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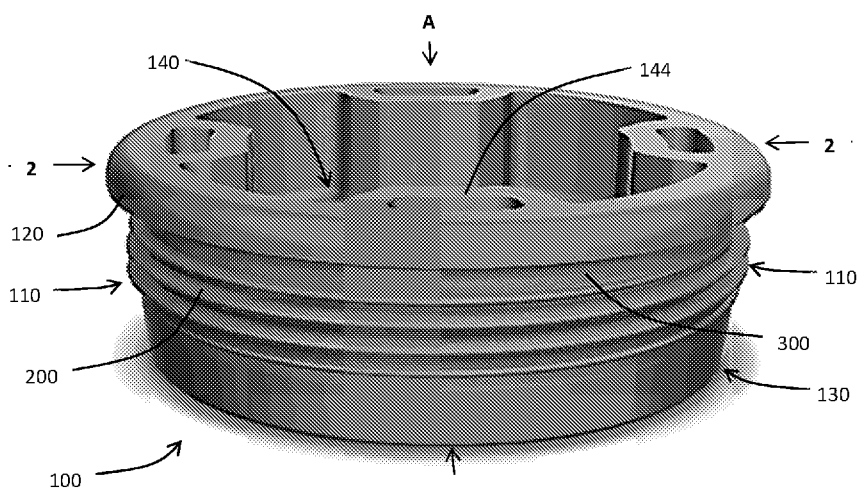


FIGURE 1A

(57) Abstract: A closure plug for drums and container is contemplated. By reducing the height and increasing the pitch of the thread over only a portion of its top-most arc, a sealing gasket is confined to the sealing interface. Advantageously, this upturned arc portion is coupled with a curved gasket seat. This combination results in acceptable gasket retention without the need to axially space apart additional features (e.g., annular bands, distinct retaining lip, etc.), while preventing fluids from collecting and drying out along the threads/sealing face.



TITLE
CLOSURE FOR DRUMS

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to United States provisional patent application serial no. 62/859,960 filed on June 11, 2019, which is incorporated by reference herein.

TECHNICAL FIELD

[0002] The present invention relates to a closure for sealing drums and, more specifically, a threaded plug including features to ensure a sealing member remains properly positioned as the plug is repeatedly installed and removed during normal use.

BACKGROUND

[0003] Drums, pails, and other industrial shipping containers are widely used to transport and store a variety of flowable substances (e.g., liquids, powdered compositions, slurries, etc.). In order to efficiently draw fluids when wanted, dispensing openings are often formed within these containers. For example, United States Patent 1,947,425 describes and references a number of fixtures which can be secured into the panel of a container to accommodate and receive a plug in order to selectively open and seal the container.

[0004] Since that time, numerous improvements have been developed in order to allow for a better seal. For example, a gasket or sealing member can be interposed at the interface between the plug and the fixture.

[0005] United States Patent 2,906,429 describes a closure plug providing a seating for such gaskets. The threaded sidewall includes a “diminishing thread” proximate to the seat wherein the height of the thread decreases and the angle of the helix of the thread is reduced so as to converge upon itself around the top-most 360° arc. In this manner, a gasket “seat” is created between this diminishing thread at the seat’s lower end, while an annular flange defines the top edge of the seat.

[0006] United States Patent 7,287,662 contemplates a threaded plug where a completely separate annular retaining lip serves a similar function, while additional embodiments described a conical or “flared” seating space between the lip and the flange. Still further iterations of this style of plug may be found in United States Patents 7,810,668; 8,453,867; and 8,991,663.

[0007] In United States’ Patent 5,971,189, a threaded, plastic closure assembly is described. Here, an annular peripheral flange includes a groove along its underside to receive and hold a gasket in place as it is installed within a drum opening. United States Patent Publication 2002/0125205 described a series of annular sealing bands positioned within the gasket seat immediately beneath an annular peripheral flange on a threaded plastic plug.

[0008] In all of the above disclosures, structures are disclosed to receive and retain a sealing gasket proximate to the interface formed between the plug head and the container/bushing into which it is received. A common feature for these structures is a circumferential protrusion, oriented substantially parallel with (or formed directly into) the annular flange that extends radially outward as part of the plug head. In this manner, the gasket stays in place even after it has been removed and reinserted numerous times.

[0009] Notably, these protrusions (including, in some cases, a diminishing thread arcing downward to meet itself over the final revolution of the thread helix) require sufficient axial distance/offset from the plug head flange. Further, the features must be formed around a majority (if not the entire) circumferential arc. As such, these prior designs necessitate additional axial height, thereby increasing the depth/profile of the plug. In turn, the bushing must be able to accommodate these elongated features, although a diminishing thread which closes in upon itself may cause the top edge of the plug to pull away from the bushing (unless the bushing itself is specially machined to accommodate the diminishing thread).

SUMMARY

[0010] The inventors have now discovered, by simultaneously reducing the height and increasing the pitch of the thread over only a portion of its top-most arc, the same gasket retention can be achieved. Advantageously, this upturned arc portion is coupled with a curved gasket seat. This combination results in acceptable gasket retention without the need to axially space apart additional features (e.g., annular bands, distinct retaining lip, etc.). Further, by providing an upturned thread pitch, closed recesses within the second to top set of threads are eliminated so as to avoid fluids from collecting and drying out within that recess.

[0011] Specific reference is made to the appended claims, drawings, and description below, all of which disclose elements of the invention. While specific embodiments are identified, it will be understood that elements from one described aspect may be combined with those from a separately identified aspect. In the same manner, a person of ordinary skill will have the requisite understanding of common processes, components, and methods, and this description is intended to encompass and disclose such common aspects even if they are not expressly identified herein.

DESCRIPTION OF THE DRAWINGS

[0012] Operation of the invention may be better understood by reference to the detailed description taken in connection with the following illustrations. These appended drawings form part of this specification, and any information on/in the drawings is both literally encompassed (i.e., the actual stated values) and relatively encompassed (e.g., ratios for respective dimensions of parts). In the same manner, the relative positioning and relationship of the components as shown in these drawings, as well as their function, shape, dimensions, and appearance, may all further inform certain aspects of the invention as if fully rewritten herein. Unless otherwise stated, all dimensions in the drawings are with reference to inches, and any printed information on/in the drawings form part of this written disclosure.

[0013] In the drawings and attachments, all of which are incorporated as part of this disclosure:

[0014] Figure 1A is a three dimensional, perspective view of a closure according to one aspect of the invention described herein, taken at an angle to highlight the threaded sidewall feature, while Figure 1B is a three dimensional, perspective view of that closure taken at a higher elevation to highlight the top facing features.

[0015] Figure 2 is a cross sectional, perspective view taken along line 2-2 in Figure 1A.

[0016] Figures 3A through 3H are three dimensional, side views of the closure of Figure 1A, with each view rotated by 45° to highlight the changes in pitch and height of the top-most thread.

[0017] Figure 4 is a partial view of Figure 3B, where the change in pitch and difference in height of the top-most thread is most noticeable.

[0018] Figure 5 is a partial, cross sectional, silhouette view of the curved section forming the partial hyperbolic shape of the gasket seat, framed by the flange/facing at the top end and the upper facing of the top-most thread on the lower end according to callout 5 of Figure 3H.

[0019] Figure 6 is a top perspective view of the closure of Figure 1A, with arrow B indicating the $\sim 70^\circ$ arc along which the change in pitch and height of the top-most thread may take place.

[0020] Figure 7A shows a schematic cross sectional side view of an alternative shape for the grasping or torque-engagement formation formed in or on the panel/sidewall of the plug, while Figure 7B is a photographic top view of the formation contemplated in Figure 7A.

DETAILED DESCRIPTION

[0021] Reference will now be made in detail to exemplary embodiments of the present invention, examples of which are illustrated in the accompanying drawings. It is to be understood that other embodiments may be utilized and structural and functional changes may be made without departing from the respective scope of the invention. As such, the following description is presented by way of illustration only and should not limit in any way the various alternatives and modifications that may be made to the illustrated embodiments and still be within the spirit and scope of the invention.

[0022] As used herein, the words “example” and “exemplary” mean an instance, or illustration. The words “example” or “exemplary” do not indicate a key or preferred aspect or embodiment. The word “or” is intended to be inclusive rather an exclusive, unless context suggests otherwise. As an example, the phrase “A employs B or C,” includes any inclusive permutation (e.g., A employs B; A employs C; or A employs both B and C). As another matter, the articles “a” and “an” are generally intended to mean “one or more” unless context suggest otherwise.

[0023] The descriptions and drawings in this disclosure, and any written matter within the drawings should be deemed to be reproduced as part of this specification. The terms axial and radial should be afforded their normal meaning in the context in which they are used but, generally speaking, a cross sectional plane capturing the circular shape of the plugs contemplated herein is radial, whereas a line, plane or axis bisecting that cross sectional plane at an orthogonal angle is axial. Further, references to forming, attaching, providing, and making will generally refer to any manufacturing process which imparts, imprints, creates, or attaches the feature or component(s) described as such. These manufacturing processes might include molding, welding, coupling by way of adhesives, etching, casting, or any other similar process that is appropriate to the context and circumstances of the disclosure.

[0024] With reference to Figures 1A, 1B, and 2, plug 100 has a generally circular, cylindrical shape. Parallel sidewalls 110 are bounded on the top by a peripheral flange 120

and, optionally, on the bottom by a straight wall section 130. A panel 140 spans the sidewalls 110 so as to enclose and provide a seal. Threads 200 are formed on at least a portion of the outer-facing of the sidewalls 110, while a curved gasket seat 300 spans the axial offset between the flange 120 and the top-most thread 200, relative to the central axis defined by line A-A.

[0025] In some embodiments, straight wall section 130 may extend downward beyond the vertical plane occupied by the panel 140, thereby imparting a cross sectional H-shape to plug 100. The section 130 can provide for a reduced thickness of the sidewall as it approaches its terminal edge 132. In this manner, section 130 can provide a reduced outer diameter (in comparison to the threaded section 200), so as to facilitate alignment and insertion of the plug 100 into a bushing (not shown).

[0026] Along its underside, panel 140 may have a reduced thickness at its center 142 proximate to central axis A. This reduction in thickness may reduce costs by reducing the amount of material required. It also provides additional internal volume (i.e., on the facing of plug 100 exposed to the internal volume of the container) to accommodate fluid that might be displaced as the plug 100 is screwed down into the container/bushing.

[0027] On the top side of panel 140, one or more formations 144 may be provided to accommodate tools to facilitate torqueing the plug 100 as part of the insertion/removal process. In one embodiment, formations 144 include at least two, three, four (as shown), five, or six axial recesses or catch protrusions sized to receive prongs of a wrench or driver tool. To the extent the panel 140 is formed along a midpoint of the sidewalls 110 (i.e., not at either terminal edge), the formation(s) 144 may also be integrally formed as part of the sidewalls 110 and top panel 140. In some embodiments, formation(s) 144 may even extend onto the flange 120.

[0028] In another embodiment, a grasping handle may be formed in addition to or in place of formations 144. The grasping handle can be a simple raised protrusion, although ergonomic contours can be formed for a distinctive appearance and/or to better accommodate a human hand/fingers. For example, such a handle could have a rectangular or polygonal (e.g., butterfly-like) shape when viewed from the top down along axis A-A.

[0029] In a still further embodiment, a single formation 144 may be fastened to the panel by conventional means 148 (rivets, screws, welding, adhesive, etc.). In this case, the formation has an elongated U-shape wherein the base portion 145 in contact with the panel is longer than the pair of upright members 146 forming the parallel walls of the U-shape. Those upright members may be formed as mirror images with indents (relative to a top view along

the axis A-A) and/or have an extension 147 that folds over itself and back down toward the panel 140 (possibly with the terminal end also fastened to the panel thru a fork or aperture in the base 145). In this arrangement, the upright members 146 are shaped to engage a torquing tool. Figure 7A shows a schematic cross sectional side view for such an arrangement, while Figure 7B is a photographic top view of the member shown in Figure 7A.

[0030] In all instances, the helical engagement threads and gasket retaining features contemplated herein may be applied to a plug having any style of handle or torquing feature. Thus, the drawings and illustrations herein should not be deemed limiting to the extent that only one style of handle (e.g., formations 144) are shown in certain views.

[0031] Preferably, flange 120 extends orthogonally (i.e., at 90° , $\pm < 10^\circ$) outward relative to central axis A-A. As above, flange 120 cooperates with the gasket (not shown) to ensure a sealing interface between the plug 100 and container/bushing, although the curved shape of the gasket seat 300 means that the flange 120 does not need to act as a stop or structural support for retaining (or, in some cases, even coming into contact with) the gasket. However, flange 120 defines a larger cross sectional diameter (i.e., at a right angle to axis A-A) than that defined by the elevation of any of the threads 210.

[0032] In some embodiments, panel 140 may coincide in the plane defined by the flange 120, in which case the cross sectional shape of the plug presents in a cup-shape, such as an inverted U-shape. In other embodiments, the panel 140 may connect the terminal edges 132 to impart a U-shape.

[0033] Turning to Figure 5, the curved contour of the gasket seat 300 is schematically highlighted. Insofar as this shape is replicated along the entire circumference of the plug 100 above the threads 200, the gasket seat presents as a hyperbolic curve when viewed in full cross section, such as in Figure 2. That is, the profile of the curved gasket seat 300, when viewed along a diameter of the plug 100, conforms at least partially to the inward swooping curve of a hyperbola, with the vertex aligned at the detent 302 or proximate to where the seat meets the sidewall 110 (i.e., the bottom end of the seat, opposite its connection on the top end to the flange 120). However, other curving shapes may be employed, so long as it is consistently employed along the entire circumference of the gasket seat 300.

[0034] As shown in Figure 5, a slight curved detent 302 is provided immediately adjacent to the thread interface 304 in some embodiments. From detent 302, the curve expands upward and outward until it intersects with flange 120. Along outward curved section 304, a straight or curving outward slope is provided. Notably, detent point 302 may possess the same

diameter (in full cross section) as the thread interface 304, so that the gasket seat itself merely expands outward from interface 304.

[0035] In all cases, the flange interface 306 possesses a larger diameter (when the plug 100 is view from the top down along the axis A-A) than that of the thread interface 304. In this manner, the gasket seat 300 increases in diameter, irrespective of whether a narrower detent point 302 is provided. Also, the thread interface 304 marks the point where the sidewall 110 transitions from a substantially vertical orientation into the gasket seat 300, which has a curved profile as shown in Figure 5.

[0036] With reference to the series of Figures in 3A through 3H, as well as Figures 4 and 6, special aspects of the threads 200 are illustrated in greater detail. As described throughout, the thread 200 will be understood to comprise a uniform helix circumscribed onto the outer facing of the sidewalls 110. Because the threads 200 are along this outer facing, the connection of the panel 140 to the sidewalls 110 may occur at any elevation; for example, at a midpoint as illustrated and described above to form an H-shape.

[0037] Threads 200 must be offset from the flange 120 in order to allow for formation of the gasket seat 300. This offset is a sufficient axial distance to accommodate an annular gasket or sealing member without impinging upon the threads 200 themselves. As noted above, the curved nature of the seat 300 accommodates the sealing face, although the flange 120 may cooperate or partially contribute in some aspects.

[0038] The helix of the threads 200 preferably extends through at least three complete revolutions (i.e., $> 1080^\circ$). With reference to Figure 3A (and continuing as the plug is rotated 45° through each of the subsequent figures in this series), starting point 210 where thread 200 slowly rises and becomes set apart from the flattened portion 130. From start 210 up until diminishing point 220 begins, the helix/thread 200 is inclined or pitched at a constant/consistent angle relative to horizontal between 0.5° and 10° . In preferred embodiments, the pitch of the helix is 2.5° , 5° , and 7.5° .

[0039] After approximately one eighth to three quarters of the first and last circumferential turns of the helix (i.e., between the first 45° to 270°), the height of the thread 200 rises and falls from its maximum. In this context, height refers to the separation between the sidewall 110 and the outer-most tip/peak 214 of the thread. In this manner, more than one full turn of the helix (i.e. $> 360^\circ$) incorporate a thread 200 at its maximum, continuous height. More preferably, at least two full turns (i.e., $> 720^\circ$) are provided at this maximum height so as to ensure full engagement with the cooperating threads in a manner that seals the plug 100 to the container/bushing. The threads can circumscribe any portion or all of the sidewall 110,

although it is preferably that they do not exceed 3 to 4 turns (1080° to 1260°) at the constant pitch and threads need not be formed all the way to the bottom edge of section 130.

[0040] In one particular example, the main helix section main helix (i.e., the portion of thread except for the retaining thread portion, either from point 210 to point 220 or for the length where peak 214 remains at its maximum height) extends for about 2.2 turns (i.e., 790°), with a substantially constant pitch of 0.09/turn. The profile of the threads (i.e., the upper and lower facings forming a single thread defined by peak 214 in cross section) are formed at an acute angle between 50° and 60° , while the spacing between the threads (i.e., the gap 216 where the sidewall is substantially vertical) is about 0.02. The vertical area where the thread may be formed is approximately 0.35, while the gasket seat has a height of 0.13. The aforementioned dimensions are relative to the overall axial height of the part itself so that these may be scaled accordingly, although for the purposes of this disclosure the dimensions provided are in inches.

[0041] Thus, from the start point 210 until the beginning of the maximum height at point 212, the height (and width) of the thread increases gradually and, preferably, consistently until it attains its maximum height 214. That height (and width) is carried thru the majority of the helix until diminishing point 220, where the height (and width) are gradually and, preferably, consistently decreased until the thread blends back into the sidewall 110 at end point 222.

[0042] Sufficient gaps 216 are provided between threads 200 to receive cooperating threads formed on the bushing or container opening. Each of these gaps aligns with and defines the sidewall 110. As seen in the profiles formed in Figures 3A through 3H, these gaps 216, in combination with the peaks 216, highlight when the full height of the thread 216 begins and ends.

[0043] At the top end of the helix/threads 200, an arcing section denoted by arrow B includes a portion of the helix where the pitch is increased. That is, in this top-most terminal end, the angle at which the thread is inclined is increased so as to diverge upward and further away from the rest of the parallel threads 200 in the helix. The change in angle will be less than 10° relative to the pitch of the remaining helix (i.e., the angle, relative to horizontal, between starting point 210 and the leading edge of arc B). Thus, relative to the horizon, the pitch will be no greater than 20° but no less than about 1° .

[0044] Arc B extends for between one eighth and one half turn of the helix at its top end (i.e., 45° and 180°). Preferably, the arc B is less than one quarter turn (90°) and, more preferably, about a 70° section ($\pm 5^{\circ}$). Arc B begins at point 220 and end at point 222.

However, the change in height may occur up to 45° before or after point 220. Stated differently, the change in pitch represented by arc B preferably coincides with the change in height of the thread 200; however, the change in height may begin within one eighth turn before or within one eighth turn after the pitch of the helix is changed. Without wishing to be bound by any theory of operation, it is believed that the increase in pitch over the length of arc B is sufficient to restrain a gasket within seat 300, especially in view of the unique and curving shape of the seat 300.

[0045] Arc B represents the retaining thread portion of the helix. This retaining thread effectively creates an anchor point in which the resilient gasket attaches to and becomes effectively immobilized by the thread itself. Thus, no separate retaining lip or formation is required. In the same manner, by increasing the pitch of the helix, a closed recess where fluid might collect is thereby eliminated. Further, owing to the slight change in pitch and the limited span of arc B, the thread pattern, including the retaining arc, can still be accommodated by a conventional, consistently pitched thread on the bushing/container opening.

[0046] As noted, retaining thread/arc B includes sufficient length (of the thread), as well as sufficient height in a portion of that retaining thread/arc B, to grip into the gasket. In this manner, the gasket will not slip downward owing to surface tension when the plug is removed, while it cannot become dislodged and pushed upward as the plug is torqued fully into place within the bushing/container opening.

[0047] The shape of the gasket seat 300 further facilitates anchoring of the gasket. Specifically, the combination of the outward curvature between points 304, 306 provide a complete, circumferential counterpoint to the anchor created along retaining thread/arc B. Further, if detent 302 bows inward (i.e., to a smaller diameter in comparison to point 304), a resilient gasket would naturally tend to conform to that detent 302 and, thereby, further improve the gasket-retaining characteristics of plug 100.

[0048] The foregoing design can be implemented on plugs made of plastic or metal. If used, plastics are particularly attractive because injection molding materials could be employed. In any event, plastics, metals, or other materials should be selected with an eye toward being chemically inert, resistant to corrosion, compatibility for thermal expansion and contraction (relative to the bushing/container), workability, and cost. Various grades of stainless steel are exemplary metals, whereas nylon materials are preferred among plastics.

[0049] Gaskets and sealing members may be of any conventional material, with elastomers and polymers having particular utility. Resilient materials are preferred so as to simplify the initial installation, as well as the sealing qualities delivered by the gasket.

[0050] The plugs contemplated herein find utility in sealing large, industrial-sized containers and drums on a massive scale. They must be capable of coupling and sealing standard-sized openings on a variety of objects, while also being economical to manufacture/assemble on a large scale. Further, owing to industry standardization, the size, shape, and aspect ratio (i.e., height to diameter) is confined to a relatively narrow range. Therefore, persons of skill in this field will appreciate that any proposed change or modification to the features of these plugs (or conventional plugs before them) must be carefully considered in context, and any change that is not immediately adaptable to existing containers/drum and/or that is not easy manufacture reliably on a large scale almost certainly will not be adopted in this specialized and highly competitive field.

[0051] Specific aspects of the invention expressly contemplated herein involve a plug-style closure rotatably engageable to a bushing or container opening on/in a drum or container. These closures have a circular cylindrical member having straight sidewall portion, a lower edge portion, and a radially-extending flange connected at an upper edge portion; a sealing panel positioned within the circular cylindrical member; wherein a curved gasket seat is interposed between the radially extending flange and the threaded helix, said curved gasket seat having a larger diameter proximate to the radially extending flange as compared to a smaller diameter proximate to the threaded helix; and wherein a threaded helix is formed over more than 360° on an outer facing of the straight sidewall portion, said helix formed at a substantially constant pitch. Additional characterizing features may include any combination of the following:

- wherein the threaded helix transitions to a retaining arc at a top-most edge closest to the curved gasket seat at less than a 180° portion thereof, said retaining arc having: (i) an increased pitch relative to the pitch of the threaded helix, and (ii) a height of the retaining arc is gradually reduced to meet the straight sidewall portion;
- wherein the threaded helix includes at a bottom-most edge closest to the lower edge portion where a height of the thread is gradually increased along less than 270° of the outer facing of the straight sidewall portion;
- wherein the substantially constant pitch is between 0.5° and 10° relative to a horizontal axis of the circular cylindrical member;

- wherein the increased pitch of the retaining arc is between 0.5° and 10° greater than the substantially constant pitch of the threaded helix;
- wherein the height of the retaining arc is less than a maximum height of the threaded helix;
- wherein the sealing panel connects to the straight sidewall portion so as to impart an H-shape to a cross sectional diameter of the circular cylindrical member;
- wherein the sealing panel connects to the upper edge portion so as to impart an inverted U-shape to a cross sectional diameter of the circular cylindrical member;
- wherein the sealing panel connects to the lower edge portion so as to impart an U-shape to a cross sectional diameter of the circular cylindrical member;
- wherein the sealing panel includes a thinner wall at its center point in comparison to a periphery where the sealing panel connects to the circular cylindrical member;
- wherein the curved gasket seat includes a detent portion having a smaller diameter than both of: a point where the gasket seat connects to the radially-extending flange and a point where the gasket seat connects to the straight sidewall portion, including top-most portions of threaded helix and all of the retaining arc;
- wherein a profile of the curved gasket seat conforms at least partially to a hyperbolic curve along a diameter of the circular cylindrical member;
- wherein a vertex of the hyperbolic curve is positioned at detent portion of the gasket seat;
- wherein a vertex of the hyperbolic curve is positioned at a point where the gasket seat connects to the straight sidewall portion, including top-most portions of threaded helix and all of the retaining arc;
- wherein at least one torqueing formation is provided on a top facing of the sealing panel;
- wherein a plurality of torqueing formations are provided;
- wherein each of the torqueing formations includes an engagement recess aligned along a vertical axis of the circular cylindrical member;
- wherein at least one of the torqueing formations is integrally formed on a portion of at least one of: a top facing of the radially-extending flange, an inner facing of the straight sidewall section, and the top facing of the sealing panel
- wherein the retaining arc is provided along less than a top-most 90° portion of the threaded helix;

- wherein the retaining arc is provided at a top-most 70° portion of the threaded helix;
- wherein the thread helix extends along at least 720° of the outer facing of the straight sidewall portion;
- wherein the thread helix extends along at least 790° of the outer facing of the straight sidewall portion; and
- wherein the thread helix extends for no more than 1260° of the outer facing of the straight sidewall portion.

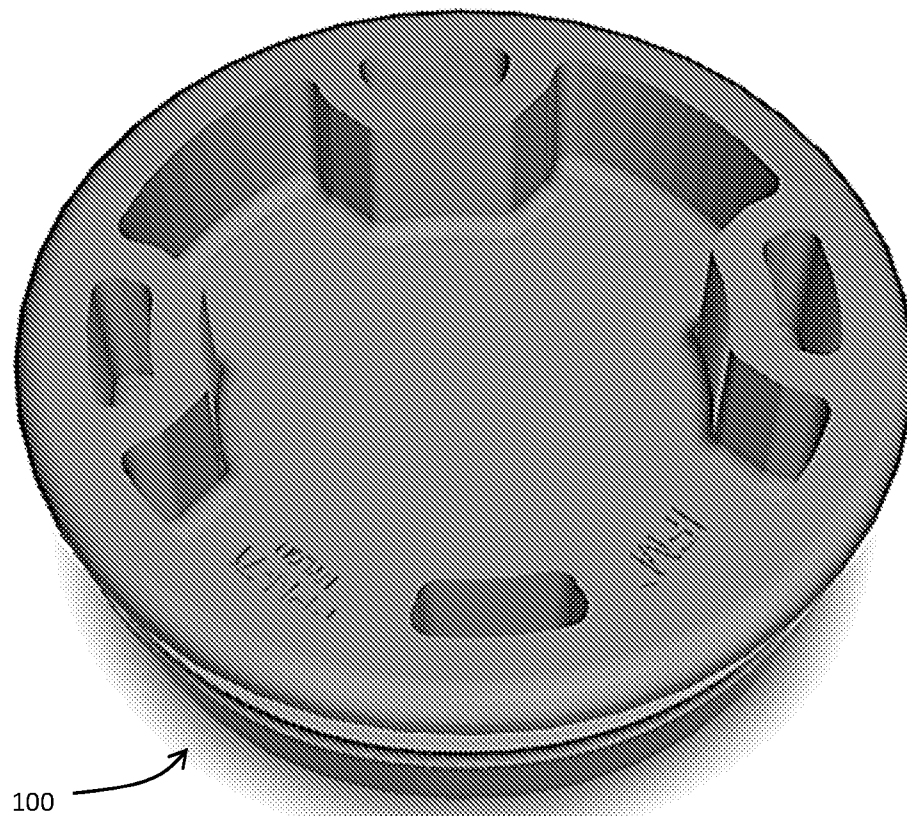
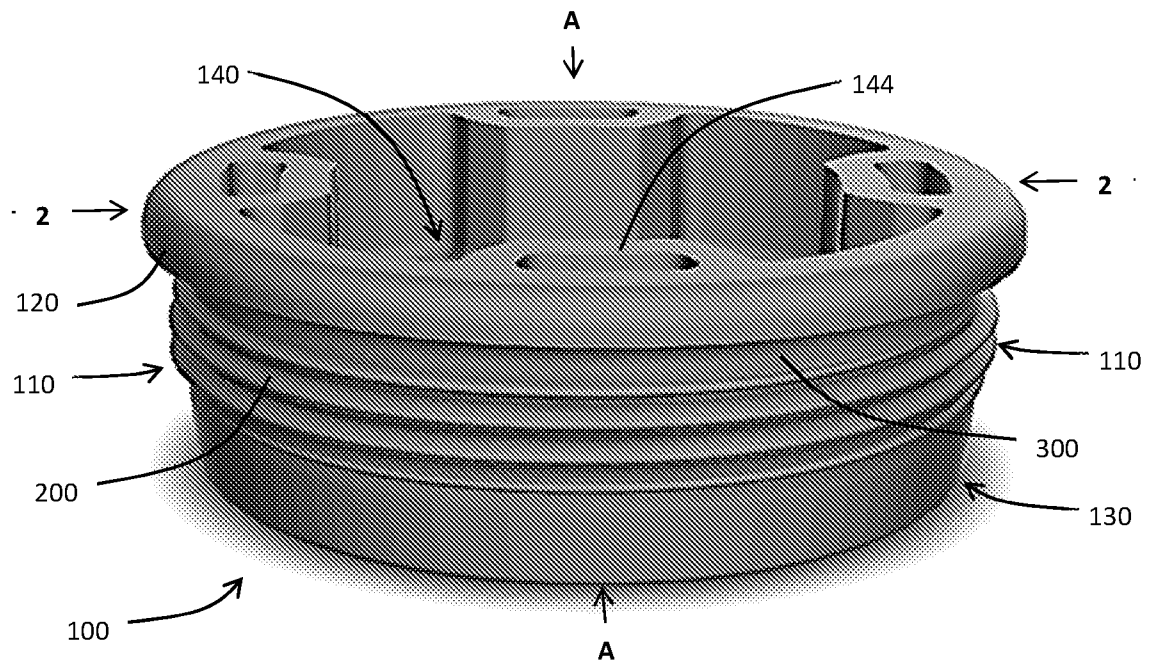
[0052] Although the present embodiments have been illustrated in the accompanying drawings and described in the foregoing detailed description, it is to be understood that the invention is not to be limited to just the embodiments disclosed, and numerous rearrangements, modifications and substitutions are also contemplated. The exemplary embodiment has been described with reference to the preferred embodiments, but further modifications and alterations encompass the preceding detailed description. These modifications and alterations also fall within the scope of the appended claims or the equivalents thereof.

CLAIMS

What is claimed is:

1. A plug-style closure rotatably engageable to a bushing or container opening of a drum or container, the closure comprising:
 - a circular cylindrical member having straight sidewall portion, a lower edge portion, and a radially-extending flange connected at an upper edge portion;
 - a sealing panel positioned within the circular cylindrical member;
 - wherein a threaded helix is formed over more than 360° on an outer facing of the straight sidewall portion, said helix formed at a substantially constant pitch;
 - wherein a curved gasket seat is interposed between the radially extending flange and the threaded helix, said curved gasket seat having a larger diameter proximate to the radially extending flange as compared to a smaller diameter proximate to the threaded helix; and
 - wherein the threaded helix transitions to a retaining arc at a top-most edge closest to the curved gasket seat at less than a 180° portion thereof, said retaining arc having: (i) an increased pitch relative to the pitch of the threaded helix, and (ii) a height of the retaining arc is gradually reduced to meet the straight sidewall portion.
2. The closure of claim 1 wherein the threaded helix includes at a bottom-most edge closest to the lower edge portion where a height of the thread is gradually increased along less than 270° of the outer facing of the straight sidewall portion.
3. The closure of claim 1 wherein the substantially constant pitch is between 0.5° and 10° relative to a horizontal axis of the circular cylindrical member.
4. The closure of claim 1 wherein the increased pitch of the retaining arc is between 0.5° and 10° greater than the substantially constant pitch of the threaded helix.
5. The closure of claim 1 wherein the height of the retaining arc is less than a maximum height of the threaded helix.
6. The closure of claim 1 wherein the sealing panel connects to the straight sidewall portion so as to impart an H-shape to a cross sectional diameter of the circular cylindrical member.
7. The closure of claim 1 wherein the sealing panel connects to the upper edge portion so as to impart an inverted U-shape to a cross sectional diameter of the circular cylindrical member.
8. The closure of claim 1 wherein the sealing panel connects to the lower edge portion so as to impart an U-shape to a cross sectional diameter of the circular cylindrical member.

9. The closure of claim 1 wherein the sealing panel includes a thinner wall at its center point in comparison to a periphery where the sealing panel connects to the circular cylindrical member.
10. The closure of claim 1 wherein the curved gasket seat includes a detent portion having a smaller diameter than both of: a point where the gasket seat connects to the radially-extending flange and a point where the gasket seat connects to the straight sidewall portion, including top-most portions of threaded helix and all of the retaining arc.
11. The closure of claim 1 wherein a profile of the curved gasket seat conforms at least partially to a hyperbolic curve along a diameter of the circular cylindrical member.
12. The closure of claim 11 wherein a vertex of the hyperbolic curve is positioned at detent portion of the gasket seat.
13. The closure of claim 11 wherein a vertex of the hyperbolic curve is positioned at a point where the gasket seat connects to the straight sidewall portion, including top-most portions of threaded helix and all of the retaining arc.
14. The closure of claim 1 wherein at least one torqueing formation is provided on a top facing of the sealing panel.
15. The closure of claim 14 wherein a plurality of torqueing formations are provided.
16. The closure of claim 15 wherein each of the torqueing formations includes an engagement recess aligned along a vertical axis of the circular cylindrical member.
17. The closure of claim 15 wherein at least one of the torqueing formations is integrally formed on a portion of at least one of: a top facing of the radially-extending flange, an inner facing of the straight sidewall section, and the top facing of the sealing panel.
18. The closure of claim 1 wherein the retaining arc is provided along less than a top-most 90° portion of the threaded helix.
19. The closure of claim 1 wherein the retaining arc is provided at a top-most 70° portion of the threaded helix.
20. The closure of claim 1 wherein the thread helix extends along at least 720° of the outer facing of the straight sidewall portion.
21. The closure of claim 1 wherein the thread helix extends along at least 790° of the outer facing of the straight sidewall portion.
22. The closure of claim 1 wherein the thread helix extends for no more than 1260° of the outer facing of the straight sidewall portion.



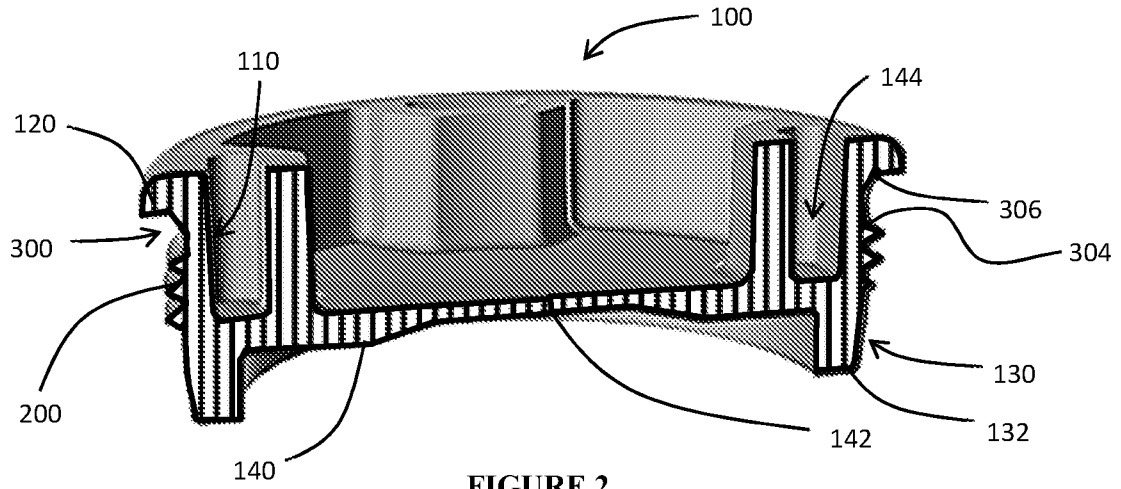


FIGURE 2

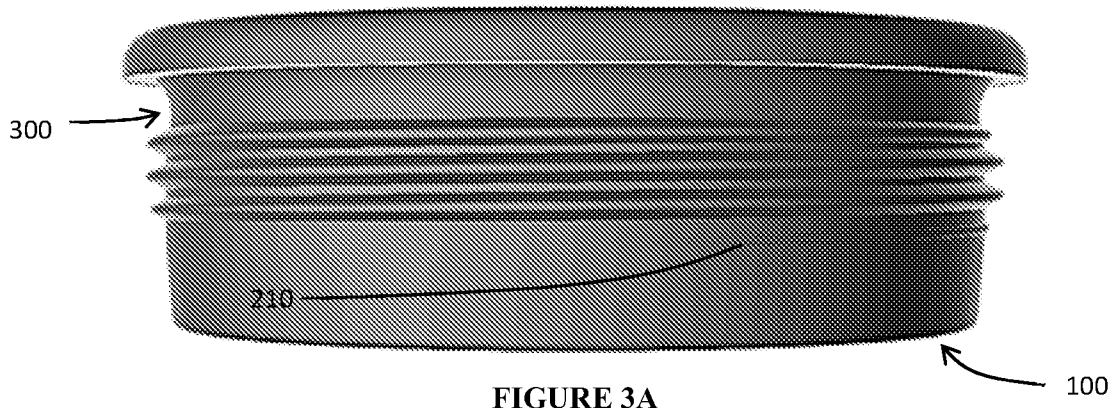


FIGURE 3A

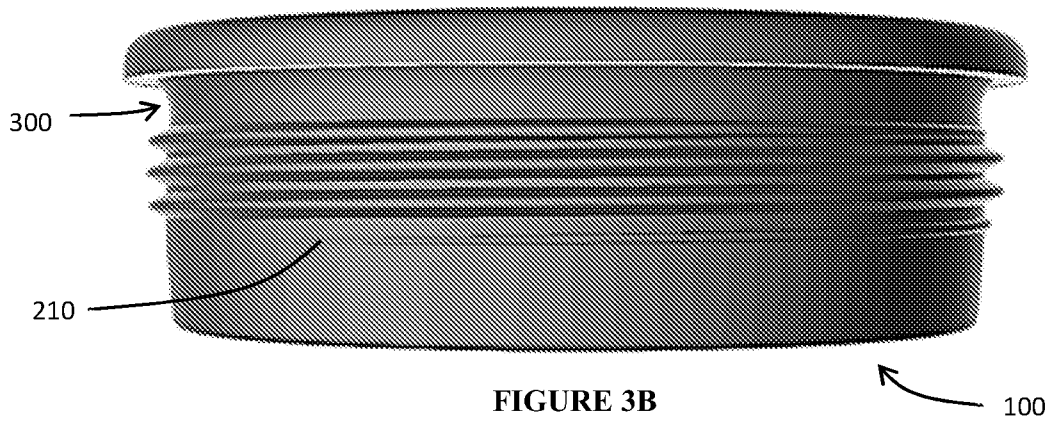


FIGURE 3B

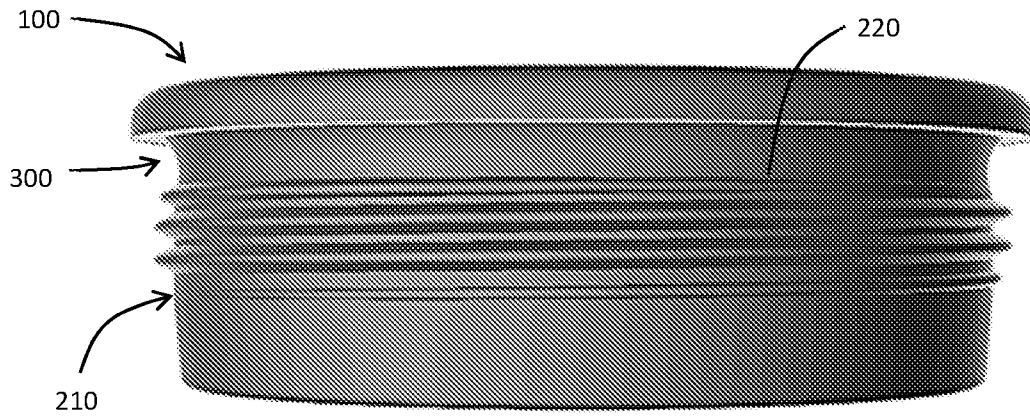


FIGURE 3C

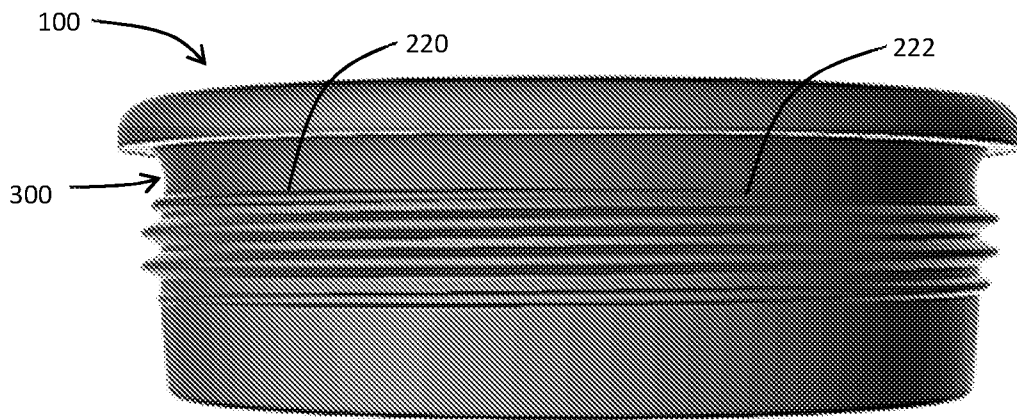


FIGURE 3D

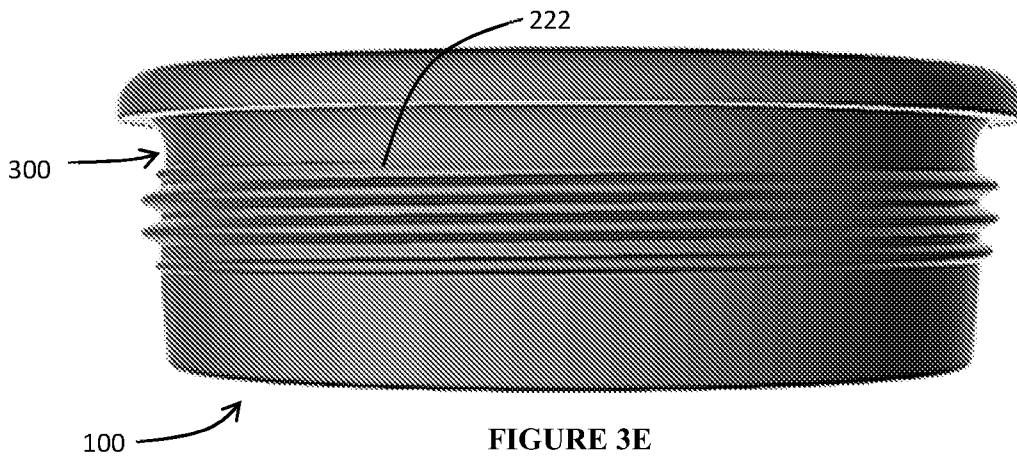
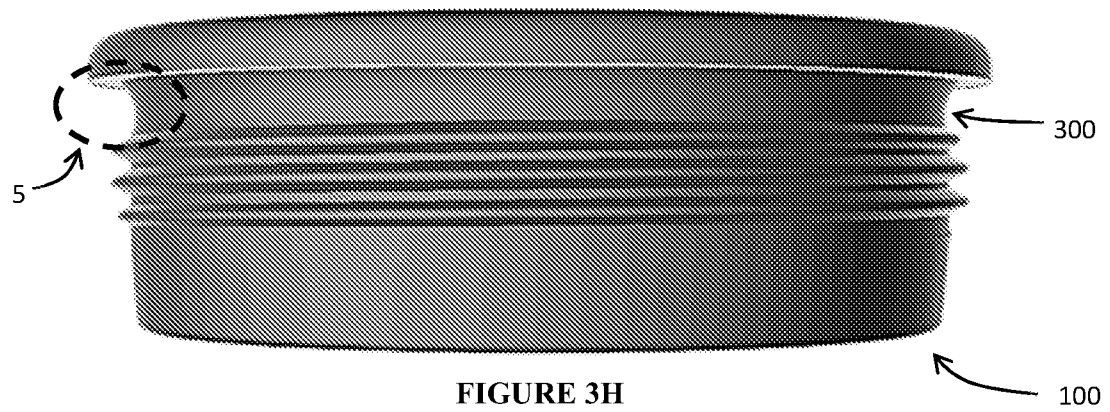
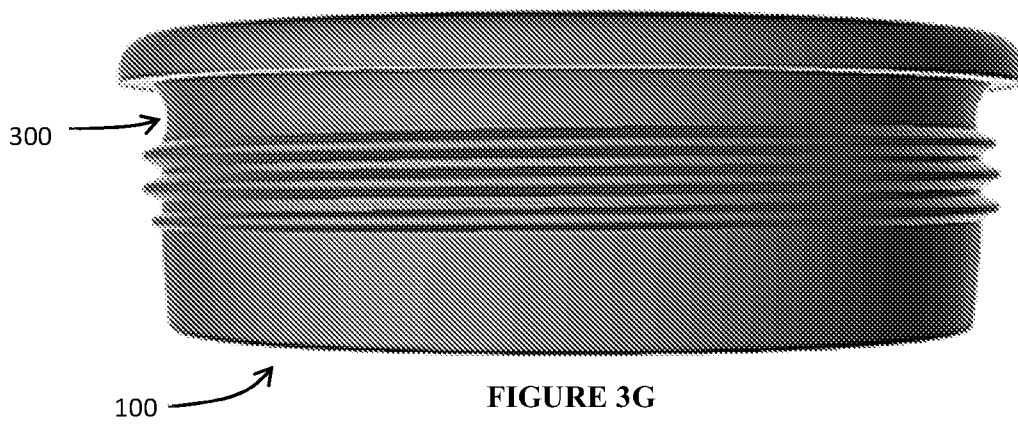
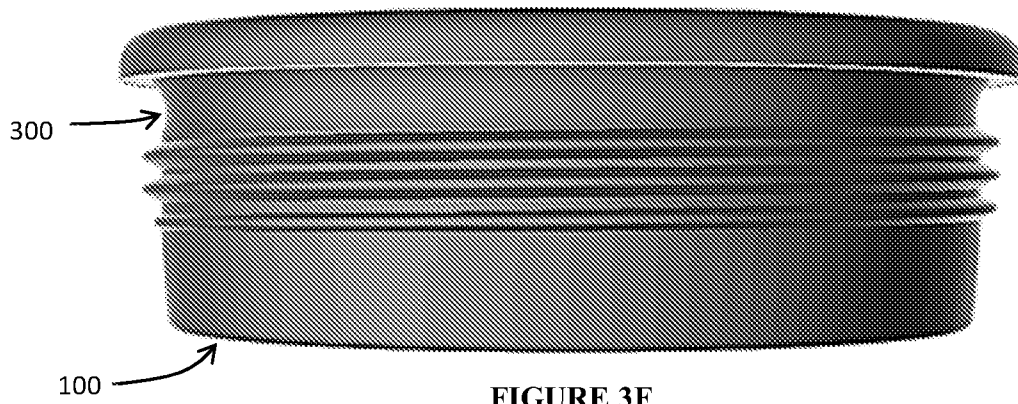


FIGURE 3E



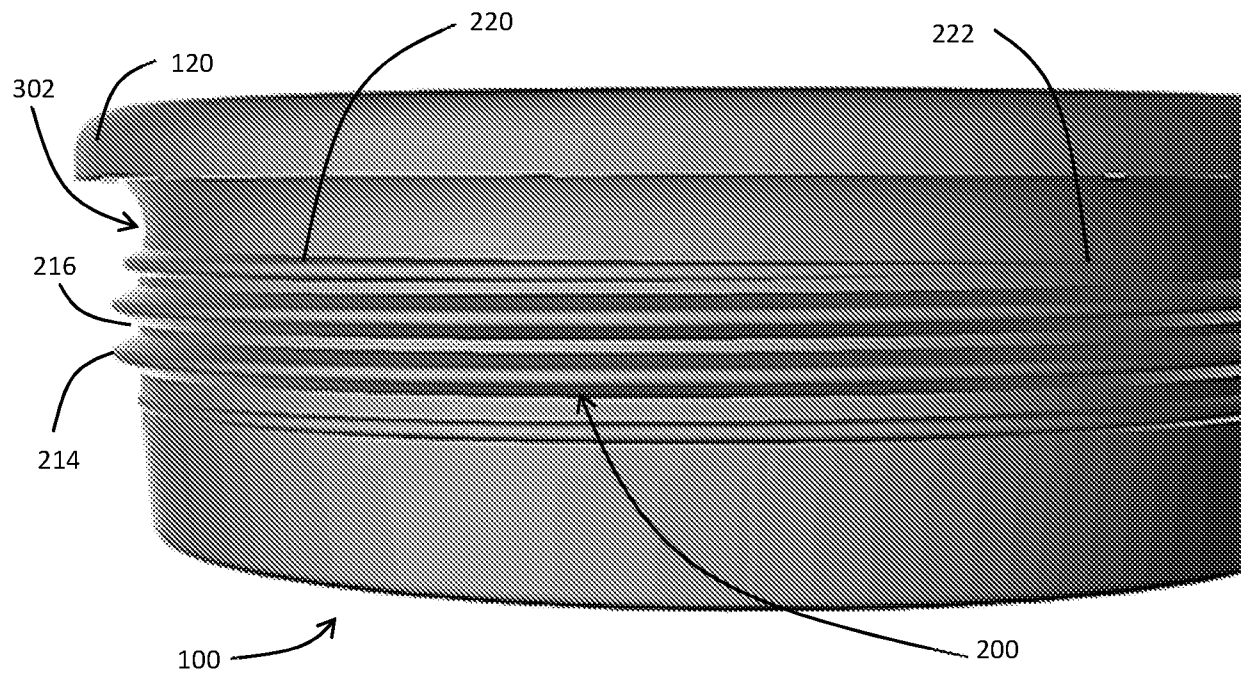


FIGURE 4

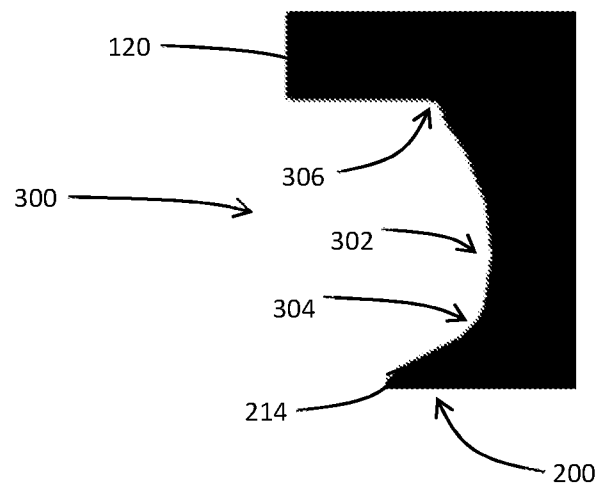


FIGURE 5

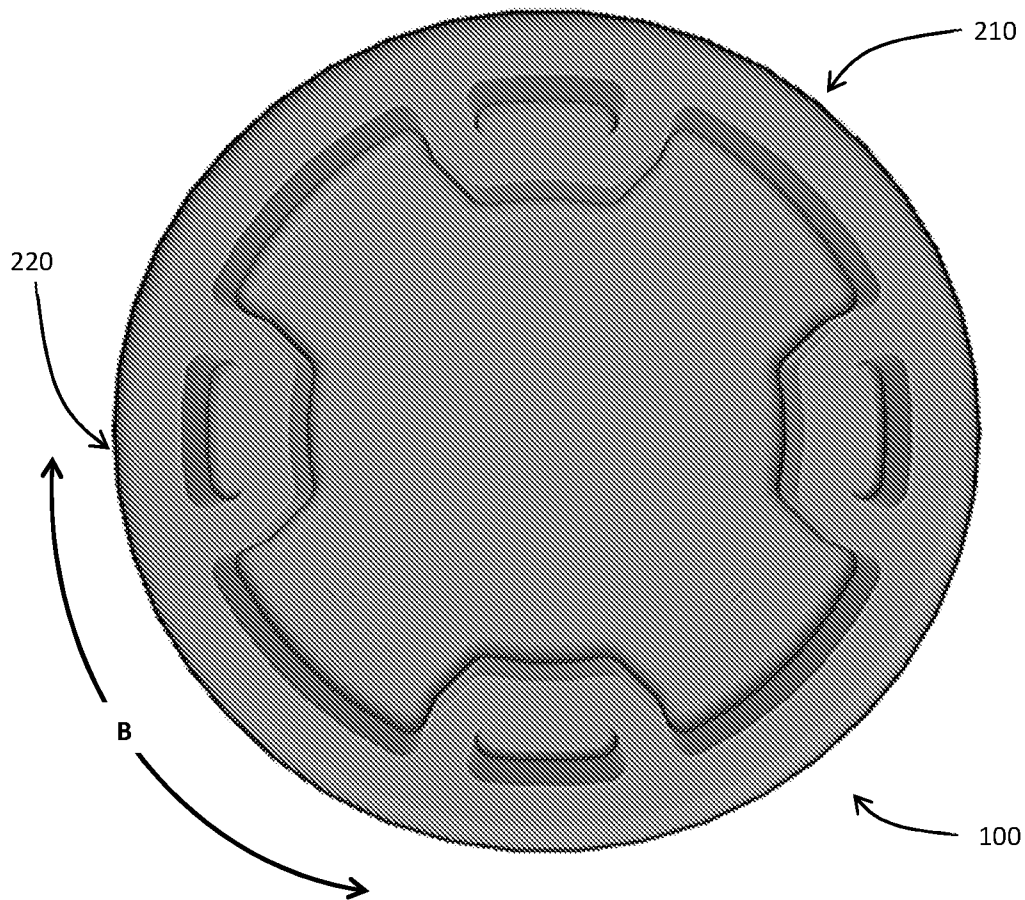


FIGURE 6

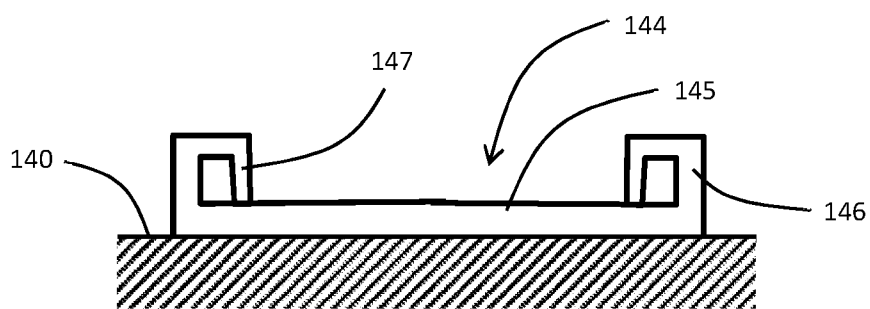


FIGURE 7A

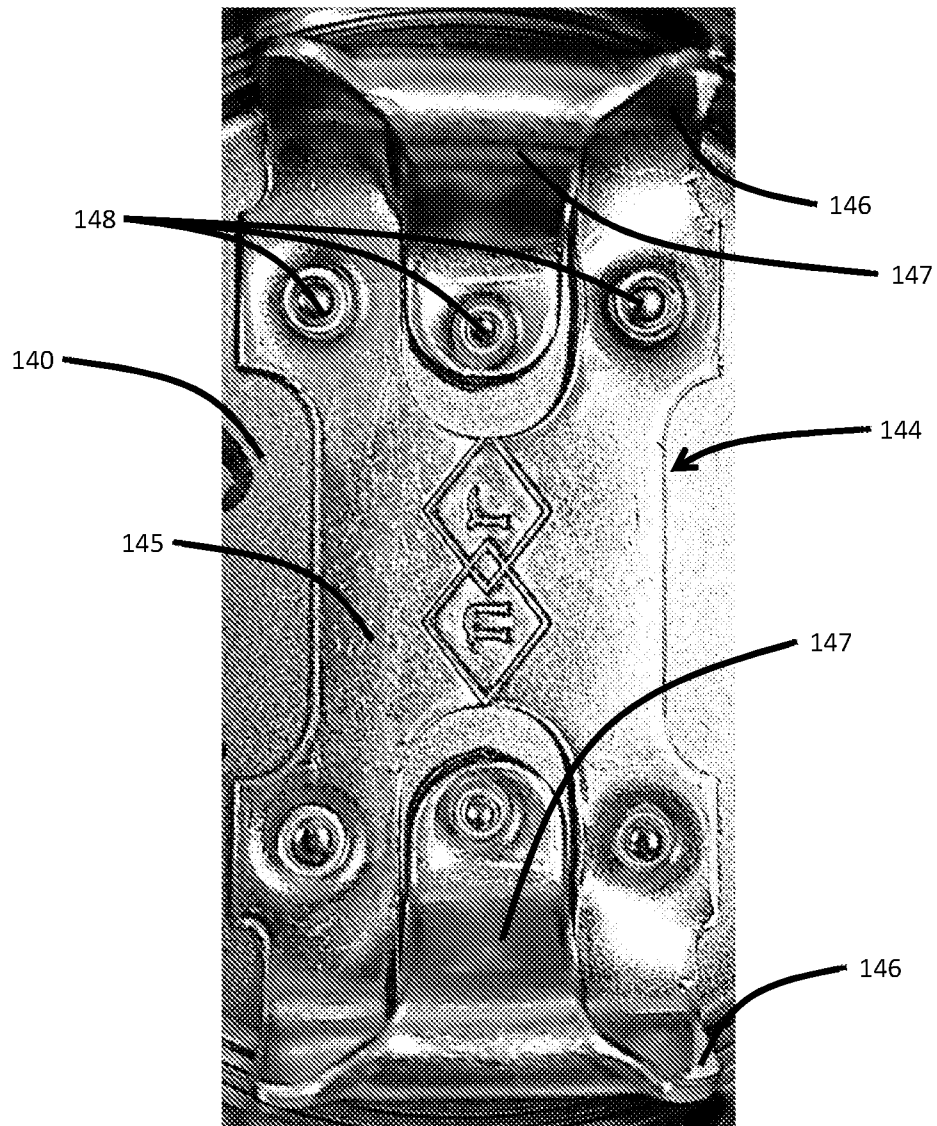


FIGURE 7B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US20/37198

A. CLASSIFICATION OF SUBJECT MATTER

IPC - B65D 39/08, 39/16, 51/18 (2020.01)

CPC - B65D 39/08, 39/16, 51/18

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 1,838,042 A (SCHWARTZ H) 22 December 1931; figures 3, 5; page 1, lines 10-15; page 2, lines 10-20	1-8, 10-14, 18-22 --- 9, 15-17
Y	US 2010/0314391 A1 (BAUGHMAN GM) 16 December 2010; figures 13, 15; paragraphs [0007], [0047]	9, 15-17
A	US 3,986,634 A (SMITH CA et al.) 19 October 1976; entire document	1-22

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Further documents are listed in the continuation of Box C.

☐

See patent family annex.

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

Date of the actual completion of the international search

05 August 2020 (05.08.2020)

Date of mailing of the international search report

27 SEP 2020

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