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(54) Title: FLAPPER ASSEMBLY, A VALVE ASSEMBLY THAT UTILIZES THE FLAPPER ASSEMBLY, AND A METHOD OF FORMING THE FLAPPER ASSEMBLY

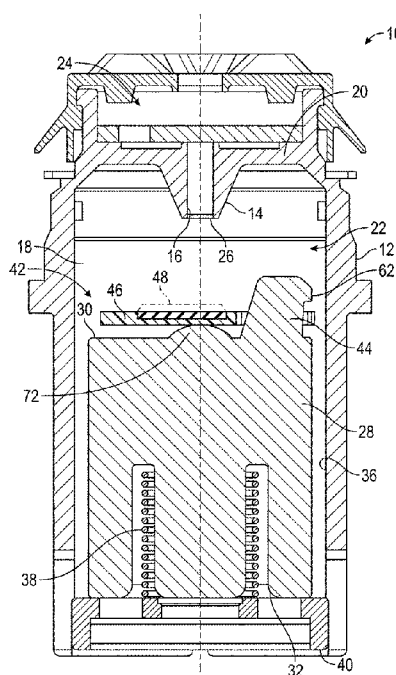


FIG. 2

(57) Abstract: A flapper assembly for closing an outlet of a valve, and a valve assembly that utilizes the flapper assembly includes a base support and a seal. One of first and second sides of the base support defines a recess. The seal is secured to the base support at the recess. The seal includes a sealing surface that faces away from the second side, and the sealing surface is configured to close the outlet of the valve. A method of forming a flapper assembly includes molding an elastomeric material to a base support to form a seal disposed along a first side of the base support. Molding the elastomeric material to the base support also forms a connector in an aperture of the base support and a plug in a recess defined by a second side of the base support to secure the seal to the base support.

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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FLAPPER ASSEMBLY, A VALVE ASSEMBLY THAT  
UTILIZES THE FLAPPER ASSEMBLY, AND A METHOD  
OF FORMING THE FLAPPER ASSEMBLY

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## TECHNICAL FIELD

**[0001]** The present teachings generally include a flapper assembly, a valve assembly that utilizes the flapper assembly and a method of forming the flapper assembly.

## 10 BACKGROUND

**[0002]** Fuel tank valves that function to vent vapors from a fuel tank are known. Generally, the vapors are vented to a canister that stores the vapors and is periodically purged. Fuel tank valves are configured to prevent liquid fuel in the fuel tank from entering the canister even when a vehicle is parked on a grade.

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## SUMMARY

**[0003]** The present teachings generally provide a flapper assembly for closing an outlet of a valve. The assembly includes a base support and a seal. The base support includes a first side and a second side opposing the first side. One of the first and second sides defines a recess. The seal is secured to the base support at the recess. The seal includes a sealing surface that faces away from the second side, and the sealing surface is configured to close the outlet of the valve.

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**[0004]** The present teachings also generally provide a valve assembly including a valve body and a float disposed inside the valve body. The valve body includes a seat defining an outlet. The float is movable between a first position and a second position relative to the valve body. The valve assembly further includes the flapper assembly as discussed above. The flapper assembly is coupled to the float and movable with the float between the first and second positions.

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**[0005]** The present teachings further provide a method of forming a flapper assembly. An elastomeric material is molded to a base support to form a seal disposed along a first side of the base support. Molding the elastomeric material to the base support also forms a connector in an aperture of the base support and a plug in a recess defined by a second side of the base support to secure the seal to the base support. The first and second sides of the base support oppose each other.

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[0006] The above features and advantages and other features and advantages of the present teachings are readily apparent from the following detailed description of the best modes for carrying out the present teachings when taken in connection with the accompanying drawings.

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## BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a schematic exploded view of a valve assembly that includes a schematic box to illustrate generally a flapper assembly.

10 [0008] FIG. 2 is a schematic cross-sectional view of the valve assembly of FIG. 1 having one example of the flapper assembly, with a float in a first position spaced from a seat.

[0009] FIG. 3 is a schematic top side view of the float and the flapper assembly of FIG. 2 coupled to the float.

[0010] FIG. 4 is a schematic side view of the float and the flapper assembly of FIG. 3.

[0011] FIG. 5 is a schematic top side view of the flapper assembly of FIGS. 3 and 4.

15 [0012] FIG. 6 is a schematic side edge view of the flapper assembly of FIG. 5.

[0013] FIG. 7 is a schematic top side view of a base support of the flapper assembly of FIGS. 5 and 6, with a seal removed.

[0014] FIG. 8 is a schematic side view of the base support of FIG. 7.

[0015] FIG. 9 is a schematic bottom side view of the base support of FIG. 7.

20 [0016] FIG. 10 is a schematic cross-sectional view of the base support taken from line 10-10 of FIG. 7, with a seal shown in phantom lines.

[0017] FIG. 11 is a schematic cross-sectional view of the valve assembly of FIG. 1 having another example of the flapper assembly, with the float in the first position spaced from the seat.

25 [0018] FIG. 12 is a schematic top side view of the float and the flapper assembly of FIG. 11 coupled to the float.

[0019] FIG. 13 is a schematic side view of the float and the flapper assembly of FIG. 12.

[0020] FIG. 14 is a schematic perspective top view of one flapper assembly that may be utilized in FIGS. 1, 11-13.

30 [0021] FIG. 15 is a schematic perspective top view of a base support of the flapper assembly of FIG. 14, with a seal removed.

[0022] FIG. 16 is a schematic perspective top view of the seal of the flapper assembly of FIG. 14.

[0023] FIG. 17 is a schematic perspective bottom view of the base support of FIG. 15.

[0024] FIG. 18 is a schematic perspective bottom view of the seal of FIG. 16.

[0025] FIG. 19 is a schematic perspective top view of yet another flapper assembly that may be utilized in FIGS. 1 and 11-13.

[0026] FIG. 20 is a schematic perspective top view of a base support of the flapper assembly of FIG. 19, with a seal removed.

[0027] FIG. 21 is a schematic perspective top view of the seal of the flapper assembly of FIG. 19.

[0028] FIG. 22 is a schematic perspective bottom view of the base support of FIG. 20.

[0029] FIG. 23 is a schematic perspective bottom view of the seal of FIG. 21.

[0030] FIG. 24 is another schematic perspective bottom view of the seal of FIG. 21.

#### DETAILED DESCRIPTION

[0031] Those having ordinary skill in the art will recognize that all directional references (e.g., above, below, upward, up, downward, down, top, bottom, left, right, vertical, horizontal, etc.) are used descriptively for the FIGS. to aid the reader's understanding, and do not represent limitations (for example, to the position, orientation, or use, etc.) on the scope of the disclosure, as defined by the appended claims.

[0032] Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a valve assembly 10 is generally shown in FIG. 1. In certain applications, the valve assembly 10 may be utilized with a tank of a vehicle, and the tank may be a fuel tank. Therefore, liquid fluid, such as fuel may be stored in the tank. It is to be appreciated that the valve assembly 10 may be utilized with tanks other than fuel tanks, and other liquid fluids may be stored in the tank.

[0033] In certain applications, the valve assembly 10 may be attached to the tank. The valve assembly 10 may be internally mounted to the tank or externally mounted to the tank. For the internally mounted valve assembly 10, the valve assembly 10 may be supported by a bracket inside the tank. For the externally mounted valve assembly 10, a portion of the valve assembly 10 may be disposed inside the tank and another portion of the valve assembly 10 may be disposed outside of the tank. The features of the valve assembly 10 discussed herein are the same for the internally mounted valve assembly 10 and the externally mounted valve assembly 10. It is to be appreciated that other components may be utilized with the internally or externally mounted valve assembly 10, such as, for example, components that couple the valve assembly 10 to various components outside of the tank.

[0034] Generally, the valve assembly 10 may allow vapors that build up in the tank to be vented out of the tank to a vapor control structure. The vapor control structure may store the vapor received from the tank and may be periodically purged. Therefore, under certain conditions, the vapors move or flow from the tank through the valve assembly 10 and into the vapor control structure. It is to be appreciated that the vapor control structure may be referred to as a canister, such as a charcoal canister.

[0035] Referring to FIGS. 1, 2, and 11, the valve assembly 10 includes a valve body 12 adapted to be attached to the tank. Simply stated, the valve body 12 is attached or mounted to the tank either internally or externally as discussed above. For the externally mounted valve assembly 10, a first portion of the valve body 12 is disposed inside of the tank and a second portion of the valve body 12 is disposed outside of the tank. Therefore, generally, the vapors vented out of the tank move or flow from the first portion into the second portion and out to the vapor control structure.

[0036] Turning to FIGS. 2 and 11, the valve body 12 includes a seat 14 that defines an outlet 16. The outlet 16 may vent the tank. For example, the outlet 16 may vent gaseous fluids, such as vapors, out of the tank. The gaseous fluids vented from the valve body 12 may then be guided or directed to the vapor control structure.

[0037] Continuing with FIGS. 2 and 11, the valve body 12 may define a cavity 18, and the seat 14 is disposed in the cavity 18. Therefore, the outlet 16 and the cavity 18 may be in fluid communication with each other, and in fluid communication with the vapor control structure to vent the vapors out of the tank and into the vapor control structure.

[0038] Again continuing with FIGS. 2 and 11, the seat 14 may be secured to a flange 20, and the flange 20 may be secured the valve body 12. In some configurations, as shown, the seat 14, the flange 20 and the valve body 12 may be a unitary, one-piece component. In other configurations, the seat 14, the flange 20 and the valve body 12 may be separate components integrally attached to one another.

[0039] Generally, the flange 20 and the seat 14 are disposed inside the cavity 18. The seat 14 and the flange 20 separate the cavity 18 into a first chamber 22 and a second chamber 24. The outlet 16 fluidly connects the first and second chambers 22, 24. Therefore, the vapors may move or flow from the first chamber 22 through the outlet 16 and into the second chamber 24, and from the second chamber 24 out to the vapor control structure. The seat 14 may present a face 26 which will be discussed further below.

[0040] Turning to FIGS. 1-4 and 11-13, the valve assembly 10 also includes a float 28 disposed inside the valve body 12. More specifically, the float 28 is disposed in the cavity 18

of the valve body 12. Specifically, the float 28 is disposed in the first chamber 22. The float 28 is movable between a first position and a second position relative to the valve body 12. Generally, the float 28 may be movable toward and away from the seat 14 in response to a liquid fluid level inside the tank. When the float 28 is combined with a biasing force, which is discussed further below, the float 28 is buoyant in the liquid fluid, such as fuel, stored in the tank. Thus, the float 28 may move toward and away from the seat 14 depending on the liquid fluid level of the fuel inside the tank. For example, if the liquid fluid level rises, the float 28 moves toward the seat 14. As another example, if the liquid fluid level descends, the float 28 moves away from the seat 14. The float 28 is shown in the first position in FIGS. 2 and 11.

**[0041]** Continuing with FIGS. 1-4 and 11-13, the float 28 may include a first end 30 and a second end 32 spaced from each other. Generally, the first end 30 faces the seat 14, and the second end 32 opposes the first end 30. More specifically, the first end 30 of the float 28 and the face 26 of the seat 14 face each other.

**[0042]** It is to be appreciated that the float 28 may optionally include one or more alignment features 34 disposed between the first and second ends 30, 32 to assist in aligning or centering the float 28 relative to the seat 14. The alignment features 34 may include one or more ribs that surround the float 28 and face an inner wall 36 of the valve body 12. For example, the alignment features 34 assist in aligning or centering the float 28 as the float 28 moves between the first and second positions, which aligns or centers the float 28 relative to the seat 14. Therefore, the alignment features 34 may minimize transverse movement of the float 28 relative to movement between the first and second positions. In other words, the ribs and the valve body 12 cooperate to minimize play in the float 28.

**[0043]** Additionally, it is to be appreciated that the valve body 12 may optionally include one or more fins disposed in the first chamber 22 such that the fins are disposed between the inner wall 36 of the valve body 12 and the float 28. The fins may also assist in aligning or centering the float 28 relative to the seat 14. Therefore, the ribs may selectively engage the valve body 12 or the fins during movement of the float 28 between the first and second positions. It is to be appreciated that the ribs and the fins may be any suitable configuration.

**[0044]** Referring to FIGS. 1, 2, and 11, the valve assembly 10 may further include a biasing member 38 engaging the second end 32 of the float 28 to continuously bias the float 28 toward the seat 14. In other words, the biasing member 38 applies the biasing force to the float 28 as discussed above. The biasing force overcomes the weight of the float 28 and

frictional forces between the float 28 engaging the inner wall 36/the fins as the float 28 moves between the first and second positions.

**[0045]** The valve body 12 may include an end cap 40 that generally closes the first chamber 22 to contain the float 28 inside the first chamber 22. The biasing member 38 may engage the end cap 40, and provides a surface for the biasing member 38 to react against. The end cap 40 remains stationary as the float 28 moves between the first and second positions. Furthermore, the end cap 40 is spaced from the seat 14, and the second end of the float faces the end cap 40.

**[0046]** It is to be appreciated that in a vehicle roll-over situation, the float 28 will move to the second position without the buoyancy of the float 28 affecting the float's position due to the biasing force applied to the float 28 overcoming the buoyancy of the float 28, the weight of the float 28, and the frictional forces between the float 28 engaging the fins. Therefore, when in the vehicle roll-over situation, the biasing member 38 assists in maintaining the float 28 in the second position. In certain configurations, the biasing member 38 may be a spring, such as a coil spring. It is to be appreciated that the biasing member 38 may be any suitable configuration to continuously bias the float 28 toward the seat 14.

**[0047]** Referring to FIGS. 2-4 and 11-13, a flapper assembly 42 is coupled to the float 28, and the flapper assembly 42 is configured to selectively close the outlet 16 of the seat 14. As best shown in FIGS. 1, 2 and 4, the float 28 may include a post 44 extending outwardly from the first end 30, and the flapper assembly 42 is coupled to the post 44. In certain configurations, the post 44 is elongated and extends toward the flange 20 or the second chamber 24. The flapper assembly 42 may be coupled to the first end 30 of the float 28 via the post 44. The flapper assembly 42 is movable with the float 28 between the first and second positions. Even though the flapper assembly 42 is movable with the float 28, the flapper assembly 42 also has some ability to move independently of the float 28. As such, the flapper assembly 42 is movable with and movable independently of the float 28 as discussed further below.

**[0048]** Referring to FIGS. 5, 10, 14, and 19, the flapper assembly 42 includes a base support 46 and a seal 48. Generally, the flapper assembly 42 is configured for closing the outlet 16 of a valve or the valve assembly 10. The base support 46 supports the seal 48, and the seal 48 selectively engages the seat 14 to selectively close the outlet 16. More specifically, the seal 48 may engage the face 26 of the seat 14. Therefore, the seal 48 is configured to close the outlet 16, which generally occurs when the float 28 is in the second position. Any of the flapper assembly 42 configurations of FIGS. 5, 10, 14 and 19 may be

used in FIGS. 1-4 and 11-13. For illustrative purposes, part of the seal 48 is shown in phantom lines in FIGS. 2 and 4 because the seal 48 may be configured to be flush with a top surface 50 of the base support 46 or may be configured to be elevated above the top surface 50 of the base support 46.

5   **[0049]**     Depending on the application, the valve assembly 10 may include the flapper assembly 42, and the generic box shown in phantom lines in FIG. 1 is to generally represent any of the flapper assemblies 42 discussed herein. As such, in certain configurations, the flapper assembly 42 may be coupled to the float 28 and is movable with the float 28 between the first and second positions. It is to be appreciated that the flapper assembly 42 may be  
10 utilized in other applications besides valve assemblies 10.

**[0050]**     With regard to the features that couple the flapper assembly 42 to the float 28, as best shown in FIGS. 5, 14, and 19, the base support 46 may include a coupler 52 spaced from the seal 48. In certain configurations, the coupler 52 may engage the post 44 to movably couple the base support 46 to the float 28 (see FIGS. 3 and 12). The coupler 52 and the base  
15 support 46 may be integrally formed to each other or formed of one piece. It is to be appreciated that the coupler 52 may be attached to the base support 46 by any suitable methods. It is to further be appreciated that the coupler 52 may be any suitable configuration and location.

**[0051]**     Continuing with FIGS. 5, 14, and 19, the coupler 52 of the base support 46 may  
20 include a first appendage 54 and a second appendage 56 spaced from each other to define an opening 58 between the first and second appendages 54, 56. The first and second appendages 54, 56 cooperate with each other to receive the post 44 therebetween. As best shown in FIGS. 3 and 12, when the flapper assembly 42 is coupled to the float 28, the post 44 is disposed in the opening 58, and the first and second appendages 54, 56 surround the post 44.  
25 Specifically, the post 44 is disposed in the opening 58 between the first and second appendages 54, 56 such that the coupler 52 couples the base support 46 to the float 28.

**[0052]**     Referring to FIGS. 5, 14, and 19, the first and second appendages 54, 56 may generally be a hook-shape configuration to surround the post 44. The first and second appendages 54, 56 may include a distal end spaced from each other to define a slot 60  
30 between the distal end of the first and second appendages 54, 56 for coupling the flapper assembly 42 to the post 44. Therefore, the flapper assembly 42 may be coupled to the post 44 by sliding the first and second appendages 54, 56 around the post 44 (the post 44 enters the slot 60) until the post 44 is disposed in the opening 58 and the appendages 54, 56 surround the post 44. The first and second appendages 54, 56 may flex under force away from one

another around the post 44 to increase the width of the slot 60 to attach or detach the base support 46 from the post 44, and then bias back once the post 44 is positioned in the slot 60 or completely removed from the post 44. It is to be appreciated that the coupler 52 may be any suitable configuration.

5    **[0053]**     Turning back to FIGS. 1-4 and 11-13, the float 28 may include a stop 62 attached to the post 44 to retain the flapper assembly 42 coupled to the float 28. Under certain conditions, the coupler 52 may selectively engage the stop 62. The stop 62 may be attached to an end of the post 44, and the stop 62 may be spaced from the first end 30 of the float 28. The stop 62 is larger than the opening 58 to prevent the flapper assembly 42 from decoupling  
10   from the float 28 by sliding off the end of the post 44. Respective sides 64 of the first and second appendages 54, 56 may selectively abut the stop 62 to limit independent movement of the flapper assembly 42 relative to the float 28. The independent movement of the flapper assembly 42 relative to the float 28 allows the flapper assembly 42 to quickly open and close without fluttering as discussed further below. For example, one or more sections of the stop  
15   62 and/or the post 44 may be flat, arcuate, sloped, flat or angled, etc., depending on the desired movement characteristics of the flapper assembly 42. It is to be appreciated that the stop 62 may be any suitable configuration.

**[0054]**     Referring back to the flapper assembly 42 and FIGS. 5, 14, and 19, the base support 46 may include a tail 66 spaced from the coupler 52. The tail 66 may extend  
20   outwardly away from the first and second appendages 54, 56 for assisting in balancing the base support 46. In other words, the tail 66 generally counter-balances the coupler 52. The tail 66 and the base support 46 may be integrally formed to each other or formed of one piece. It is to be appreciated that the tail 66 may be attached to the base support 46 by any suitable methods. It is to further be appreciated that the tail 66 may be any suitable  
25   configuration and location.

**[0055]**     As best shown in FIGS. 2 and 11, the seal 48 may include a sealing surface 68 that is spaced from the seat 14 when the float 28 is in the first position to allow fluid communication through the outlet 16, and the sealing surface 68 engages the seat 14 when the float 28 is in the second position to prevent fluid communication through the outlet 16. More  
30   specifically, the sealing surface 68 of the seal 48 is configured to selectively engages the seat 14 to close the outlet of the valve. Therefore, the sealing surface 68 may be configured to close the outlet 16. Referring to FIG. 6, a contact zone 70 is identified on the seal 48 to indicate the zone that the seat 14 may contact on the sealing surface 68. Additionally, the post 44 and the coupler 52 cooperate to position the sealing surface 68 of seal 48 relative to

the seat 14. As such, the post 44 and the coupler 52 may cooperate to minimize lateral movement of the sealing surface 68 relative to the seat 14 when the float 28 is in the second position.

**[0056]** As best shown in FIGS. 1, 2, and 4, in certain configurations, the float 28 may include a centering member 72 for centering the sealing surface 68 relative to the seat 14. In certain configurations, the centering member 72 is attached to the first end 30 of the float 28. The centering member 72 acts as a gimbal to position the sealing surface 68 of the seal 48 in a desired orientation relative to the face 26 of the seat 14. For example, the base support 46 gimbals to substantially align the sealing surface 68 with the face 26 of the seat 14 across the outlet 16. Therefore, when the sealing surface 68 engages the face 26, the outlet 16 is sealed by positioning or aligning the sealing surface 68. Generally, the base support 46 may gimbal at a relatively low force such that the seal 48 remains in the desired orientation relative to the face 26. As such, the centering member 72 may position the sealing surface 68 to assist in tightly sealing the outlet 16 when the sealing surface 68 is sealed against the seat 14 when the float 28 is in the second position. Gimbaling of the base support 46 may occur as the sealing surface 68 is proximal or close to engaging the face 26 of the seat 14. The centering member 72 may be any suitable configuration, and non-limiting examples may include a cone, a bulge, an arcuate protrusion, a pin, a cross or plus configuration, etc. The centering member 72 and the float 28 may be integrally formed to each other or formed of one piece. It is to be appreciated that the centering member 72 may be attached to the first end 30 of the float 28 by any suitable methods.

**[0057]** The seal 48 provides improved opening and closing features of the outlet 16. For example, the seal 48 fully opens quickly when the float 28 moves from the second position back to the first position to provide fully open fluid communication through the outlet 16.

Therefore, generally for all of the configurations herein, the seal 48 peels away from the seat 14 crisply such that the sealing surface 68 does not flutter to partially engage the seat 14 and thus partially cover the outlet 16. With regard to the configurations of FIGS. 14 and 19, the seal 48 may act as a ribbon seal, where part of the seal 48 is movable independently of the base support 46, and thus the seal 48 peels angularly from one end, instead of lifting straight up/down like FIG. 5. Therefore, the seal 48 in FIG. 5 is not movable independently of the base support 46.

**[0058]** As another example, the sealing surface 68 of the seal 48 seals against the seat 14 to close the outlet 16 when the float 28 is in the second position to prevent fluid communication through the outlet 16, and more specifically, minimize fuel or vapor in the

tank from entering the vapor control structure. Specifically, the sealing surface 68 engages the face 26 of the seat 14 when the float 28 is in the second position to close the outlet 16. Therefore, for example, when the float 28 is in the second position and the sealing surface 68 engages the seat 14 to seal the outlet 16, fuel or vapor in the tank is prevented from entering the vapor control structure. The seal 48 closes the outlet 16 quickly and crisply such that the seal 48 does not flutter to partially engage the seat 14 and thus partially cover the outlet 16.

**[0059]** If the vehicle is partially/fully rolled over, the float 28 may move to the second position and the sealing surface 68 will engage the seat 14 to seal the outlet 16, which minimizes or prevents fuel and vapor in the tank from entering into the vapor control structure. Furthermore, if the liquid fluid level is relatively high in the tank and/or the vehicle is on a grade, the liquid fluid or fuel shifts in the tank which may also cause the float 28 to move to the second position and the sealing surface 68 will engage the seat 14 to seal the outlet 16, which minimizes fuel and vapor in the tank from entering into the vapor control structure. In addition, if the vehicle is being driven such that the fuel is sloshing around in the tank, the sealing surface 68 may engage the face 26 of the seat 14 to seal the outlet 16 to minimize fuel in the tank from entering the vapor control structure. Therefore, for example, the sealing surface 68 and the seat 14 cooperate to seal the outlet 16 when the float 28 is in the second position to prevent liquid fluid or fuel in the tank from entering the vapor control structure.

**[0060]** The details of the flapper assembly 42 are discussed below and are best illustrated in FIGS. 5-10 and 14-24. FIGS. 5-10 illustrate one configuration of the flapper assembly 42, FIGS. 14-18 illustrate another configuration of the flapper assembly 42, and FIGS. 19-24 illustrate another configuration of the flapper assembly 42. The flapper assembly 42 of FIGS. 5-10 have the seal 48 secured to the base support 46 such that the seal 48 is not movable independently of the base support 46. The flapper assemblies 42 of FIGS. 14-24 have the seal 48 partially movable independent of the base support 46, and thus may act as the ribbon seal.

**[0061]** Referring to FIGS. 5, 6, 14, and 19, the base support 46 includes a first side 74 and a second side 76 opposing the first side 74. As best shown in FIGS. 9, 17, and 22, one of the first and second sides 74, 76 defines a recess 78. The seal 48 is secured to the base support 46 at the recess 78, which will be further discussed below. Generally, the sealing surface 68 faces away from the second side 76, and thus, the sealing surface 68 is disposed closer to the first side 74 than the second side 76.

**[0062]** In certain configurations, the second side 76 of the base support 46 defines the recess 78, and this recess 78 will be referred to as a first recess 78 in the below discussion. Furthermore, the first recess 78 is spaced from the first side 74 of the base support 46. As such, the first recess 78 does not extend completely through the base support 46. In certain configurations, the first recess 78 is further defined as a plurality of first recesses 78 spaced from each other, and will be discussed further below.

**[0063]** Referring to FIGS. 6, 8, 15, and 19, the base support 46 may also include an outer periphery 80 that spaces apart the first and second sides 74, 76. The outer periphery 80 may be at an outer side or edge of the base support 46. The outer periphery 80 defines a side boundary of the base support 46. The recess 78 may be spaced from the outer periphery 80. Also, the seal 48 may be spaced from the outer periphery 80. In certain embodiments, the coupler 52 of the base support 46 may be attached to the outer periphery 80. For example, the coupler 52 may be integrally formed to the base support 46 to attach the coupler 52 to the outer periphery 80. In other words, the coupler 52 may be integrally formed with the base support 46 such that the coupler 52 extends from the outer periphery 80. Furthermore, the tail 66 of the base support 46 may be attached to the outer periphery 80. The tail 66 may be integrally formed to the base support 46 to attach the tail 66 to the outer periphery 80. In other words, the tail 66 may be integrally formed with the base support 46 such that the tail 66 extends from the outer periphery 80.

**[0064]** As best shown in FIGS. 9, 17, and 22, the first recess 78 is open to one side (such as the second side 76 in certain configurations), and the first recess 78 may be various configurations. For example, the first recess 78 may be oval, circular, elongated, etc. Therefore, the base support 46 may include a first wall 82 to define a first boundary of the first recess 78. Generally, the first wall 82 may be adjoined to the second side 76 and spaced from the first side 74. As such, the first boundary is disposed closer to the second side 76 of the base support 46 than to the first side 74 of the base support 46.

**[0065]** Referring to FIGS. 10, 18, 23, and 24, the seal 48 may include a plug 84 disposed in the first recess 78 to secure the seal 48 to the base support 46. More specifically, the plug 84 may be disposed inside the first wall 82 of the base support 46 to secure the seal 48 to the base support 46. Generally, the plug 84 and the sealing surface 68 are disposed along opposite sides of the base support 46. The plug 84 is shown in phantom lines in FIG. 10 for illustrative purposes.

**[0066]** Furthermore, referring to FIGS. 10, 17, and 22, the first wall 82 may include a bottom portion 86 and a side portion 88 disposed in a different orientation than the bottom

portion 86. The plug 84 may abut the bottom portion 86 and the side portion 88 of the first wall 82. The plug 84 will take the shape of the first recess 78 due to the way that the seal 48 is attached to the base support 46, which is discussed further below. The side portion 88 of the first wall 82 defines the first boundary.

5   **[0067]**     As best shown in FIGS. 9, 10, 17, and 22, the base support 46 may define an aperture 90 that connects to the first recess 78. In certain configurations, one aperture 90 is defined by the base support 46, and in other configurations, the aperture 90 is further defined as a plurality of apertures 90 spaced from each other, and the apertures 90 are defined by the base support 46. When using more than one aperture 90, the apertures 90 of the base support  
10   46 connect to the first recess 78. Therefore, one or more apertures 90 may be connected to one first recess 78. The option of having more than one of the apertures 90 is illustrated in FIG. 9, and in phantom lines in FIG. 22.

**[0068]**     In certain configurations, such as FIG. 9, the apertures 90 are spaced apart into a first group 91 of apertures 90 and a second group 93 of apertures 90, with one of the first  
15   recesses 78 surrounding the first group 91 of apertures 90 and another one of the first recesses 78 surrounding the second group 93 of apertures 90, and so on depending on the number of apertures 90 and first recesses 78. Depending on the number of apertures 90 being used, the first and second groups 91, 93 may change, and additional groups of apertures 90 may also be used. Referring to FIG. 7, for illustrative purposes, the first and second groups 91, 93 each  
20   include a pair or two apertures 90.

**[0069]**     Generally, the aperture(s) 90 are utilized to attach the seal 48 to the base support 46 by connecting the part of the seal 48 along the first side 74 of the base support 46 with the plug 84 along the second side 76 of the base support 46. The aperture(s) 90 may be the same configuration or different configurations from each other. Also, the aperture(s) 90 may be  
25   any suitable configuration.

**[0070]**     Generally, the first recess 78 surrounds the aperture 90, and in certain configurations, the first recess 78 surrounds more than one aperture 90. Therefore, the aperture(s) 90 are fluidly connected to the respective first recess(es) 78. Furthermore, the first side 74 of the base support 46 may define the aperture(s) 90.

30   **[0071]**     Generally, the aperture(s) 90 is spaced from the second side 76 (due to the apertures 90 being disposed inside the first recess 78). More specifically, the bottom portion 86 of the first wall 82 may define the aperture(s) 90. The bottom portion 86 of the first wall 82 is spaced from the second side 76. Therefore, the aperture(s) 90 are spaced from the second side 76 of the base support 46. In other words, the aperture(s) 90 are not defined in

the second side 76. The apertures 90 may be in any suitable arrangement relative to each other, and in certain configurations, more than one of the apertures 90 may be grouped together or evenly spaced apart from each other, etc.

**[0072]** Referring to FIGS. 10, 18, 23, and 24, the seal 48 may include a connector 92

5 disposed in the aperture 90 to secure the seal 48 to the base support 46. The connector 92 is connected to the plug 84. Therefore, the sealing surface 68 is connected to the plug 84 via the connector 92.

**[0073]** In certain configurations, the connector 92 is further defined as a plurality of connectors 92 spaced from each other, which are disposed in additional apertures 90 such as

10 the apertures 90 illustrated in phantom lines in FIG. 22 or the apertures 90 of FIGS. 7 and 9. One of the connectors 92 may be disposed in the respective apertures 90 to secure the seal 48 to the base support 46. Even though the connectors 92 are not shown in all of the figures, each of the apertures 90 illustrated in FIGS. 7, 9, 15, 17, 20, and 22, will have one of the connectors 92 disposed therein. In certain configurations, each of the connectors 92 may be

15 connected to one plug 84 (see FIG. 22 where the apertures 90 are disposed in one first recess 78). Alternatively, the plug 84 may be defined as a plurality of plugs 84 spaced from each other, with one of the plugs 84 connected to one or more of the connectors 92, and so on depending on the number of connectors 92 and the number of first recesses 78 (see FIGS. 7 and 9). The connectors 92 will take the shape of the respective apertures 90 due to the way

20 that the seal 48 is attached to the base support 46, which is discussed further below.

**[0074]** An outer surface 94 of the plug 84 may be recessed or flush with the second side 76 of the base support 46. In other words, the plug 84 does not protrude beyond the second side 76 as best indicated in FIG. 2, 4, 11, and 13 where the plug 84 is not visible as protruding beyond the second side 76.

25 **[0075]** Turning back to the base support 46, as best shown in FIGS. 7, 15, and 20, the outer periphery 80 may include a first distal end 96 and a second distal end 98 spaced apart relative to a central axis 100. Furthermore, the coupler 52 and the tail 66 are spaced from each other axially relative to the central axis 100. In certain configurations, the central axis 100 intersects the tail 66 and the opening 58 between the first and second appendages 54, 56.

30 Additionally, the outer periphery 80 may include a first outer side 102 and a second outer side 104 spaced apart and disposed between the first and second distal ends 96, 98 transverse to the central axis 100. In certain configurations, the first recess 78 is disposed closer to the coupler 52 than to the tail 66. More specifically, the first recess 78 may be disposed adjacent to the first distal end 96. Additionally, in certain configurations, the coupler 52 may extend

outwardly from the outer periphery 80 along the first distal end 96, and the tail 66 may extend outwardly from the second distal end 98.

**[0076]** The location of the first recess 78 may change depending on the desired application, and the figures are for illustrative purposes, but some illustrated examples are discussed next. Referring to FIGS. 7 and 9, the first recess 78 is spaced from the central axis 100 such that the central axis 100 does not intersect the first recess 78. Now turning to FIGS. 15 and 20, the first recess 78 is disposed proximal to the coupler 52 such that the central axis 100 intersects the first recess 78.

**[0077]** More specifically, when referring to FIG. 9, more than one first recess 78 is disposed along opposite sides of the central axis 100. In this configuration, each of the first recesses 78 may be spaced from the central axis 100. In certain configurations, the first recesses 78 oppose each other relative to opposite sides of the central axis 100 (again see FIG. 9). As such, some of the first recesses 78 may be mirror images to each other relative to opposite sides of the central axis 100.

**[0078]** Furthermore, in certain configurations, the first recess 78 is elongated between the first and second outer sides 102, 104 (compare FIGS. 17 and 22). In other words, in certain configurations, the first recess 78 is elongated across the base support 46 from the first and second outer sides 102, 104. Furthermore, one or more apertures 90 may be surrounded via the elongated first recess 78 (again, the phantom lines illustrate the optional additional apertures 90). In other configurations, optionally, which includes FIGS. 9, 17, and 22) the base support 46 may define a plurality of first recesses 78 along the second side 76 of the base support 46 that are spaced from each other, with one or more apertures 90 being surrounded via respective first recesses 78. When the first recess 78 is elongated or more than one spaced apart first recesses 78 are used, these features may prevent rotation of the seal 48 about the aperture 90 of the base support 46 in FIGS. 14-24, as well as secure the seal 48 to the base support 46 for all of the configurations discussed herein. Furthermore, when the first recess 78 is elongated and more than one of the apertures 90 are disposed in the first recess 78, these features may also prevent rotation of the seal 48 in FIGS. 14-24.

**[0079]** Turning to FIGS. 7 and 10, the second side 76 of the base support 46 defines the first recess 78, and the first side 74 of the base support 46 defines a second recess 106. The seal 48 is disposed inside of the second recess 106, and thus, the second recess 106 also assists in securing the seal 48 to the base support 46. The aperture 90 is disposed between the first and second recesses 78, 106 such that the aperture 90 connects the first and second

recesses 78, 106. Therefore, the first and second recesses 78, 106 are spaced from each other via the aperture(s) 90.

**[0080]** Continuing with FIGS. 7 and 10, the second recess 106 may be various configurations, and open to one side (such as the first side 74 of the base support 46 in certain configurations). For example, the recess 78 may be stepped or have a ledge to present different levels of the second recess 106. Therefore, the base support 46 may include a first wall portion 108 to define a first boundary of the second recess 106. In certain configurations, the base support 46 may also include a second wall portion 110 adjacent to the first wall portion 108 to define a second boundary of the second recess 106. Generally, the first wall portion 108 is disposed between one of the first and second sides 74, 76 and the second wall portion 110. For example, the first wall portion 108 may be disposed between the first side 74 and the second wall portion 110. As such, the first boundary of the second recess 106 is disposed closer to the first side 74 of the base support 46 than the second boundary of the second recess 106; and additionally, the second boundary of the second recess 106 is disposed closer to the second side 76 of the base support 46 than the first boundary of the second recess 106. Continuing with the configuration of FIGS. 5-10, the seal 48 is disposed in the second recess 106 and secured to the base support 46 via the second recess 106 and the plugs 84. In certain configurations, the seal 48 may abut the first wall portion 108 of the base support 46. Additionally, the seal 48 may abut the second wall portion 110 of the base support 46. In certain configurations, the seal 48 may abut the first and second wall portions 82, 84 of the base support 46. Referring to FIG. 10, the first recess 78 and the aperture(s) 90 are both spaced from the second wall portion 110.

**[0081]** As discussed above, FIG. 6 identifies the contact zone 70 on the seal 48 to indicate the zone that the seat 14 may contact on the sealing surface 68. The sealing surface 68 is also positioned within the contact zone 70. The sealing surface 68 of the seal 48 may at least partially overlap the second wall portion 110. Additionally, the sealing surface 68 of the seal 48 may optionally overlap the first wall portion 108.

**[0082]** Referring to FIG. 10, the first and second wall portions 108, 110 may each include a bottom wall portion 112 and a side wall portion 114 disposed in a different orientation than the bottom wall portion 112. The respective side wall portion 114 of the first and second walls 108, 110 define the first and second boundaries of the second recess 106 respectively. Additionally, the first and second wall portions 108, 110 may be different configurations. The first wall portion 108 may surround the second wall portion 110. The second wall portion 110 may at least partially separate the first wall portion 108 relative to a length of the

base support 46 between the coupler 52 and the tail 66. In other words, the second wall portion 110 may separate the first wall portion 108 relative to opposite sides of the central axis 100.

**[0083]** Continuing with FIG. 7, in certain configurations, the first wall portion 108 may define the aperture(s) 90. More specifically, the bottom wall portion 112 of the first wall portion 108 may define the aperture(s) 90. Furthermore, the aperture(s) 90 are spaced from the second wall portion 110. In other words, the aperture(s) 90 are not defined in the second wall portion 110. The second wall portion 110 may be disposed between certain groups of the apertures 90. The apertures 90 may be in any suitable arrangement relative to each other, and in certain configurations, more than one of the apertures 90 may be grouped together. For example, one group 91 of the apertures 90 may be separated from another group 93 of the apertures 90 by the second wall portion 110. In other configurations, some of the groups 91, 93 of the apertures 90 are disposed on the same side relative to the central axis 100.

**[0084]** For the configurations of FIGS. 14 and 19, while the plug 84 and the connector 92 secure the seal 48 to the base support 46, a portion of the seal 48 is movable independently of the base support 46. Specifically, the portion of the seal 48 away from the connector(s) 92 may be movable away from the first side 74 of the base support 46. As such, the seal 48 acts as the ribbon seal.

**[0085]** Therefore, in the configurations of FIGS. 14 and 19, part of the seal 48 may abut the first side 74. In other words, part of the seal 48 is not recessed into the first side 74 of the base support 46. As such, as best shown in FIGS. 15 and 20, the first side 74 of the base support 46 does not define the second recess 106 of FIG. 7. Referring to FIGS. 18, 23, and 24, the seal 48 may include a back surface 116 that opposes the sealing surface 68. The back surface 116 faces the base support 46, and specifically faces the first side 74 of the base support 46. Part of the back surface 116 of the seal 48 is movable relative to the first side 74. The sealing surface 68 may peel away from the seat 14 such that the sealing surface 68 may gradually lift up from the base support 46, and more specifically may lift up from the first side 74 of the base support 46, from one end of the seal 48 closest to the second distal end 98.

**[0086]** Continuing with FIGS. 14-24, the plug 84 is coupled to the back surface 116 of the seal 48 via the connector 92. The back surface 116 is substantially flat except where the plug 84 connects to the back surface 116. Furthermore, the first side 74 of the base support 46 is substantially flat to complement the back surface 116 of the seal 48. The connector 92 connects the plug 84 to the back surface 116 of the seal 48.

**[0087]** Turning to FIGS. 14 and 15, the base support 46 may optionally include a plurality of protrusions 118 spaced from each other and each of the protrusions 118 protrudes outwardly from the first side 74 of the base support 46. In certain configurations, the protrusions 104 protrude outwardly from the first side 74 at the first distal end 96. The seal 48 may abut the protrusions 118, and more specifically an edge of the seal 48 may abut the protrusions 118. The engagement between the seal 48 and the protrusions 118 prevent rotation of the sealing surface 68 about the aperture 90 of the base support 46. For illustrative purposes, the optional protrusions 118 are also shown in phantom lines in FIGS. 11-13.

**[0088]** Referring to FIGS. 14 and 16, in certain configurations, the seal 48 may optionally define a plurality of cutouts 120, and the cutouts 120 may be spaced from each other. The cutouts 120 may be defined by the edge of the seal 48. One of the protrusions 118 are disposed in the respective cutouts 120. Therefore, the protrusions 118 and the cutouts 120 cooperate with each other. The engagement between the protrusions 118 and the cutouts 120 prevent rotation of the sealing surface 68 about the aperture 90 of the base support 46.

**[0089]** For all of the configurations discussed herein, the seal 48 may be secured to the base support 46 by a molding process. Therefore, the present disclosure also provides a method of forming the flapper assembly 42. Generally, for each of the configurations discussed herein, an elastomeric material is molded to the base support 46 to form the seal 48 that is disposed along the first side 74 of the base support 46. During this molding process, the elastomeric material also forms the connector 92 in the aperture 90 of the base support 46 and the plug 84 in the first recess 78 defined by the second side 76 of the base support 46 to secure the seal 48 to the base support 46. Each of the configurations are discussed further below with regard to the method.

**[0090]** For all of the configurations discussed herein, the base support 46 is formed of one or more material(s) different from the seal 48. Therefore, different materials are bonded together during the molding process. Generally, the base support 46 is formed of one or more material(s) that is more rigid than the seal 48. The base support 46 may be formed of a polymer material or any other suitable material, and is formed before the molding process with the seal 48. Non-limiting examples that the base support 46 may be formed of include plastic, nylon, metal, etc.

**[0091]** Referring to FIGS. 2-10, the seal 48 may be secured to the base support 46 by overmolding the seal 48 to the base support 46. The material(s) used to form the seal 48, the plug(s) 84, and the connector(s) 92 flow into the first recess(es) 78, the second recess 106, and the aperture(s) 90; and therefore, the seal 48 with the sealing surface 68, the plug(s) 84

and the connector(s) 92 are formed during the molding process, and contour to the configurations of the first recess(es) 78, the second recess 106, and the aperture(s) 90 when the material(s) cures. Since the first recess(es) 78 are larger the apertures 90, the plug 84 that form in the respective first recess 78 secure the seal 48 to the base support 46 such that the seal 48 cannot pull away or detach from the base support 46. Furthermore, in the configuration illustrated, each of the plugs 84 connect with one or more of the connector(s) 92, and thus due to this configuration, again, the plugs 84 secure the seal 48 to the base support 46 such that the seal 48 cannot pull away or detach from the base support 46.

**[0092]** Continuing with FIGS. 2-10, the method may include overmolding the elastomeric material into the first recess 78 defined by the second side 76 of the base support 46, and the second recess 106 defined by the first side 74 of the base support 46 to form the seal 48 secured to the base support 46. The seal 48 is disposed inside the second recess 106, and the aperture 90 is disposed between the first and second recesses 78, 106 and the aperture 90 connects the first and second recesses 78, 106. Therefore, the seal 48 is formed of the elastomeric material, and the seal 48 is secured to the base support 46 by overmolding the elastomeric material to the base support 46 to form the seal 48 in the second recess 106, the connectors 92 in the respective groups 91, 93 of the apertures 90 and the plugs 84 in the respective first recesses 78. For example, the seal 48 may be a fluorinated elastomer. Non-limiting examples of the elastomeric material of the seal 48 include fluorosilicone, fluorocarbon, etc. It is to be appreciated that any other suitable elastomeric material may be utilized. The seal 48, and specifically, the sealing surface 68, provides an elastomeric sealing interface with the seat 14 so the desired sealing requirement is met without affecting other characteristics of the valve assembly 10.

**[0093]** Turning to FIGS. 11-24, the seal 48 may be secured to the base support 46 by molding the seal 48 to the base support 46. The material(s) used to form the seal 48, which includes the sealing surface 68, the connector(s) 92 and the plug(s) 84 are formed during the molding process. Some of the material(s) abut the first side 74 of the base support to form the seal 48 when the material(s) cure, and some of the material(s) flow into the first recess(es) 78 and the aperture(s) 90; and therefore, form the connector(s) 92 and the plug(s) 84, and contour to the configurations of the first recess 78 and the apertures 90 when the material(s) cures. Since the first recess(es) 78 are larger the aperture(s) 90, the plug(s) 84 that form in the respective first recess(es) 78 secure the seal 48 to the base support 46 such that the seal 48 cannot pull away or detach from the base support 46. Furthermore, if more than one of the apertures 90 are used, each of the connectors 92 disposed in the respective one of the

apertures 90 reduce rotation of the sealing surface 68 relative to the first side 74 of the base support 46.

**[0094]** Continuing with FIGS. 11-24, the method may include molding the elastomeric material into the first recess 78 and the aperture 90 of the base support 46 to form the seal 48 secured to the base support 46. Molding the seal 48 creates part of the seal 48 that is disposed along the first side 74 of the base support 46 and is movable relative to the first side 74. Therefore, the seal 48 is formed of the elastomeric material, and the seal 48 is secured to the base support 46 by molding the elastomeric material to the base support 46 to form the back surface 116 of the seal 48 that abuts the first side 74, the plug(s) 84 in the first recess(es) 78, the connector(s) 92 in the aperture(s) 90. The back surface 116 of the seal 48 is not bonded to the first side 74 of the base support 46, which allows the sealing surface 68 to act as the ribbon seal.

**[0095]** Continuing with FIGS. 11-24, the seal 48 may be overmolded to the base support 46 without chemically bonding the seal 48 to the base support 46. Therefore, with this overmolding process, the seal 48 is attached to the base support 46 via the first recess(es) 78 and the aperture(s) 90. As such, the seal 48 is not attached to the base support 46 between the back surface 116 of the seal 48 and the first side 74 of the base support 46; which thus provides that the sealing surface 68 is movable independently of the base support 46.

**[0096]** In another process, continuing with FIGS. 11-24, instead of overmolding as discussed immediately above, the seal 48 may be compression molded. After the seal 48 is formed via the compression molding, then the seal 48 may be manually attached to the base support 46 via the plug(s) 84, the connector(s) 92, the aperture(s) 90 and the first recess(es) 78. In this process, the seal 48 is not attached to the base support 46 between the back surface 116 of the seal 48 and the first side 74 of the base support 46; which thus provides that the sealing surface 68 is movable independently of the base support 46.

**[0097]** In the configurations of FIGS. 11-24, the seal 48 may be a fluorinated elastomer. Non-limiting examples of the elastomeric material of the seal 48 include fluorosilicone, fluorocarbon, etc. It is to be appreciated that any other suitable elastomeric material may be utilized. The seal 48, and specifically, the sealing surface 68, provides an elastomeric sealing interface with the seat 14 so the desired sealing requirement is met without affecting other characteristics of the valve assembly 10.

**[0098]** Optionally, various internal components of the valve assembly 10 discussed herein may be utilized in a valve body of another configuration. For example, the float 28 (with the post 44 and the centering member 72, etc.) and the flapper assembly 42 may be

designed to fit inside another valve body. Additionally, the valve assembly 10 may include other components or features, and one non-limiting example includes a head valve or pressure relief valve which may be configured to open the outlet 16 to relieve pressure in the tank under certain conditions, and one non-limiting example may be during refueling of the tank.

**[0099]** While the best modes for carrying out the many aspects of the present teachings have been described in detail, those familiar with the art to which these teachings relate will recognize various alternative aspects for practicing the present teachings that are within the scope of the appended claims.

## CLAIMS

1. A flapper assembly for closing an outlet of a valve, the flapper assembly comprising:

5 a base support including a first side and a second side opposing the first side, and one of the first and second sides defines a recess; and

a seal secured to the base support at the recess, and the seal includes a sealing surface that faces away from the second side, and the sealing surface is configured to close the outlet of the valve.

10 2. The flapper assembly as set forth in claim 1 wherein the second side of the base support defines the recess, and wherein the seal includes a plug disposed in the recess to secure the seal to the base support.

15 3. The flapper assembly as set forth in claim 2 wherein the base support defines an aperture that connects to the recess, and wherein the seal includes a connector disposed in the aperture to secure the seal to the base support.

20 4. The flapper assembly as set forth in claim 3 wherein the recess is spaced from the first side of the base support, and wherein the recess surrounds the aperture.

25 5. The flapper assembly as set forth in claim 4 wherein the recess is further defined as a first recess, and wherein the second side of the base support defines the first recess, and the first side of the base support defines a second recess, and wherein the seal is disposed inside of the second recess, and wherein the aperture is disposed between the first and second recesses such that the aperture connects the first and second recesses.

30 6. The flapper assembly as set forth in claim 5 wherein:  
the base support includes a first wall portion to define a first boundary of the second recess;

the base support includes a second wall portion adjacent to the first wall portion to define a second boundary of the second recess;

the second boundary is disposed closer to the second side of the base support than the first boundary; and

35 the seal abuts the first and second wall portions of the base support.

7. The flapper assembly as set forth in claim 3 wherein the aperture is further defined as a plurality of apertures spaced from each other, and wherein the recess surrounds each of the apertures.

5

8. The flapper assembly as set forth in claim 7 wherein the connector is further defined as a plurality of connectors spaced from each other, and wherein one of the connectors disposed in the respective apertures to secure the seal to the base support.

10

9. The flapper assembly as set forth in claim 3 wherein the seal includes a back surface opposing the sealing surface, and wherein the back surface faces the first side and part of the back surface of the seal is movable relative to the first side.

10. The flapper assembly as set forth in claim 9 wherein the base support includes a plurality of protrusions spaced from each other and each of the protrusions protrudes outwardly from the first side of the base support, and wherein the seal abuts the protrusions.

15

11. The flapper assembly as set forth in claim 1 wherein the base support includes an outer periphery that spaces apart the first and second sides, and wherein the recess is spaced from the outer periphery.

20

12. The flapper assembly as set forth in claim 11 wherein:  
the base support includes a coupler attached to the outer periphery;  
the base support includes a tail attached to the outer periphery; and  
the coupler and the tail are spaced from each other axially relative to a central axis.

25

13. The flapper assembly as set forth in claim 12 wherein the recess is disposed closer to the coupler than to the tail.

30

14. The flapper assembly as set forth in claim 13 wherein the recess is disposed proximal to the coupler such that the central axis intersects the recess.

15. The flapper assembly as set forth in claim 12 wherein the recess is spaced from the central axis such that the central axis does not intersect the recess.

35

16. The flapper assembly as set forth in claim 15 wherein:

the recess is further defined as a plurality of recesses spaced from each other;  
the base support defines a plurality of apertures spaced apart into a first group of apertures and a second group of apertures;  
one of the recesses surrounds the first group of apertures and another one of the  
5 recesses surrounds the second group of apertures; and  
each of the recesses is spaced from the central axis.

17. The flapper assembly as set forth in claim 16 wherein the recesses oppose each other relative to opposite sides of the central axis.

10 18. A valve assembly comprising:  
a valve body including a seat defining an outlet;  
a float disposed inside the valve body and movable between a first position and a  
second position relative to the valve body;  
15 a flapper assembly coupled to the float and movable with the float between the first  
and second positions, wherein the flapper assembly comprises:  
a base support including a first side and a second side opposing the first side,  
and one of the first and second sides defines a recess; and  
a seal secured to the base support at the recess, and the seal includes a sealing  
20 surface that faces away from the second side, and the sealing surface is configured to close  
the outlet of the valve.

19. A method of forming a flapper assembly, the method comprising:  
molding an elastomeric material to a base support to form a seal disposed along a first  
25 side of the base support; and  
wherein molding the elastomeric material to the base support also forms a connector  
in an aperture of the base support and a plug in a recess defined by a second side of the base  
support to secure the seal to the base support, wherein the first and second sides of the base  
support oppose each other.

30 20. The method as set forth in claim 19 wherein molding the elastomeric material  
further includes molding the elastomeric material into a second recess defined by the first  
side of the base support such that the seal is disposed inside of the second recess, and wherein  
the aperture is disposed between the recesses and connects the recesses.

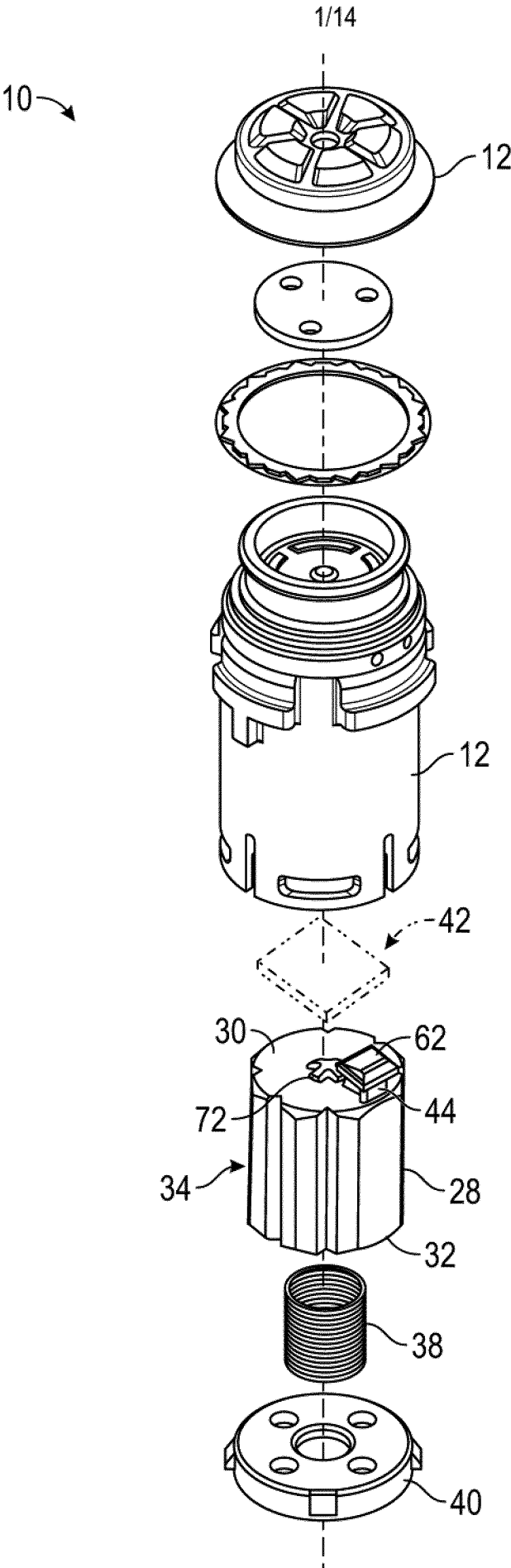


FIG. 1

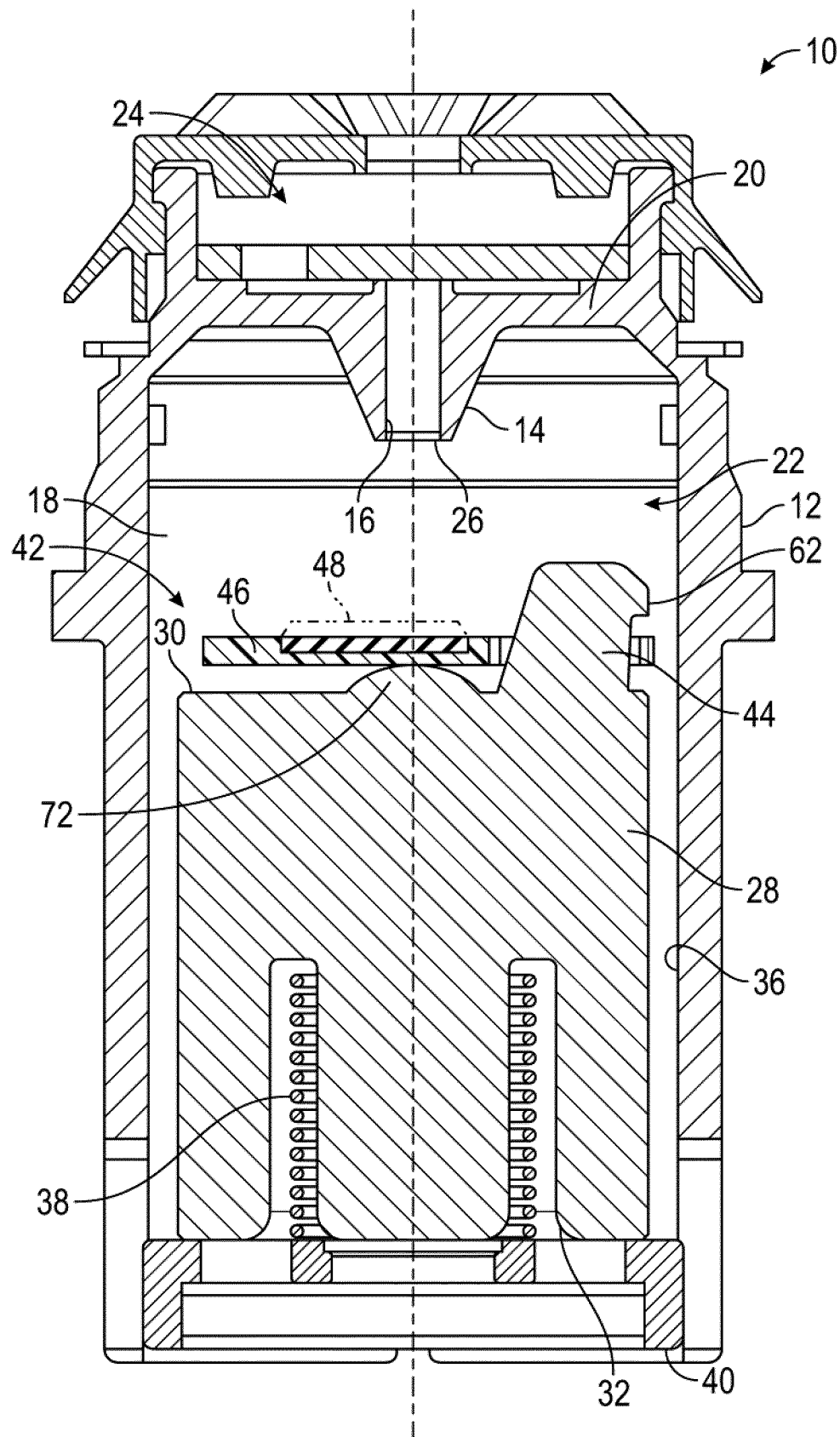


FIG. 2

3/14

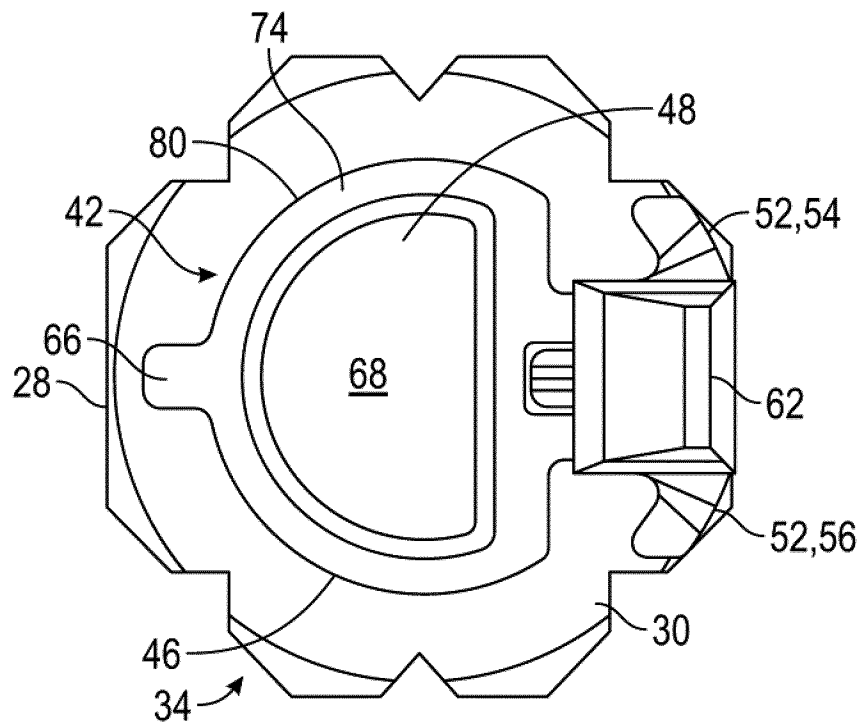


FIG. 3

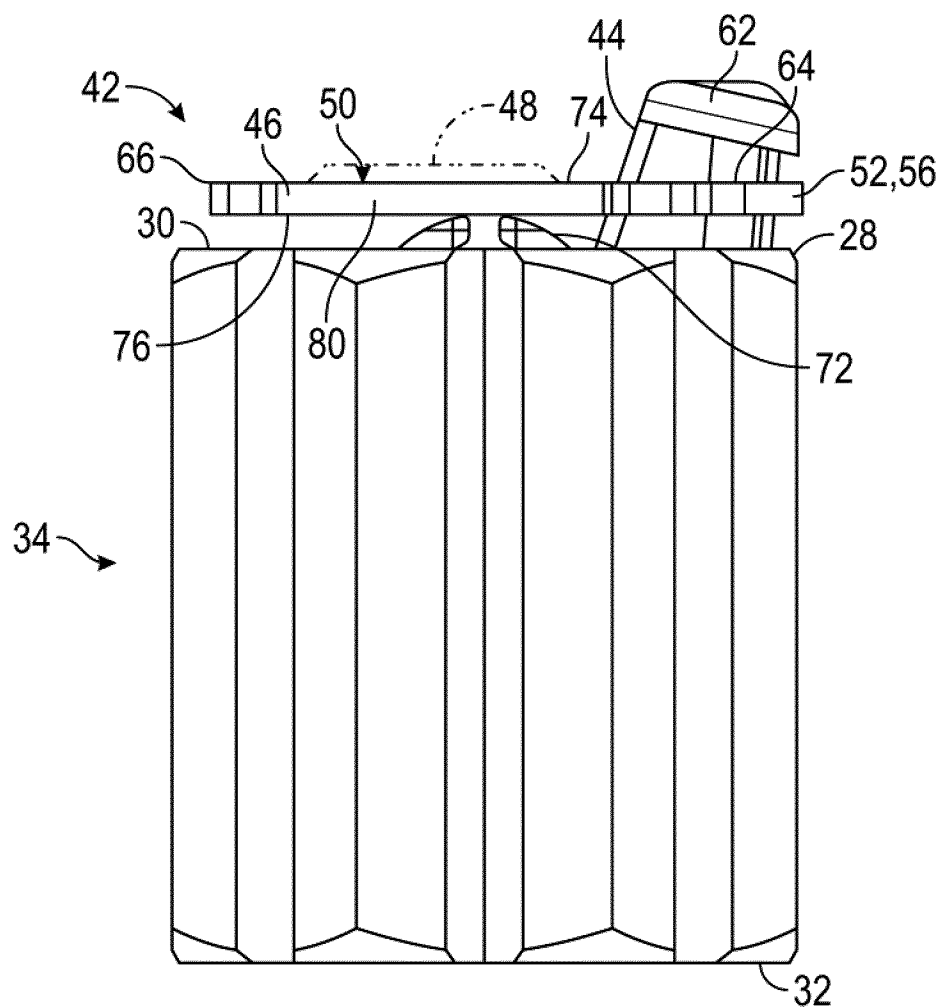


FIG. 4

4/14

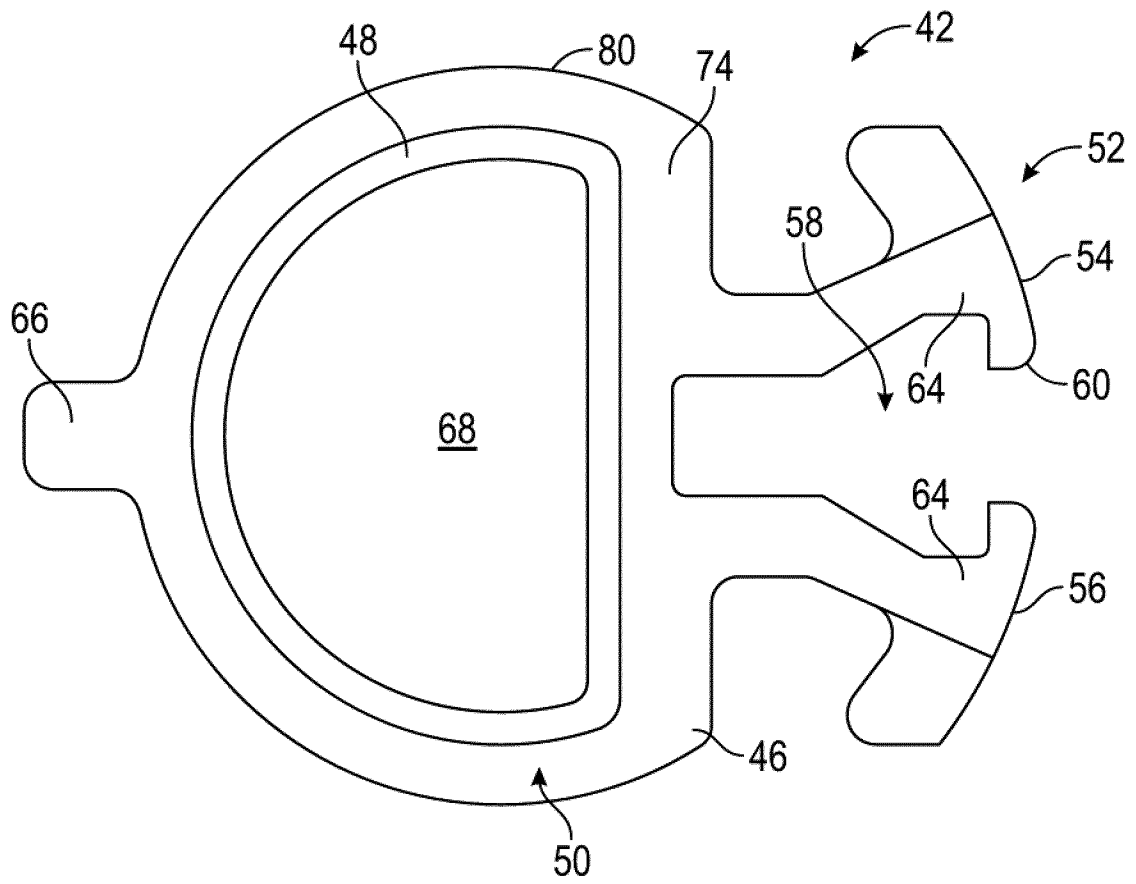


FIG. 5

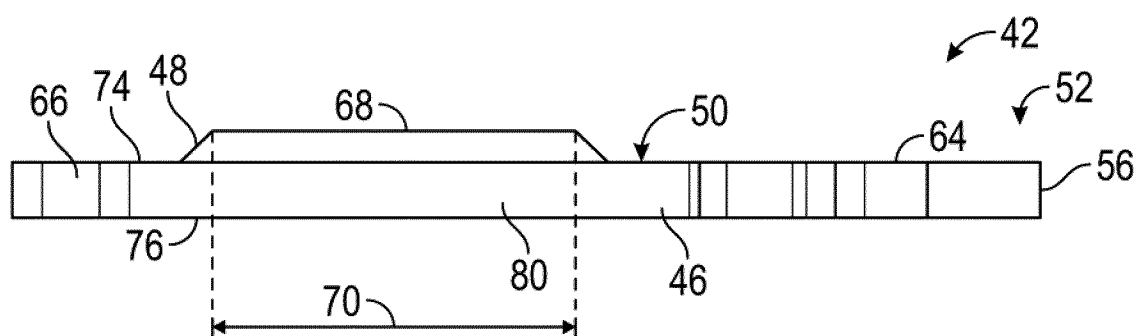


FIG. 6

5/14

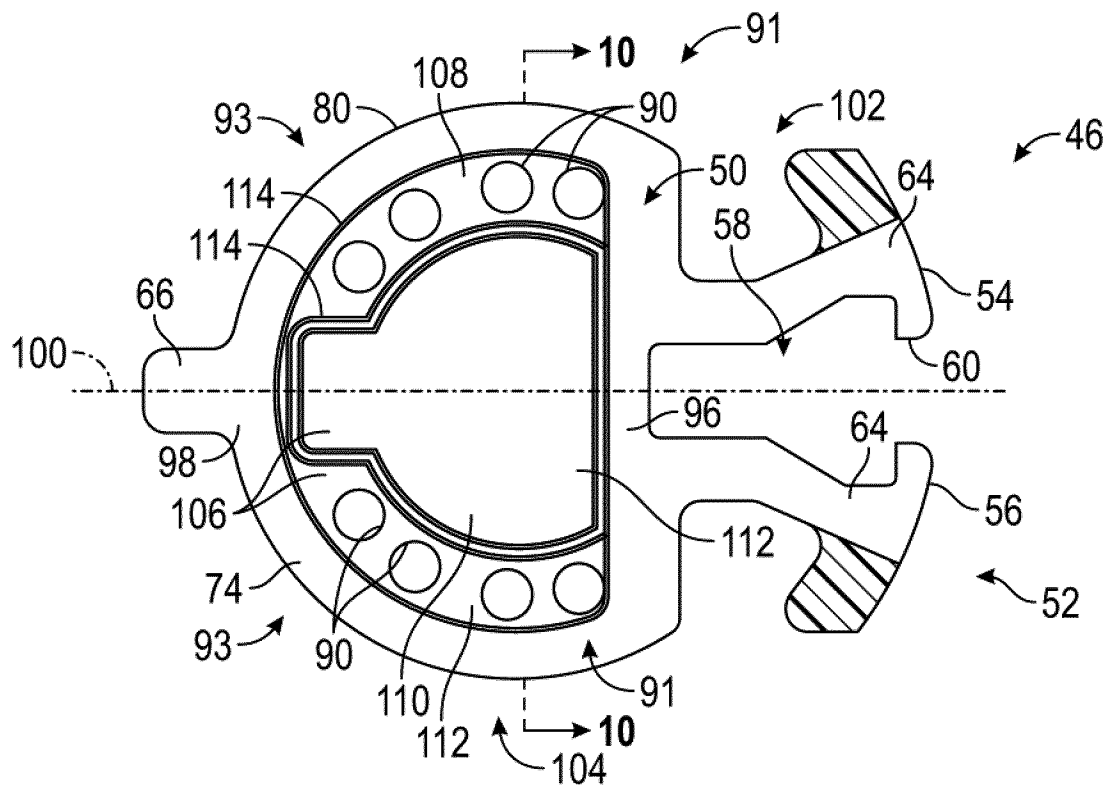


FIG. 7

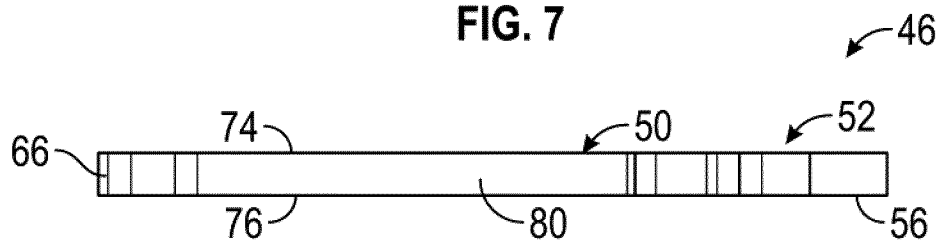


FIG. 8

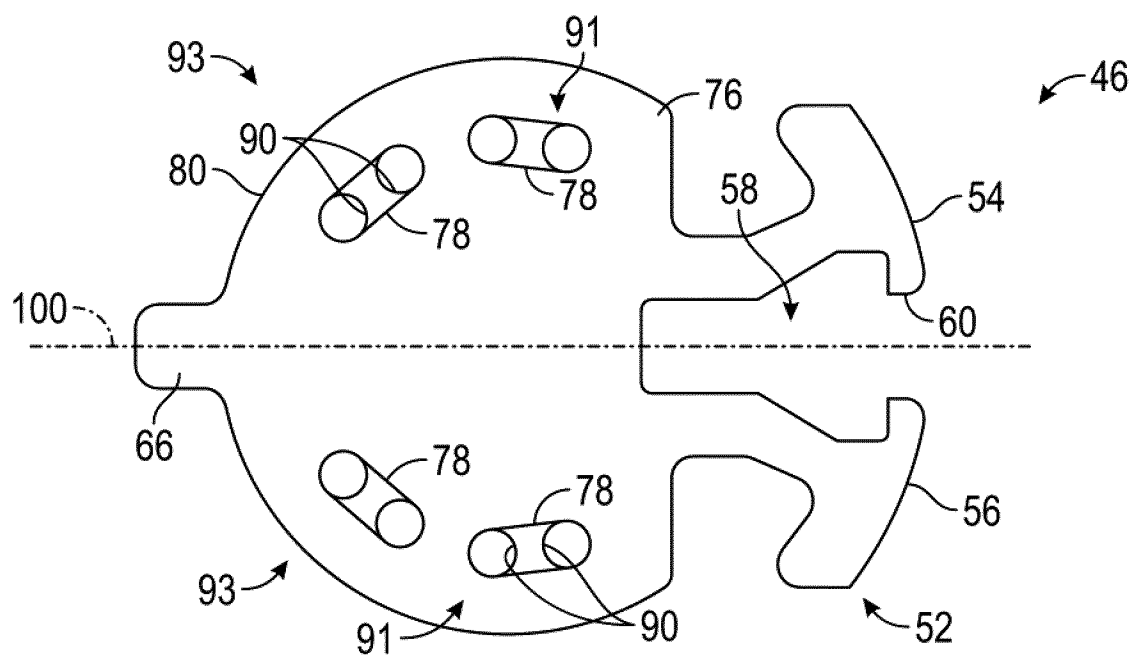


FIG. 9

6/14

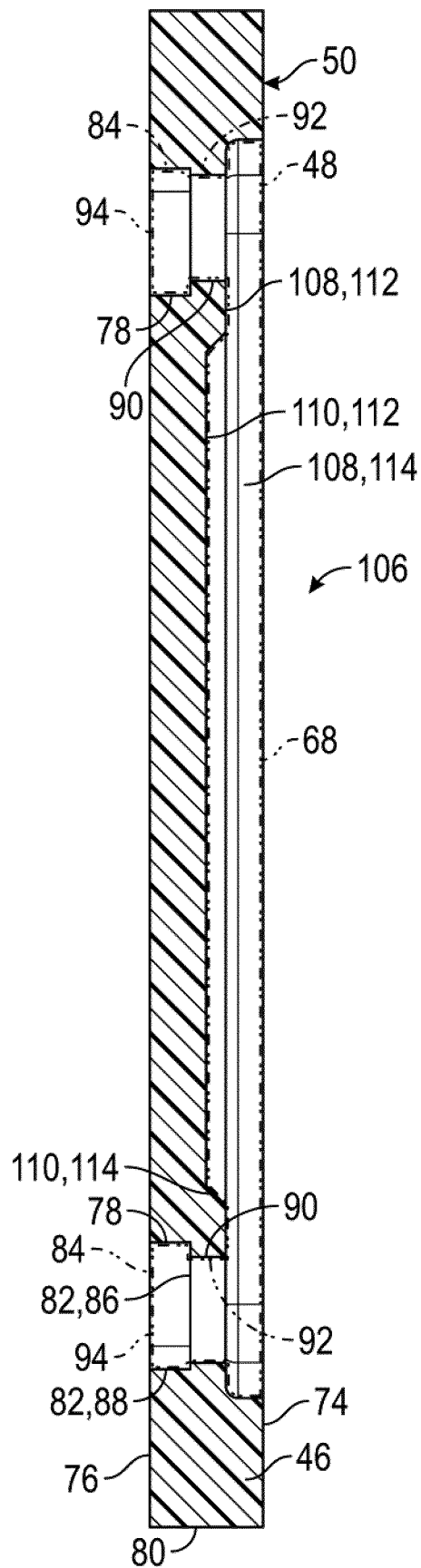


FIG. 10

7/14

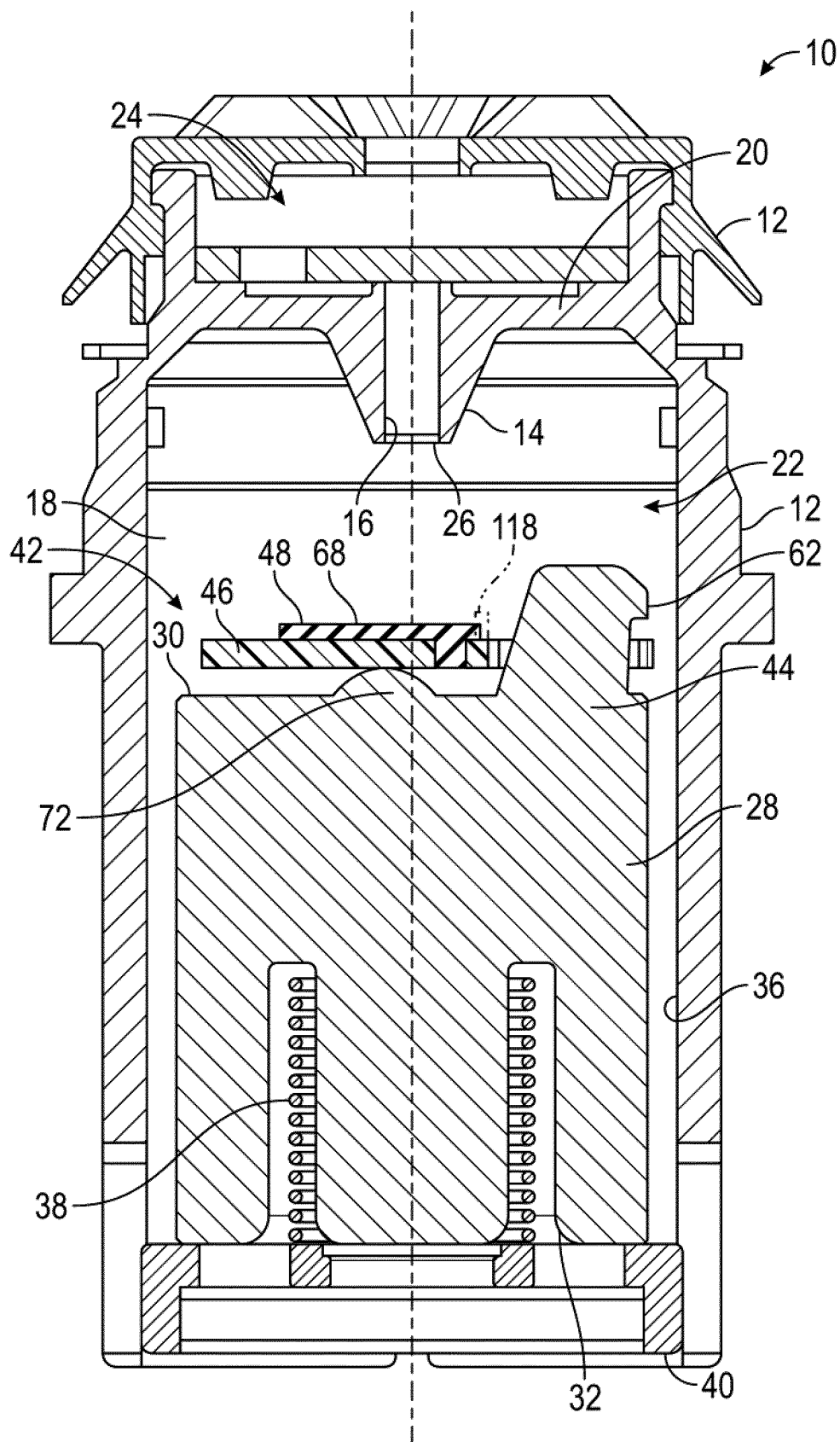


FIG. 11

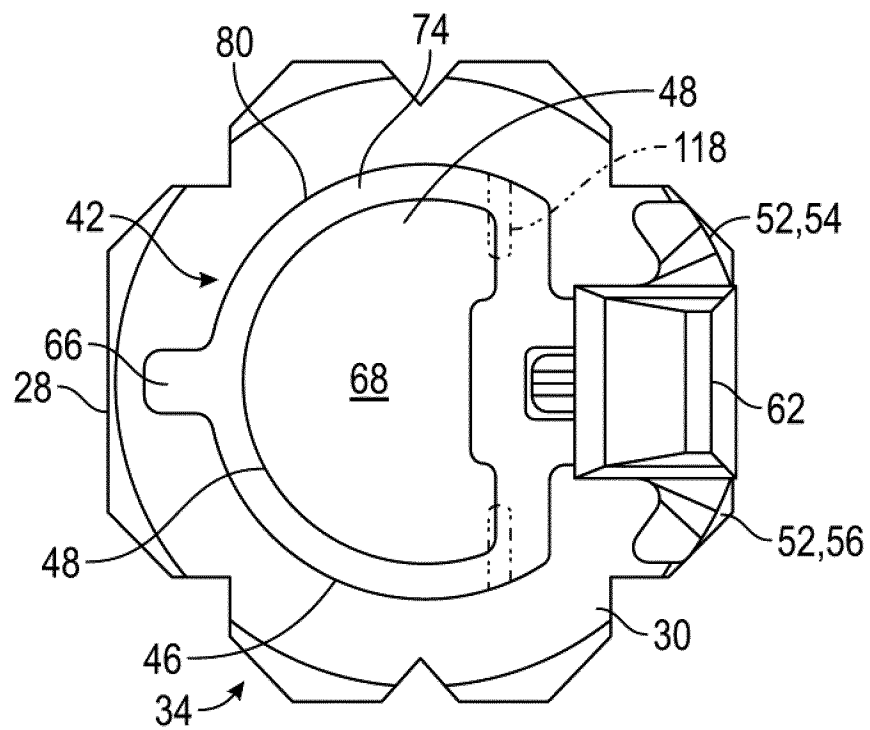


FIG. 12

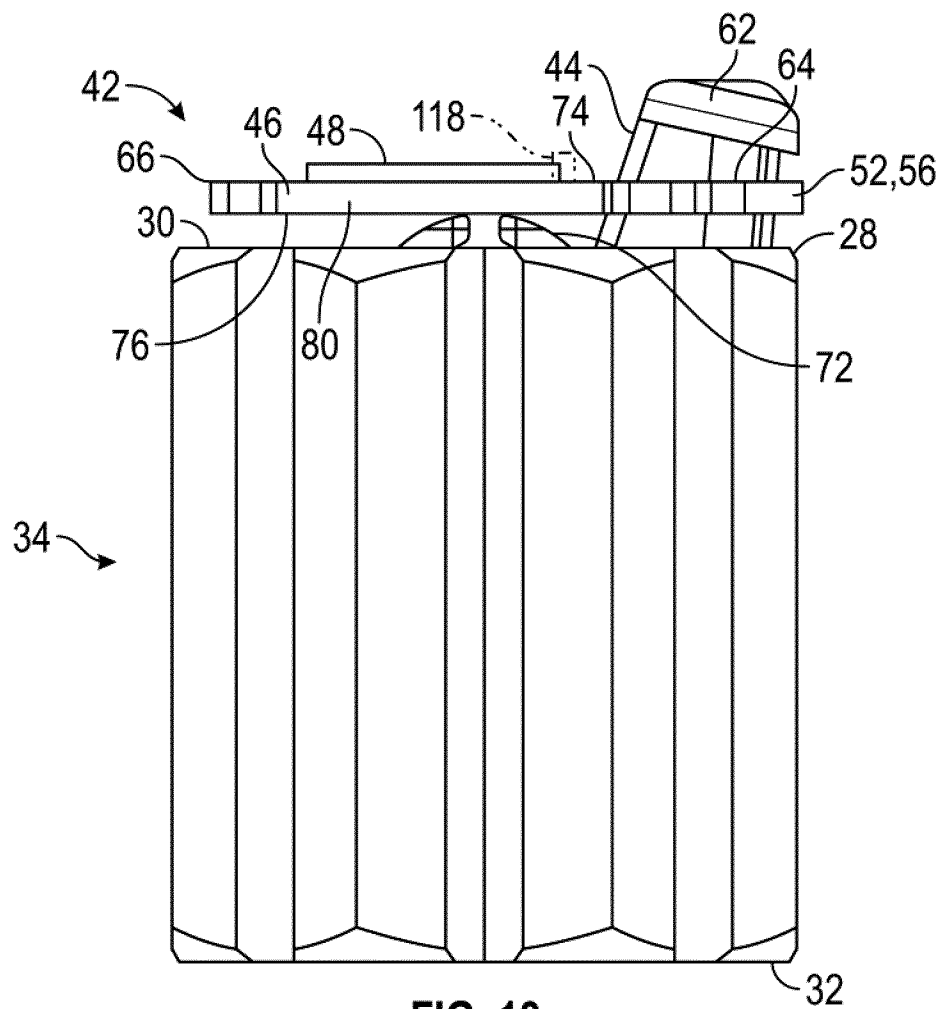
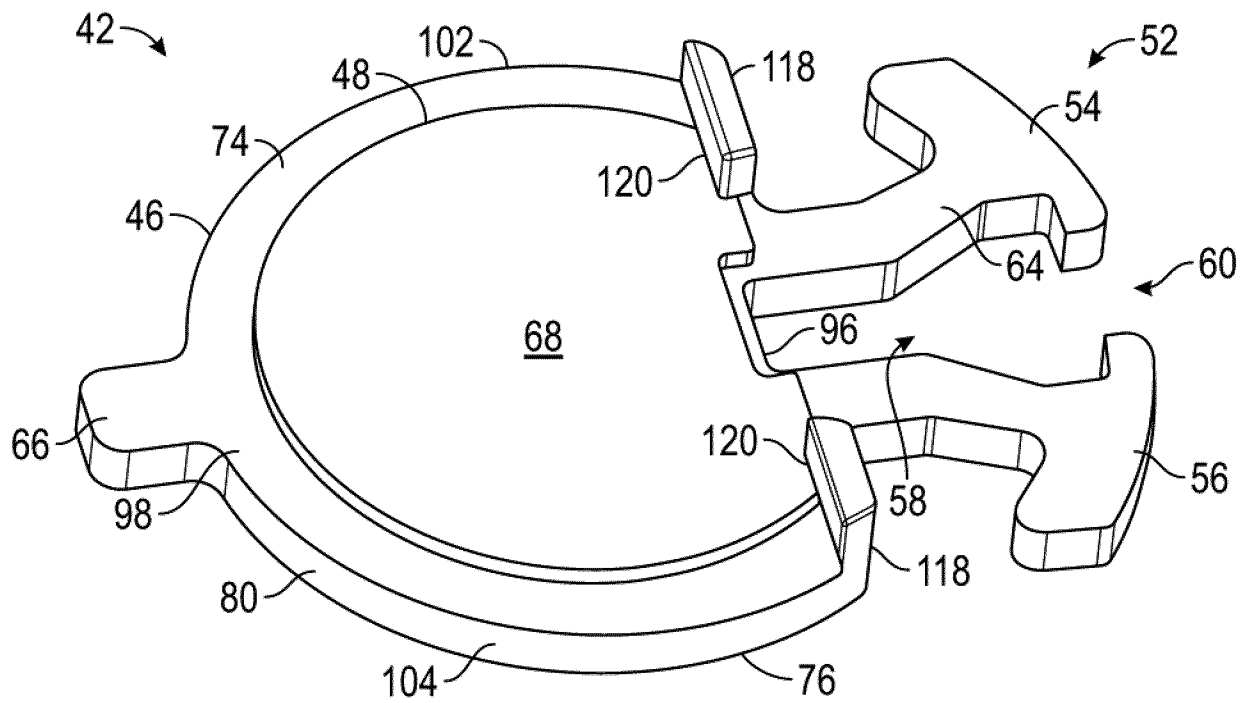
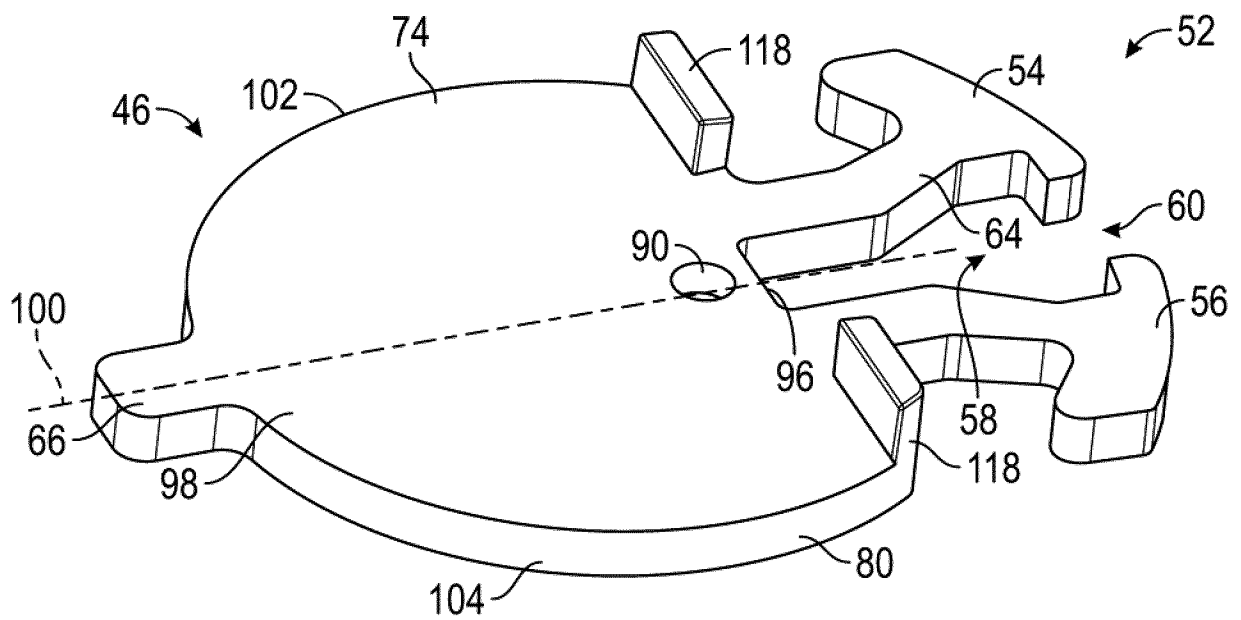


FIG. 13

9/14



**FIG. 14**



**FIG. 15**

10/14

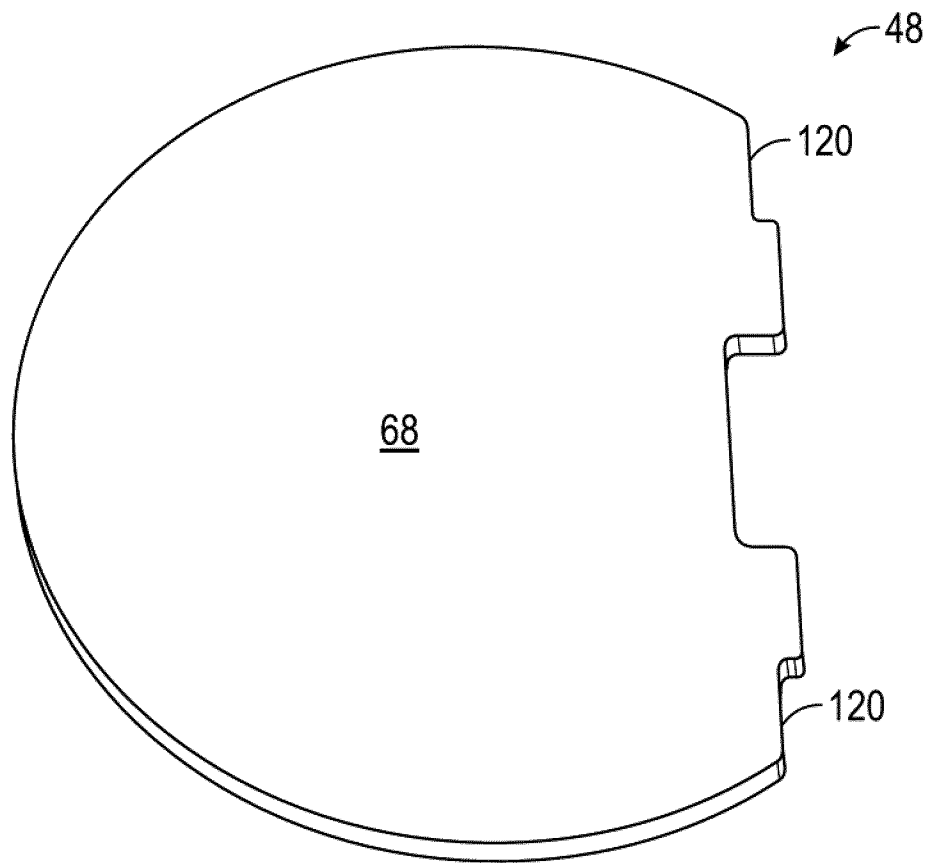


FIG. 16

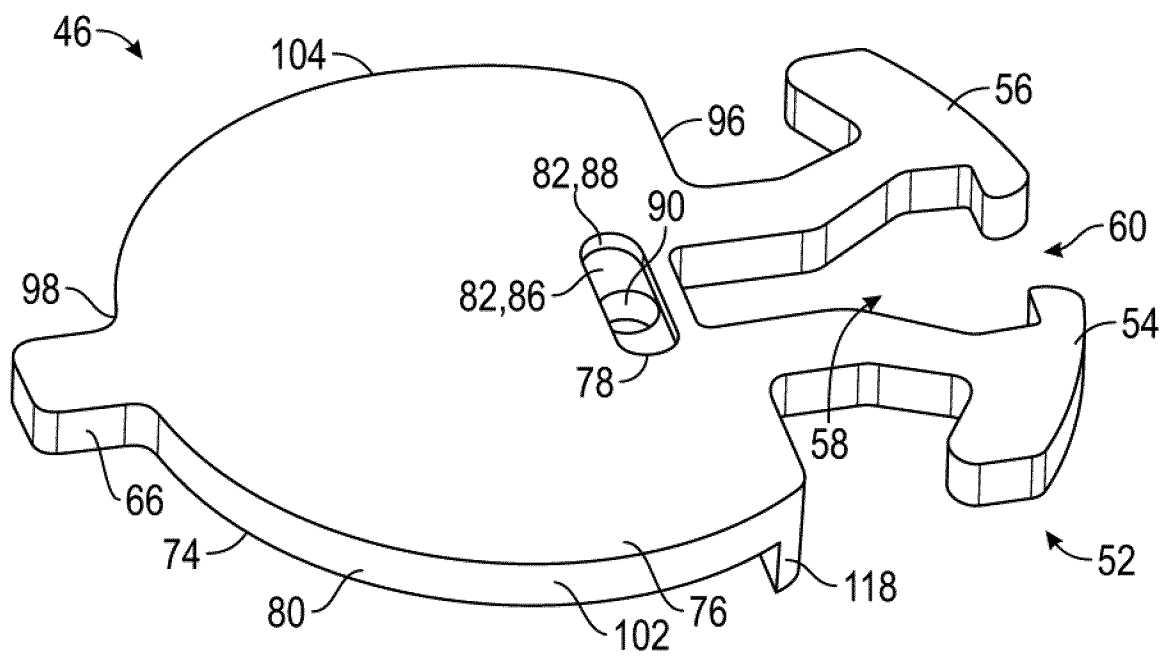


FIG. 17

11/14

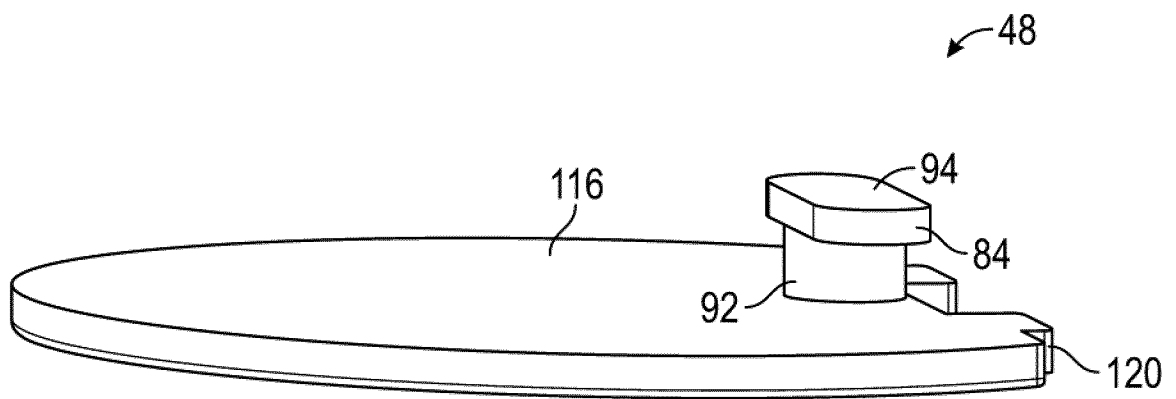


FIG. 18

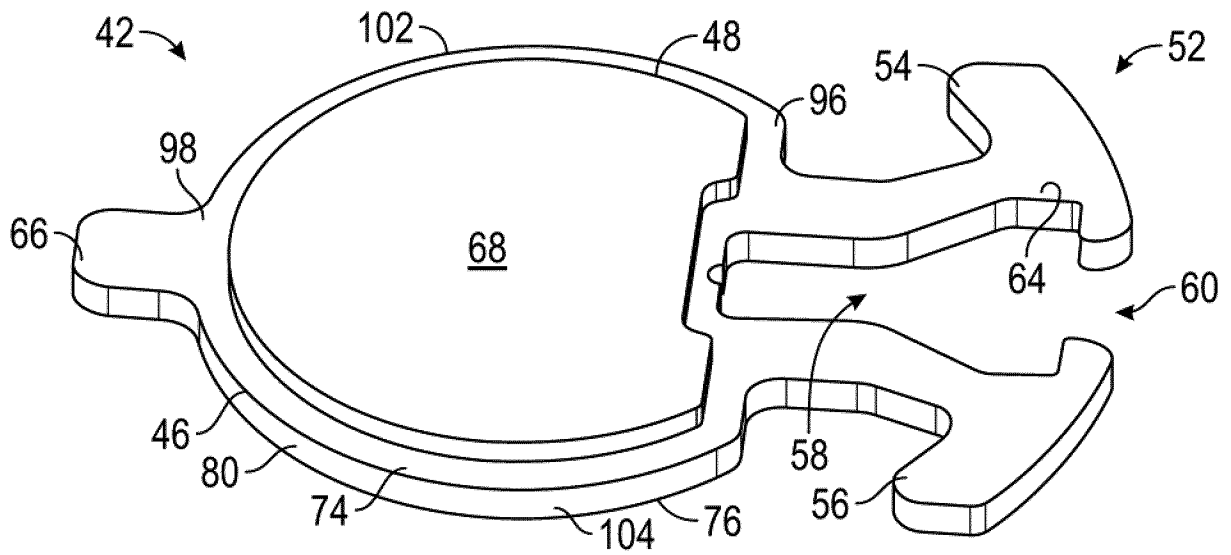


FIG. 19

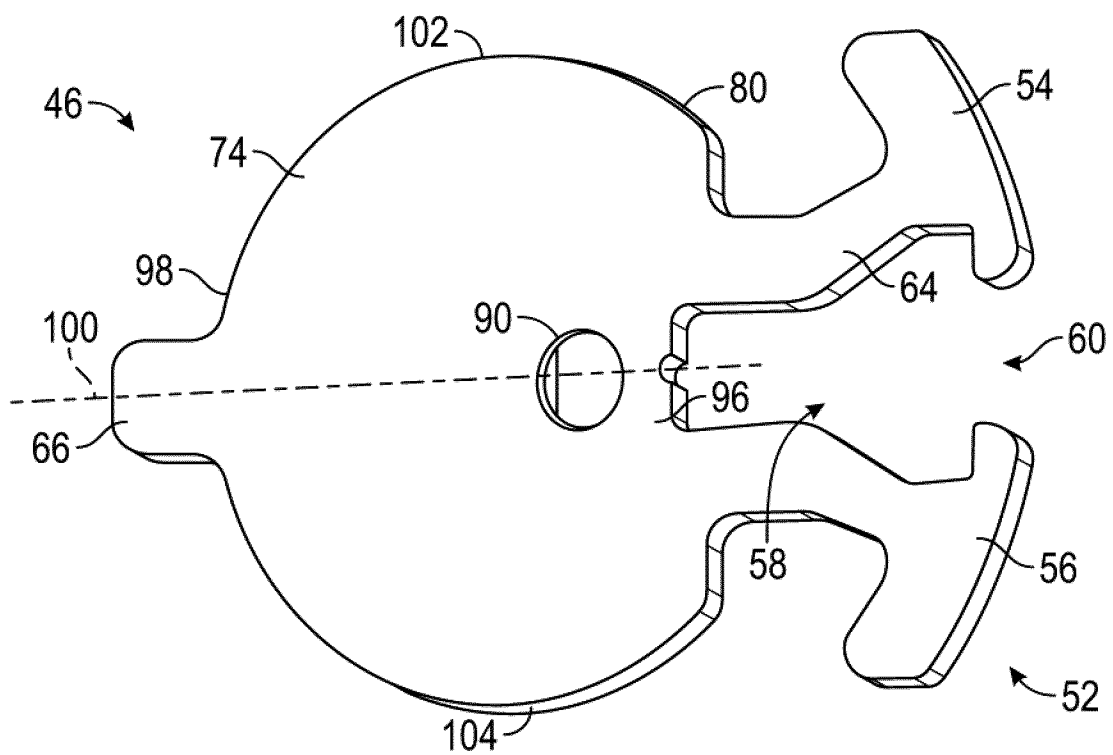


FIG. 20

13/14

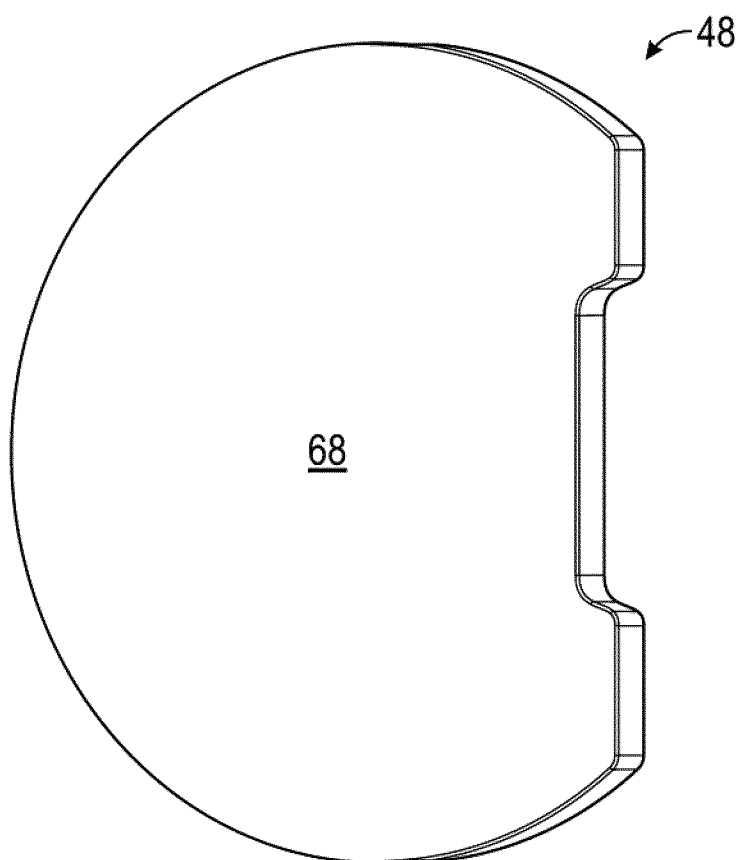


FIG. 21

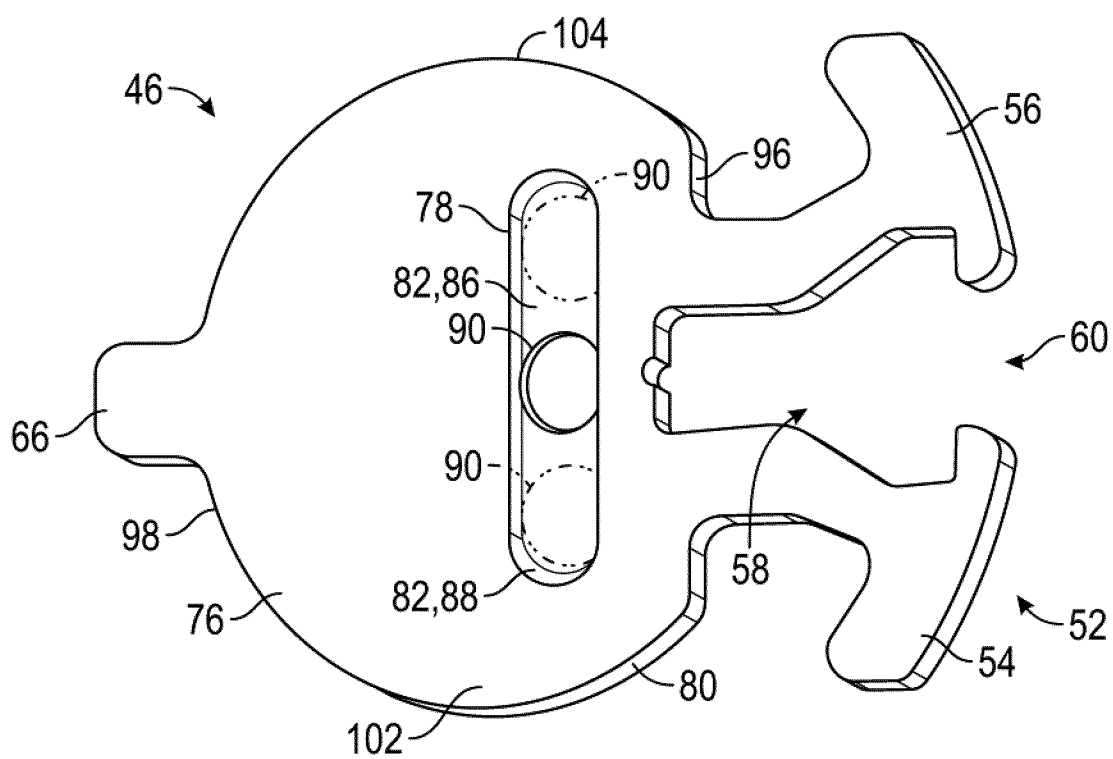


FIG. 22

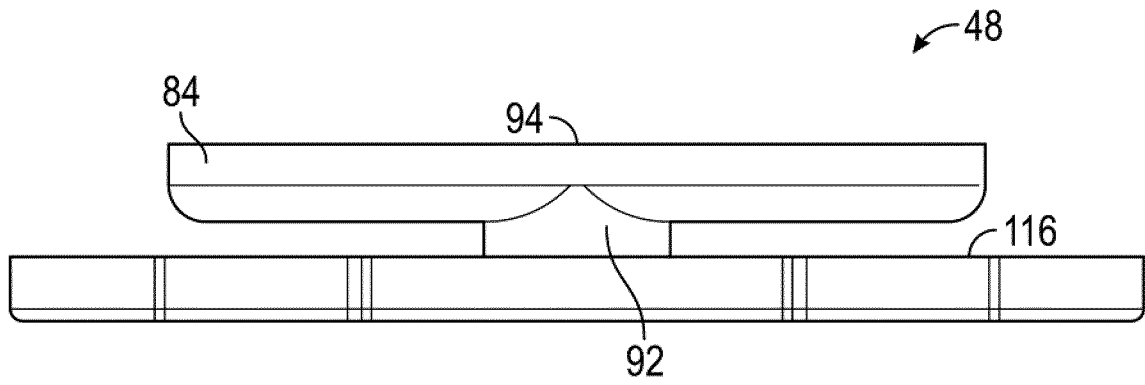


FIG. 23

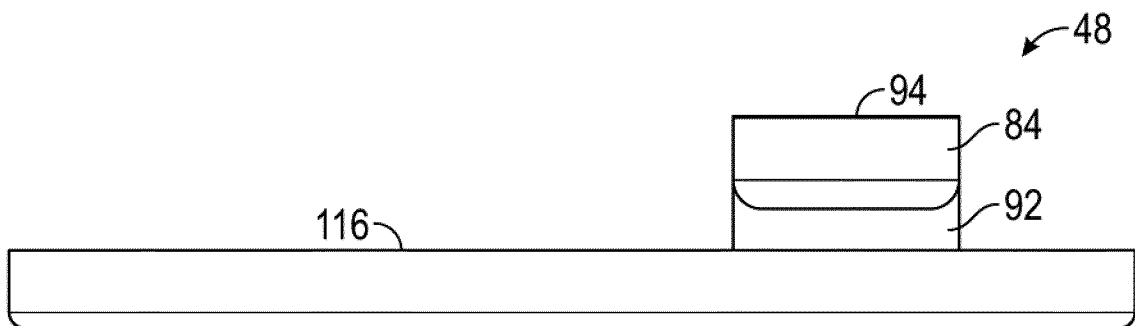


FIG. 24

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2020/025004

## A. CLASSIFICATION OF SUBJECT MATTER

INV. B60K15/035 F16K24/04 F16K31/24  
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60K F16K

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

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

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| X         | US 2003/098063 A1 (MORI EISHIN [JP] ET AL)<br>29 May 2003 (2003-05-29)             | 1,18                  |
| Y         | figure 3                                                                           | 6                     |
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| A         | figure 4                                                                           | 5                     |



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

26 March 2020

Date of mailing of the international search report

06/04/2020

Name and mailing address of the ISA/

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Yildirim, Ismet

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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