared to the first component, the second component positioned between the first component and the wall of the reservoir; a sealing surface on the first component or the second component, where the sealing surface closes the aperture when the closure member is in an unvented position and the sealing surface does not close the aperture when the closure member is in a vented position; a closure member retainer configured to retain the closure member on the reservoir; and a cam surface between the closure member and the wall of the reservoir, the cam surface configured to generate a compressive force on the sealing surface when the closure member is moved into the unvented position.

[0095] In at least one embodiment, the present disclosure provides that the first component is made of a material having a Shore A Hardness greater than 100 as measured by ASTM D2240 or the closure member comprising a first component made of a material having a modulus of elasticity greater than 100 MPa as measured by the Nano Indentation Test Method as described herein.

[0096] In at least one embodiment, the present disclosure provides that the second component is made of a material having a Shore A Hardness up to 100 as measured by ASTM D2240 or the closure member comprising a second component made of a material having a modulus of elasticity no greater than 100 MPa as measured by the Nano Indentation Test Method as described herein.

[0097] In a second embodiment, the present disclosure provides the vent assembly of the first embodiment, wherein the first component is made of a thermoplastic material.

[0098] In a third embodiment, the present disclosure provides the vent assembly of the first or second embodiment, wherein the first component comprises at least one of a polypropylene, a high density polyethylene (HDPE), a polyamide, a polyester, a glass-filled polyamide and an acetal.

[0099] In a fourth embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the second component comprises at least one of a thermoplastic elastomer, a thermoplastic vulcanizate and a rubber.

[0100] In a fifth embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the second component has a modulus of elasticity of less than 0.01 GPa.

[0101] In a sixth embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the first component has a modulus of elasticity greater than the second component.

[0102] In a seventh embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the closure member comprises both the first component and the second component, and the sealing surface is on the second component.

[0103] In an eighth embodiment, the present disclosure provides the vent assembly of any one of the first through sixth embodiments, wherein the closure member comprises the first component, and the second component forms at least part of the cam surface, where the sealing surface is on the first component.

[0104] In a ninth embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the sealing surface at least partially protrudes into the aperture when the closure member is in the unvented position.

[0105] In a tenth embodiment, the present disclosure provides the vent assembly of any one of the first through eighth embodiments, wherein the sealing surface covers but does not protrude into the aperture when the closure member is in the unvented position.

[0106] In an eleventh embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the reservoir comprises a container having an opening and a detachable lid configured to close the opening.

[0107] In a twelfth embodiment, the present disclosure provides the vent assembly of any one of the preceding claims, wherein the aperture is in the wall of the container.

[0108] In a thirteenth embodiment, the present disclosure provides the vent assembly of the first through eleventh embodiments, wherein the aperture is in the wall of the lid.

[0109] In a fourteenth embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the closure member is configured for rotation about an axis extending through the wall of the reservoir when moving between the vented position and the unvented position.

[0110] In a fifteenth embodiment, the present disclosure provides the vent assembly of the fourteenth embodiment, wherein the axis is perpendicular to the wall of the reservoir proximate the aperture.

[0111] In a sixteenth embodiment, the present disclosure provides the vent assembly of the fourteenth or fifteenth embodiment, further comprising a post extending from the wall of the reservoir in a direction parallel to the axis, wherein the closure member is configured for rotation on the post, wherein the closure member retainer is located on the post and configured to retain the closure member on the post when the closure member is in the vented position, and wherein the compressive force is generated between the closure member retainer and the cam surface when the sealing surface is positioned over the aperture.

[0112] In a seventeenth embodiment, the present disclosure provides the vent assembly of the sixteenth embodiment, wherein the closure member retainer comprises a shoulder extending outwardly from the post relative to the axis.

[0113] In an eighteenth embodiment, the present disclosure provides the vent assembly of the seventeenth embodiment, wherein the closure member comprises an inner surface facing the post and a top surface facing away from the wall of the reservoir, wherein the inner surface and top surface of the closure member form an edge, and wherein the edge mechanically engages with the shoulder of the closure member retainer when the closure member is in the unvented position.

[0114] In a nineteenth embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the aperture extends through the cam surface.

[0115] In a twentieth embodiment, the present disclosure provides the vent assembly of the nineteenth embodiment, wherein the cam surface comprises an aperture surface portion that is located in a plane that is perpendicular to the axis about which the closure member rotates, and wherein the aperture extends through the aperture surface portion of the cam surface.

[0116] In a twenty-first embodiment, the present disclosure provides the vent assembly of the eighteenth embodiment, wherein the vent assembly is configured so that:

$$0.9\ D1 \leq DV < D2 \text{ and } H1 < HV < 1.2\ H2$$

[0117] where

[0118] D**1** is the outer diameter of the post at its narrowest dimension;

[0119] DV is the diameter of the inner surface of the closure member;

[0120] D**2** is the outer diameter of the closure member retainer as measured closest to the shoulder;

[0121] HV is the thickness of the closure member;

[0122] H**1** is the height of the post, as measured from an aperture surface portion of the cam surface to the point at which the outer diameter of the post begins to increase;

[0123] H**2** is the height of the post, as measured from the aperture surface portion to the shoulder.

[0124] In an embodiment, the present disclosure provides that the use of a second component in the closure member allows for greater diameter and height tolerances compared to no use of the second component.

[0125] In a twenty-second embodiment, the present disclosure provide the vent assembly of any one of the preceding claims, further comprising a stop configured to limit movement of the closure member in one direction when the closure member is in the unvented position.

[0126] In a twenty-third embodiment, the present disclosure provides the vent assembly of the twenty-second embodiment, wherein the stop protrudes from the wall of the reservoir.

[0127] In a twenty-fourth embodiment, the present disclosure provides the vent assembly of the twenty-second or twenty-third embodiment, wherein the stop is located proximate the cam surface.

[0128] In a twenty-fifth embodiment, the present disclosure provides the vent assembly of any one of the preceding embodiments, wherein the vent assembly comprises a plurality of apertures, wherein the closure member comprises a plurality of sealing surfaces, and wherein each aperture of the plurality of apertures is closed by a sealing surface of the plurality of sealing surfaces when the closure member is in the unvented position.

[0129] In a twenty-sixth embodiment, the present disclosure provides the vent assembly of the twenty-fifth embodiment, wherein the closure member comprises a plurality of relief surfaces. wherein a relief surface is positioned above each aperture of the plurality of apertures when the closure member is in the vented position.

[0130] In a twenty-seventh embodiment, the present disclosure provides the vent assembly of the twenty-fifth or twenty-sixth embodiment, wherein the vent assembly comprises a plurality of cam surfaces, wherein each aperture of the plurality of apertures is located in a cam surface of the plurality of cam surfaces, and wherein each aperture of the plurality of apertures is closed by a sealing surface of the plurality of sealing surfaces when the closure member is in the unvented position.

[0131] In a twenty-eighth embodiment, the present disclosure provides the vent assembly of any one of the preceding claims, wherein the closure member is made by overmolding.

[0132] In a twenty-ninth embodiment, the present disclosure provides the vent assembly of any one of the preceding claims, wherein the closure member is made by insert molding.

[0133] In a thirtieth embodiment, the present disclosure provides a vent assembly comprising: an aperture formed in a wall of a reservoir, the reservoir having an internal surface defining the volume of the reservoir and an external surface; a closure member retained on the external surface of the reservoir, the closure member comprising a first component and a second component, the second component is relatively conformable compared to the first component, the second component positioned between the first component and the wall of the reservoir; a sealing surface on the first component or the second component, where the sealing surface closes the aperture when the closure member is in an unvented position and the sealing surface does not close the aperture when the closure member is in a vented position; a closure member retainer configured to retain the closure member on the reservoir, wherein the closure member is displaced from the wall of the reservoir when moving from the unvented position to the vented position.

[0134] In at least one embodiment, the present disclosure provides that the first component is made of a material having a Shore A Hardness greater than 100 as measured by ASTM D2240 or the closure member comprising a first component made of a material having a modulus of elasticity greater than 100 MPa as measured by the Nano Indentation Test Method as described herein.

[0135] In at least one embodiment, the present disclosure provides that the second component is made of a material having a Shore A Hardness up to 100 as measured by ASTM D2240 or the closure member comprising a second component made of a material having a modulus of elasticity no greater than 100 MPa as measured by the Nano Indentation Test Method as described herein.

[0136] In a thirty-first embodiment, the present disclosure provides the vent assembly of the thirtieth embodiment, wherein the first component is made of a thermoplastic material.

[0137] In a thirty-second embodiment, the present disclosure provides the vent assembly of the thirtieth or thirty-first embodiment, wherein the first component comprises at least one of a polypropylene, a high density polyethylene (HDPE), a polyamide, a polyester, a glass-filled polyamide and an acetal.

[0138] In a thirty-third embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through thirty-second embodiments, wherein the second component comprises at least one of a thermoplastic elastomer, a thermoplastic vulcanizate and a rubber.

[0139] In a thirty-fourth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through thirty-third embodiments, wherein the second component has a modulus of elasticity of less than 0.1 GPa.

[0140] In a thirty-fifth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth though thirty-fourth embodiments, wherein the first component has a modulus of elasticity greater than the second component.

[0141] In a thirty-sixth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through thirty-fifth embodiments, wherein the closure member comprises both the first component and the second component, and the sealing surface is on the second component.

[0142] In a thirty-seventh embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through thirty-fifth embodiments, wherein the closure member comprises the first component, and the second component forms at least part of the wall of the reservoir, where the scaling surface is on the first component.

[0143] In a thirty-eight embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through thirty-seventh embodiments, wherein the sealing surface at least partially protrudes into the aperture when the closure member is in the unvented position.

[0144] In a thirty-ninth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through thirty-seventh embodiments, wherein the sealing surface covers but does not protrude into the aperture when the closure member is in the unvented position.

[0145] In a fortieth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through thirty-ninth embodiments, wherein the reservoir comprises a container having an opening and a detachable lid configured to close the opening.

[0146] In a forty-first embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through fortieth embodiments, wherein the aperture is in the wall of the container.

[0147] In a forty-second embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through fortieth embodiments, wherein the aperture is in the wall of the lid.

[0148] In a forty-third embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through forty-second embodiments, further comprising a post extending from the wall of the reservoir, the post having an inner surface that surrounds the aperture and an outer surface, the end of the post opposite the wall of the reservoir defining an opening, wherein the closure member is inserted into the opening of the post.

[0149] In a forty-fourth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through forty-third embodiments, wherein the closure member is configured for linear movement between the vented position and the unvented position.

[0150] In a forty-fifth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through forty-fourth embodiments, wherein the closure member retainer is located on the inner surface of the post, and the closure member retainer creates a friction fit with the closure member.

[0151] In a forty-sixth embodiment, the present disclosure provides the vent assembly of on any one of the thirtieth through forty-fifth embodiments, wherein the closure member comprises at least one aperture to permit venting through the closure member when the closure member is in the vented position.

[0152] In a forty-seventh embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through forty-sixth embodiments, wherein venting occurs between the closure member and inner surface of the post when the closure member is in the vented position.

[0153] In a forty-eighth embodiment, the present disclosure provides the vent assembly of any one of the thirtieth through forty-second embodiments, further comprising a post extending from the wall of the reservoir, the post having an inner surface that surrounds the aperture and an outer surface, the end of the post opposite the wall of the reservoir defining an opening, wherein the closure member is hinged to the closure member retainer, and wherein the closure member is moved between the unvented position and vented position by rotation about the closure member retainer.

[0154] In a forty-ninth embodiment, the present disclosure provides the vent assembly of the forty-eighth embodiment, wherein the closure member further comprises a latch that mechanically engages with a notch in an outer surface of the post.

[0155] In a fiftieth embodiment, the present disclosure provides for a system comprising a) a paint cup reservoir for holding paint when attached to a paint gun having a wall, the paint cup reservoir having an internal surface defining the volume of the reservoir and an external surface, a first aperture formed in the wall, a post extending from the wall of the reservoir, the post having an inner surface that surrounds the first aperture and an outer surface, the end of the post opposite the wall of the reservoir defining an opening, and b) a closure member formed entirely from a conformable material, the closure member having second apertures that allow venting of the volume via the first aperture in a vented position and do not allow venting of the volume via the first aperture in an unvented position.

[0156] In at least one embodiment, the present disclosure provides for the reservoir having an opening, and c) a lid that is attachable to the opening, and optionally d) a paint gun, the lid attachable to the paint gun in a siphon or gravity feed operation.

EXAMPLES

[0157] Objects and advantages of this invention are further illustrated by the following examples, but the particular materials and amounts thereof recited in these examples, as well as other conditions and details, should not be construed to unduly limit this invention. These examples are merely for illustrative purposes only and are not meant to be limiting on the scope of the appended claims.

Materials

Abbreviation	Description and Source
ACE	Acetone, obtained from Keystone Automotive Operations, Inc., Exeter, PA.
BER	BERGAMID B70 H BLACK UV, obtained from PolyOne Corporation, Avon Lake, OH.
CRS	CrastinS600F40BK851, obtained from DuPont de Nemours, Inc., Wilmington, DE.
CYC	Cyclohexane, obtained from EMD Millipore Corp., Billerica, MA.
DELR	DuPont Delrin 500P, obtained from DuPont de Nemours, Inc., Wilmington, DE.
DELT	Deltron Solvent Borne Base Coat, Obtained from PPG Industries, Inc., Pittsburgh, PA.

-continued

Abbreviation	Description and Source
ENV	Envirobase Waterborne Basecoat, obtained from PPG Industries, Inc., Pittsburgh, PA.
FC	Green Food Coloring, obtained from McCormick & Co., Baltimore, MD.
GLS	Glasurit Waterborne Basecoat, obtained from BASF, Ludwigshafen, Germany.
HDPE	Marlex 9006 Polyethylene, obtained from Chevron Phillips Chemical, The Woodlands, TX
HYL1	Hylon (Nylon) N1013HL, obtained from Ravago Manufacturing Americas, LLC, Orlando FL.
HYL2	Hylon (Nylon) N1000EHL, obtained from obtained from Ravago Manufacturing Americas, LLC, Orlando FL.
LDPE	Dow 722 Low Density Polyethylene Resin, obtained from Dow Chemical Co., Midland, MI
MEK	Methyl Ethyl Ketone, obtained from VWR Chemicals, West Chester, PA.
NYM	Nymax 623 Zip 5 HS BLK 13, obtained from PolyOne Corporation, Avon Lake, OH.
PB1	SX840 Paint Blender, obtained from PPG Industries, Inc., Pittsburgh, PA.
PB2	DT870 Paint Blender, obtained from PPG Industries, Inc., Pittsburgh, PA.
PET	Rynite 935 PET, obtained from Dupont de Nemours, Inc., Wilmington, DE.
PETG	Eastar 6763 PETG, obtained from Eastman Chemical Company, Kingsport, TN.
PP	BORPURE RJ377M obtained from Borealis, Vienna, Austria.
PP1	Braskem RP 350 Polypropylene, obtained from Braskem USA, Philadelphia, PA
PK	Polyketone M330A, obtained from Hyosung Cooperation, Ulsan, Republic of Korea.
TB	TangoBlack FLX973, obtained from Stratysys, Ltd., Eden Prairie, MN.
TOL	Toluene, obtained from EMD Millipore Corp., Billerica, MA.
VF1	Versaflex OM 1040X, obtained from PolyOne Corporation, Avon Lake, OH.
VF2	Versaflex OM 6240, obtained from PolyOne Corporation, Avon Lake, OH.
VF3	Versaflex OM9-801N, obtained from PolyOne Corporation, Avon Lake, OH.
VJF	VisiJet SL Flex, obtained from 3D Systems, Rock Hill, SC.
VW	Vero White RGD835, obtained from Stratysys, Ltd., Eden Prairie, MN.
XYL	Xylene, obtained from VWR Chemicals, West Chester, PA.

Test Method 1: Leak Testing

[0158] Leakage tests were conducted on select reservoirs. A reservoir was place on a surface with the opening facing upward and the closure member in the unvented position, enabling the reservoir to be filled with fluid. Approximately 600 ml of water containing a few drops of FC to aid visual detection of a leak were added to each reservoir. A stopwatch was started when the dyed water was initially added to a reservoir and the reservoir was visually monitored for leakage over a 30 minute test duration. The reservoir was determined to leak with the appearance of a pendant droplet of the colored water outside the reservoir. Results are tabulated in Table 1. Reservoirs that did not leak within the 30 minute test period were given a value of "0"; reservoirs that leaked within the 30 minute test period were given a value of "1".

[0159] Comparative Examples represent vent assemblies having only the first component (i.e., no second component) and/or vent assemblies that completely failed the leak test or gave inconsistent results, demonstrating inability to accommodate variations due to manufacturing tolerances or environmental factors.

Test Method 2: Sealing Surface Uniformity

[0160] Samples consisted of reservoirs like those illustrated in FIG. **1**A and made from PP by plastic injection molding. For the purposes of the test, the sealing surface was defined as the aperture surface portions of the vent assembly (see FIG. **3**, element **52**). The flatness of 160 samples (i.e., 40 reservoirs with four apertures each) was measured with an optical measurement system (SmartScope Flash 302, available from OGP—Optical Gaging Products, Rochester, New York). Four measurement locations were selected on each aperture surface portion of a reservoir, and the flatness was calculated as the orthogonal projection of the 4^{th} point onto a plane defined by points 1-3. Results are summarized in Table 2 and indicate an average flatness variation of 0.0016 inches (0.0406 mm), with a standard deviation of 0.0014 inches (0.0356 mm).

Test Method 3: Stability of Closure Members Made From Various Materials

[0161] The stability of various materials to a variety of solvents was assessed. The materials included NYM, PK, CRS, DELR, and PET. The materials were made into a single component closure member (similar to that illustrated in FIG. **1**A without the second component) by plastic injection molding. Each closure member sample was weighed, and the inner diameters and heights were measured. The samples were then immersed in either water, CYC, ACE, TOL, XYL, or MEK. After 48 hours of immersion, the samples were removed, dried with a pneumatic blow gun, and weighed and measured again. Results of the testing are summarized in Table 3.

Test Method 4: Reservoir Storage Testing

[0162] The storage capability of a reservoir for a variety of solvents was assessed. The reservoirs were configured like those illustrated in FIG. **1***a*. The closure members had a first component made of DELR and a second component made of VF3.

[0163] A reservoir was place on a surface with the opening facing upward and the closure member in the unvented position, enabling the reservoir to be filled with fluid. Approximately 600 ml of fluid consisting of ACE, PB1, PB2, DELT, GLS or ENV were added to the reservoir followed by a few drops of FC to aid visual detection of a leak. A lid was used to seal the reservoir.

[0164] The vent assemblies of the reservoir were visually monitored for failure. A failure was noted if a leak was visually observed (as described in Test Method 1 above) or the closure member cracked or dissolved in the working fluid being tested. Failure monitoring was observed for up to 3 months. The resulting "Storage Time" and respective "Failure" is summarized in Table 4.

Test Method 5: Nano Indentation Test Method

[0165] The modulus of elasticity was assessed for a relatively thin sample (less than 6 mm thickness). The sample was oriented such that the sample is self-supported or where the thickness of the material of interest is much larger than the indentation depth (in the direction of indentation) to minimize the influence of any underlying layers on an indentation-based measurement. The indentation can be performed in an "in-plane" direction.

[0166] A cryo microtomy sample preparation method was used which involved cross-sectioning the samples and performing surface preparation using a microtome at cryogenic temperatures as shown below

Cutting Temperatures

Material	Cutting Temperature (° C.)
DELR	−72
LDPE	−75
HDPE	−20
PP1	−30
VF3	−115

A 1-micron diameter ruby sphere probe tip was used to perform the indentation. This is a round ruby that is well-suited for measuring relatively soft materials. A KLA Tencor Nano Indenter® G200 (commercially available from KLA-Tencor, Milpitas, California) with an XP indenter head was used to make all measurements. A minimum of 10 individual indentation measurements were performed on each sample with a minimum spacing of 250 microns. A surface detection criteria 100 N/m was used to define the surface of the test specimen during the approach of the indenter; and the indenter approach velocity was 50 nm/see. Each indentation was performed to a target indentation depth of 1000 nm. Upon reaching the target indentation depth, a 10 second dwell was performed in load control prior to unloading. Both unloading and loading segments were performed at a constant target strain rate of 0.05; the target strain rate is defined as the loading rate (N/see) divided by the load on the sample (N).

[0167] Individual measurements of elastic modulus were made using the unloading segment of each individual indentation. Elastic modulus was calculated using the maximum indentation depth at the beginning of the unloading segment and the slope of the unloading segment. The slope of the unloading segment was calculated using a linear regression using all unloading segment data between the maximum load and the load at 50% of maximum. Sample elastic modulus was calculated using the analytical solution of a rigid sphere in contact with an elastic half-space. In the case of each sample material, an estimate of the material's Poisson's ratio was used in the modulus calculations and these estimates are summarized in Table 5.

Prep & Examples

[0168] All examples utilized a reservoir having a singular side-wall with a circular cross-section, a base, an opening opposite the base, and a reservoir volume of about 700 ml. The reservoir was prepared from PP using a conventional injection molding process. The reservoir base contained four apertures, having a diameter of about 1.25 mm, located in a circular pattern each spaced at 90-degree intervals, similar to the vent assembly shown in FIG. **3**. With reference to FIG. **20**, the vent assembly composes a post **40** and a closure member retainer **42**. The outer diameter (D**2**) of the closure member retainer **42** had an average value of 15.15 mm, and the height of the post (H**2**) as measured from the aperture surface portion **52** to the shoulder **44**, had an average value of 3.65 mm.

[0169] The closure members were prepared using different manufacturing methods, as shown in Table 1. The manufacturing methods included 3D printing and injection molding. Materials utilized are referenced in Table 1. The height (HV) and inner diameter (DV) of each closure member, as illustrated in FIG. **19**, were measured and recorded. Each reservoir was tested for leakage via the Test Method 1. The results are summarized in Table 1 and FIG. **20**.

TABLE 1

Leak Testing Results.

Example	MFG. Method	First Component	Second Component	HV/H2	DV/D2	Leak
Example 1	3D Printed	VW	TB	1.00	0.98	0
Example 2	3D Printed	VW	TB	1.01	0.98	0
Example 3	3D Printed	VW	TB	1.00	0.98	0
Example 4	3D Printed	VW	TB	1.00	0.99	0
Example 5	3D Printed	VW	TB	1.01	0.97	0
Example 6	3D Printed	VW	TB	1.01	0.97	0
Example 7	3D Printed	VW	TB	1.01	0.97	0
Example 8	3D Printed	VW	TB	1.01	0.97	0
Example 9	3D Printed	VW	TB	1.03	0.98	0
Example 10	3D Printed	VW	TB	1.03	0.98	0
Example 11	3D Printed	VW	TB	1.04	0.98	0
Example 12	3D Printed	VW	TB	1.03	0.98	0
Comparative Example 13	Injection Molded	PET	VF1	0.99	1.01	1
Comparative Example 14	Injection Molded	PET	VF1	0.98	1.01	1
Comparative Example 15	Injection Molded	PET	VF1	0.98	1.01	1
Comparative Example 16	Injection Molded	PET	VF1	0.98	1.01	1
Comparative Example 17	Injection Molded	HYL1	VF2	0.98	1.01	1
Comparative Example 18	Injection Molded	HYL1	VF2	0.99	1.01	1
Comparative Example 19	Injection Molded	HYL1	VF2	0.99	1.01	1

TABLE 1-continued

Leak Testing Results.						
Example	MFG. Method	First Component	Second Component	HV/H2	DV/D2	Leak
Comparative Example 20	Injection Molded	HYL1	VF2	0.98	1.01	1
Comparative Example 21	Injection Molded	PETG	VF1	1.01	1.00	1
Comparative Example 22	Injection Molded	PETG	VF1	1.00	1.00	1
Comparative Example 23	Injection Molded	PETG	VF1	1.00	1.01	1
Comparative Example 24	Injection Molded	PETG	VF1	1.00	1.00	1
Comparative Example 25	Injection Molded	PETG	VF1	1.00	1.01	1
Example 26	Injection Molded	PETG	VF1	1.01	0.95	0
Comparative Example 27	Injection Molded	HYL2	VF2	1.02	1.00	1
Comparative Example 28	Injection Molded	HYL2	VF2	1.00	1.00	1
Comparative Example 29	Injection Molded	HYL2	VF2	1.00	1.00	1
Comparative Example 30	Injection Molded	HYL2	VF2	1.00	1.01	1
Comparative Example 31	Injection Molded	HYL2	VF2	1.01	1.01	1
Example 32	Injection Molded	DELR	VF3	0.98	0.99	0
Example 33	Injection Molded	DELR	VF3	0.98	0.99	0
Example 34	Injection Molded	DELR	VF3	0.98	0.99	0
Example 35	Injection Molded	DELR	VF3	0.98	0.99	0
Example 36	Injection Molded	DELR	VF3	0.98	0.99	0
Example 37	Injection Molded	DELR	VF3	0.97	0.99	0
Example 38	Injection Molded	DELR	VF3	0.99	0.99	0
Example 39	Injection Molded	DELR	VF3	0.99	0.98	0
Example 40	Injection Molded	DELR	VF3	0.98	0.99	0
Example 41	Injection Molded	DELR	VF3	0.98	0.99	0
Example 42	Injection Molded	DELR	VF3	0.98	0.99	0
Example 43	Injection Molded	DELR	VF3	0.98	0.99	0
Example 44	Injection Molded	DELR	VF3	0.98	0.99	0
Example 45	Injection Molded	DELR	VF3	0.98	0.99	0
Example 46	Injection Molded	DELR	VF3	0.98	0.99	0
Example 47	Injection Molded	DELR	VF3	0.98	0.99	0
Example 48	Injection Molded	DELR	VF3	0.98	0.99	0
Example 49	Injection Molded	DELR	VF3	0.98	0.99	0
Example 50	Injection Molded	DELR	VF3	0.98	0.99	0
Example 51	Injection Molded	DELR	VF3	0.98	0.99	0
Example 52	Injection Molded	DELR	VF3	0.98	0.99	0
Example 53	Injection Molded	DELR	VF3	0.99	0.99	0
Example 54	Injection Molded	DELR	VF3	0.98	0.99	0
Example 55	Injection Molded	DELR	VF3	0.99	0.98	0
Example 56	Injection Molded	DELR	VF3	0.98	0.98	0
Example 57	Injection Molded	DELR	VF3	0.99	0.99	0
Example 58	Injection Molded	DELR	VF3	0.98	0.99	0
Example 59	Injection Molded	DELR	VF3	0.98	0.99	0
Example 60	Injection Molded	DELR	VF3	0.98	0.99	0
Example 61	Injection Molded	DELR	VF3	0.99	0.99	0
Example 62	Injection Molded	DELR	VF3	0.98	0.99	0
Example 63	Injection Molded	DELR	VF3	0.98	0.98	0
Example 64	Injection Molded	DELR	VF3	0.98	0.98	0
Example 65	Injection Molded	DELR	VF3	0.98	0.98	0
Example 66	Injection Molded	DELR	VF3	0.98	0.98	0
Example 67	Injection Molded	DELR	VF3	0.98	0.97	0
Example 68	Injection Molded	DELR	VF3	0.98	0.99	0
Example 69	Injection Molded	DELR	VF3	0.98	0.97	0
Comparative Example 70	Injection Molded	BER	N/A	0.97	1.00	1
Comparative Example 71	Injection Molded	BER	N/A	0.97	1.00	1
Comparative Example 72	Injection Molded	BER	N/A	0.97	1.00	0
Comparative Example 73	Injection Molded	BER	N/A	0.97	0.99	1
Comparative Example 74	Injection Molded	BER	N/A	0.96	0.99	1

TABLE 1-continued

Leak Testing Results.						
Example	MFG. Method	First Component	Second Component	HV/H2	DV/D2	Leak
Comparative Example 75	Injection Molded	BER	N/A	0.96	0.99	1
Comparative Example 76	Injection Molded	BER	N/A	0.96	0.99	1
Comparative Example 77	Injection Molded	BER	N/A	0.96	0.99	1
Comparative Example 78	Injection Molded	BER	N/A	0.96	0.98	0
Comparative Example 79	Injection Molded	BER	N/A	0.96	0.99	0
Comparative Example 80	Injection Molded	BER	N/A	0.96	0.99	0
Comparative Example 81	Injection Molded	BER	N/A	0.95	0.98	0
Comparative Example 82	Injection Molded	CRS	N/A	0.96	0.98	1
Comparative Example 83	Injection Molded	CRS	N/A	0.95	0.98	0
Comparative Example 84	Injection Molded	CRS	N/A	0.95	0.98	1
Comparative Example 85	Injection Molded	CRS	N/A	0.96	0.98	1
Comparative Example 86	Injection Molded	CRS	N/A	0.97	0.99	1
Comparative Example 87	3D Printed	VJF	N/A	0.94	0.98	1
Comparative Example 88	3D Printed	VJF	N/A	0.95	0.98	1
Comparative Example 89	3D Printed	VJF	N/A	0.96	0.98	1
Comparative Example 90	3D Printed	VJF	N/A	0.98	0.98	1
Comparative Example 91	3D Printed	VJF	N/A	0.95	0.98	1
Comparative Example 92	3D Printed	VJF	N/A	0.98	0.98	1
Comparative Example 93	3D Printed	VJF	N/A	0.98	0.98	1
Comparative Example 94	3D Printed	VJF	N/A	0.97	0.97	1
Comparative Example 95	3D Printed	VJF	N/A	0.99	0.98	1
Comparative Example 96	3D Printed	VJF	N/A	0.98	0.98	1
Comparative Example 97	3D Printed	VJF	N/A	1.01	0.98	1
Comparative Example 98	3D Printed	VJF	N/A	1.00	0.98	1
Comparative Example 99	3D Printed	VJF	N/A	1.01	0.98	1
Comparative Example 100	3D Printed	VJF	N/A	1.01	0.97	1
Comparative Example 101	3D Printed	VJF	N/A	1.01	0.98	1
Comparative Example 102	3D Printed	VJF	N/A	1.03	0.98	1
Comparative Example 103	3D Printed	VJF	N/A	1.03	0.98	1
Comparative Example 104	3D Printed	VJF	N/A	1.03	0.98	1
Comparative Example 105	3D Printed	VJF	N/A	1.04	0.98	1
Comparative Example 106	3D Printed	VJF	N/A	1.03	0.98	1
Comparative Example 107	3D Printed	VJF	N/A	1.06	0.98	1
Comparative Example 108	3D Printed	VJF	N/A	1.06	0.98	1
Comparative Example 109	3D Printed	VJF	N/A	1.06	0.98	1

TABLE 1-continued

Leak Testing Results.

Example	MFG. Method	First Component	Second Component	HV/H2	DV/D2	Leak
Comparative Example 110	3D Printed	VJF	N/A	1.06	0.98	1
Comparative Example 111	3D Printed	VJF	N/A	1.06	0.98	1

TABLE 2

Sealing Surface Uniformity Results

Example	Sealing Surface Flatness inches (mm)
Example 112	0.0001 (0.00254)
Example 113	0.0027 (0.0686)
Example 114	0.0013 (0.0330)
Example 115	0.0048 (0.121)
Example 116	0.0057 (0.145)
Example 117	0.0015 (0.0381)
Example 118	0.0000 (0.000)
Example 119	0.0021 (0.0533)
Example 120	0.0003 (0.0076)
Example 121	0.0039 (0.0991)

TABLE 3

Stability of Closure Members Made from Various Materials

			Initial			48 Hour			% Change		
Example	Resin Type	Fluid	Closure Member Mass [g]	Closure Member Inner Diameter [mm]	Closure Member Height [mm]	Closure Member Mass [g]	Closure Member Inner Diameter [mm]	Closure Member Height [mm]	48 Hr. Mass Change [%]	48 Hr. Inner Diameter [%]	48 Hr. Height Change [%]
Example 122	NMY	water	1.2881	14.92	3.97	1.366	15.04	4.03	6.0%	0.8%	1.5%
Example 123	NMY	water	1.289	14.88	3.97	1.3691	15.04	4.03	6.2%	1.1%	1.5%
Example 124	NMY	water	1.2892	14.91	3.97	1.3708	15.09	4.04	6.3%	1.2%	1.8%
Example 125	NMY	water	1.2902	14.92	3.98	1.369	15.08	4.04	6.1%	1.1%	1.5%
Example 126	NMY	water	1.288	14.92	3.97	1.3695	15.06	4.03	6.3%	0.9%	1.5%
Example 127	NMY	water	1.2879	14.91	3.98	1.3682	15.07	4.03	6.2%	1.1%	1.3%
Example 128	NMY	water	1.2885	14.92	3.98	1.3691	15.06	4.04	6.3%	0.9%	1.5%
Example 129	NMY	water	1.2909	14.91	3.97	1.3681	15.07	4.03	6.0%	1.1%	1.5%
Example 130	NMY	water	1.2878	14.93	3.97	1.3674	15.09	4.04	6.2%	1.1%	1.8%
Example 131	NMY	water	1.2883	14.93	3.98	1.368	15.09	4.04	6.2%	1.1%	1.5%
Example 132	PK	water	1.2178	14.84	3.9	1.236	14.93	3.92	1.5%	0.6%	0.5%
Example 133	PK	water	1.2181	14.81	3.91	1.2361	14.93	3.92	1.5%	0.8%	0.3%
Example 134	PK	water	1.2186	14.84	3.92	1.2372	14.92	3.95	1.5%	0.5%	0.8%
Example 135	PK	water	1.2184	14.82	3.91	1.2371	14.95	3.92	1.5%	0.9%	0.3%
Example 136	PK	water	1.2181	14.8	3.9	1.2371	14.94	3.93	1.6%	0.9%	0.8%
Example 137	PK	water	1.2182	14.83	3.91	1.2368	14.92	3.93	1.5%	0.6%	0.5%
Example 138	PK	water	1.2185	14.83	3.91	1.2367	14.94	3.93	1.5%	0.7%	0.5%
Example 139	PK	water	1.2185	14.84	3.91	1.237	14.93	3.93	1.5%	0.6%	0.5%
Example 140	PK	water	1.2183	14.82	3.9	1.2368	14.94	3.93	1.5%	0.8%	0.8%
Example 141	PK	water	1.2185	14.83	3.9	1.2372	14.95	3.93	1.5%	0.8%	0.8%
Example 142	DELR	water	1.5324	14.79	3.92	1.5465	14.88	3.93	0.9%	0.6%	0.3%
Example 143	DELR	water	1.5348	14.79	3.92	1.5496	14.86	3.92	1.0%	0.5%	0.0%
Example 144	DELR	water	1.5309	14.79	3.92	1.5454	14.87	3.92	0.9%	0.5%	0.0%
Example 145	DELR	water	1.5328	14.79	3.93	1.5474	14.86	3.94	1.0%	0.5%	0.3%
Example 146	DELR	water	1.5321	14.79	3.93	1.5465	14.87	3.93	0.9%	0.5%	0.0%
Example 147	DELR	water	1.5312	14.79	3.92	1.5459	14.86	3.92	1.0%	0.5%	0.0%
Example 148	DELR	water	1.5316	14.79	3.92	1.5454	14.86	3.93	0.9%	0.5%	0.3%
Example 149	DELR	water	1.5317	14.79	3.92	1.5462	14.87	3.93	0.9%	0.5%	0.3%
Example 150	DELR	water	1.5335	14.79	3.92	1.5483	14.86	3.94	1.0%	0.5%	0.5%
Example 151	DELR	water	1.5349	14.79	3.92	1.5509	14.86	3.93	1.0%	0.5%	0.3%
Example 152	CRS	water	1.439	14.83	3.92	1.4416	14.86	3.92	0.2%	0.2%	0.0%
Example 153	CRS	water	1.4404	14.85	3.92	1.443	14.87	3.93	0.2%	0.1%	0.3%
Example 154	CRS	water	1.44	14.83	3.92	1.4429	14.87	3.93	0.2%	0.3%	0.3%
Example 155	CRS	water	1.4367	14.84	3.92	1.4397	14.87	3.92	0.2%	0.2%	0.0%
Example 156	CRS	water	1.4363	14.83	3.93	1.4388	14.87	3.92	0.2%	0.3%	−0.3%
Example 157	CRS	water	1.4377	14.84	3.92	1.442	14.86	3.93	0.3%	0.1%	0.3%

TABLE 3-continued

Stability of Closure Members Made from Various Materials

			Initial			48 Hour			% Change		
Example	Resin Type	Fluid	Closure Member Mass [g]	Closure Member Inner Diameter [mm]	Closure Member Height [mm]	Closure Member Mass [g]	Closure Member Inner Diameter [mm]	Closure Member Height [mm]	48 Hr. Mass Change [%]	48 Hr. Inner Diameter [%]	48 Hr. Height Change [%]
Example 158	CRS	water	1.4421	14.84	3.93	1.4485	14.86	3.94	0.4%	0.1%	0.3%
Example 159	CRS	water	1.4363	14.84	3.92	1.4392	14.87	3.92	0.2%	0.2%	0.0%
Example 160	CRS	water	1.4391	14.83	3.92	1.443	14.87	3.92	0.3%	0.3%	0.0%
Example 161	CRS	water	1.4383	14.83	3.92	1.4415	14.86	3.92	0.2%	0.2%	0.0%
Example 162	DELR/VF3	water	1.0614	15.02	3.56	1.0683	15.11	3.54	0.7%	0.6%	−0.6%
Example 163	DELR/VF3	water	1.061	15.02	3.54	1.0678	15.12	3.54	0.6%	0.7%	0.0%
Example 164	DELR/VF3	water	1.0619	15.02	3.54	1.0684	15.1	3.53	0.6%	0.5%	−0.3%
Example 165	DELR/VF3	water	1.0611	15.02	3.54	1.0677	15.1	3.54	0.6%	0.5%	0.0%
Example 166	DELR/VF3	water	1.0608	15.02	3.54	1.067	15.1	3.53	0.6%	0.5%	−0.3%
Example 167	NMY	CYC	1.2969	14.92	3.98	1.2983	14.93	3.98	0.1%	0.1%	0.0%
Example 168	NMY	ACE	1.2894	14.93	3.98	1.2918	14.94	3.98	0.2%	0.1%	0.0%
Example 169	NMY	TOL	1.289	14.93	3.98	1.2908	14.93	3.98	0.1%	0.0%	0.0%
Example 170	NMY	XYL	1.2889	14.92	3.98	1.2903	14.94	3.98	0.1%	0.1%	0.0%
Example 171	NMY	MEK	1.2888	14.94	3.98	1.2889	14.94	3.98	0.0%	0.0%	0.0%
Example 172	PK	CYC	1.2178	14.8	3.91	1.2324	14.84	3.93	1.2%	0.3%	0.5%
Example 173	PK	ACE	1.2177	14.81	3.91	1.2368	15	3.93	1.6%	1.3%	0.5%
Example 174	PK	TOL	1.2174	14.82	3.91	1.2492	14.94	3.95	2.6%	0.8%	1.0%
Example 175	PK	XYL	1.2183	14.84	3.92	1.2417	14.86	3.95	1.9%	0.1%	0.8%
Example 176	PK	MEK	1.218	14.82	3.91	1.228	14.9	3.92	0.8%	0.5%	0.3%
Example 177	DELR	CYC	1.532	14.78	3.92	1.5331	14.79	3.91	0.1%	0.1%	−0.3%
Example 178	DELR	ACE	1.532	14.78	3.92	1.553	14.96	3.94	1.4%	1.2%	0.5%
Example 179	DELR	TOL	1.5347	14.78	3.91	1.5408	14.83	3.92	0.4%	0.3%	0.3%
Example 180	DELR	XYL	1.534	14.79	3.91	1.5387	14.83	3.9	0.3%	0.3%	−0.3%
Example 181	DELR	MEK	1.5335	14.79	3.92	1.5486	14.9	3.91	1.0%	0.7%	−0.3%
Example 182	CRS	CYC	1.4426	14.82	3.93	1.4437	14.85	3.91	0.1%	0.2%	−0.5%
Example 183	CRS	ACE	1.442	14.83	3.93	1.45	14.84	3.93	0.6%	0.1%	0.0%
Example 184	CRS	TOL	1.4394	14.87	3.92	1.446	14.87	3.92	0.5%	0.0%	0.0%
Example 185	CRS	XYL	1.4365	14.82	3.91	1.4379	14.83	3.91	0.1%	0.1%	0.0%
Example 186	CRS	MEK	1.4362	14.82	3.92	1.4441	14.85	3.91	0.6%	0.2%	−0.3%
Example 187	PET	CYC	0.8922	15.31	2.32	0.8935	15.31	2.32	0.1%	0.0%	0.0%
Example 188	PET	ACE	0.8928	15.31	2.32	0.9347	15.26	2.4	4.7%	−0.3%	3.4%
Example 189	PET	TOL	0.8942	15.33	2.32	0.9247	15.28	2.39	3.4%	−0.3%	3.0%
Example 190	PET	XYL	0.89	15.32	2.32	0.9025	15.28	2.35	1.4%	−0.3%	1.3%
Example 191	PET	MEK	0.8924	15.3	2.32	0.9349	15.25	2.41	4.8%	−0.3%	3.9%

TABLE 4

Reservoir Storage Test Results

Example	Working Fluid	Fluid Type	Storage Time (Days)	Failure	Notes
Example 192	ACE	Solvent	21	Y	VF3 Cracked
Example 193	PB1	Paint Blender	24	Y	VF3 Dissolved
Example 194	PB2	Paint Reducer	56	Y	VF3 Dissolved
Example 200	DELT	Paint (Solvent)	86	N	Test Stopped (No Failure)
Example 201	DELT	Paint (Solvent)	86	N	Test Stopped (No Failure)
Example 202	GLS	Paint (Waterborne)	96	N	Test Stopped (No Failure)
Example 203	GLS	Paint (Waterborne)	96	N	Test Stopped (No Failure)
Example 204	ENV	Paint (Waterborne)	96	N	Test Stopped (No Failure)
Example 205	ENV	Paint (Waterborne)	96	N	Test Stopped (No Failure)

TABLE 5

Elastic Modulus

Material	Component	Elastic Modulus (GPa)	Sample Size (Number of Indents)	Assumed Poisson' ratio
PP1	First Component	1.30	28	0.43
DELR	First Component	2.20	13	0.35
DELR	First Component	2.47	19	0.35
HDPE	First Component	1.05	27	0.45
LDPE	First Component	0.150	20	0.45
VF3	Second Component	0.00495	20	0.49
VF3	Second Component	0.00560	24	0.49

[0170] Thus, the present disclosure provides, among other thing, vent assemblies. Various features and advantages of the vent assemblies are set forth in the following claims

What is claimed is:

1. A system comprising:

a) a reservoir comprising:

one or more walls, the reservoir having an internal surface defining a volume of the reservoir and an external surface;

an aperture formed in a wall from the one or more walls of the reservoir;

a post extending from the wall of the reservoir, the post having an inner surface that is in fluid communication with the aperture and the external surface of the wall, and having an outer surface, an end of the post opposite the wall of the reservoir defines an opening; and

b) a closure member retained on the inner surface of the post, the closure member comprising a first component and a second component, the second component is relatively conformable compared to the first component, the second component positioned between the first component and the external surface of the wall of the reservoir;

a sealing surface on the first component or the second component, where the sealing surface closes the aperture when the closure member is in an unvented position and the sealing surface does not close the aperture when the closure member is in a vented position;

wherein the closure member is inserted into the opening of the post;

wherein the closure member is displaced from the wall of the reservoir when moving from the unvented position to the vented position;

wherein the closure member comprises both the first component and the second component, and the sealing surface is on the second component.

2. The system of claim **1**, further comprising a closure member retainer configured to retain the closure member on the reservoir.

3. The system of claim **1**, wherein the second component has a modulus of elasticity of less than 0.1 GPa according to the Nano Indentation Test Method.

4. The system of claim **1**, wherein the sealing surface is configured to at least partially protrude into the aperture when the closure member is in the unvented position.

5. The system of claim **1**, wherein the closure member comprises one or more apertures formed within the first component and the second component to vent air from a first side of the sealing surface to atmosphere while in a vented position.

6. The system of claim **1**,

wherein the closure member is hinged to the closure member retainer, and

wherein the closure member is moved between the unvented position and vented position by rotation about the closure member retainer.

* * * * *