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(54) **CONTAINER CLOSURE ASSEMBLY WITH PRESSURE SEAL**

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(57) **ABSTRACT**

A container closure assembly includes a container neck having an opening at one end, a lip extending around the opening; a cap for said neck, the cap having a base portion and a threaded skirt; a screw thread on the neck; a screw thread on an inner surface of the threaded skirt of the cap; the screw threads enabling a user to secure, remove and resecure the cap into a sealing position on the neck; an olive sealing plug extending from the cap inside and substantially concentric with said threaded skirt portion of the cap, the sealing plug forming a seal against an inside surface of the neck; and a sealing skirt extending from said base of the cap intermediate said sealing plug and said threaded skirt portion of the cap and concentric with said sealing plug and said threaded skirt portion of the cap, wherein said cap can be displaced towards said neck from said sealing position by application of an axial force without rotation of the cap on the neck and substantially without plastic deformation of the cap.

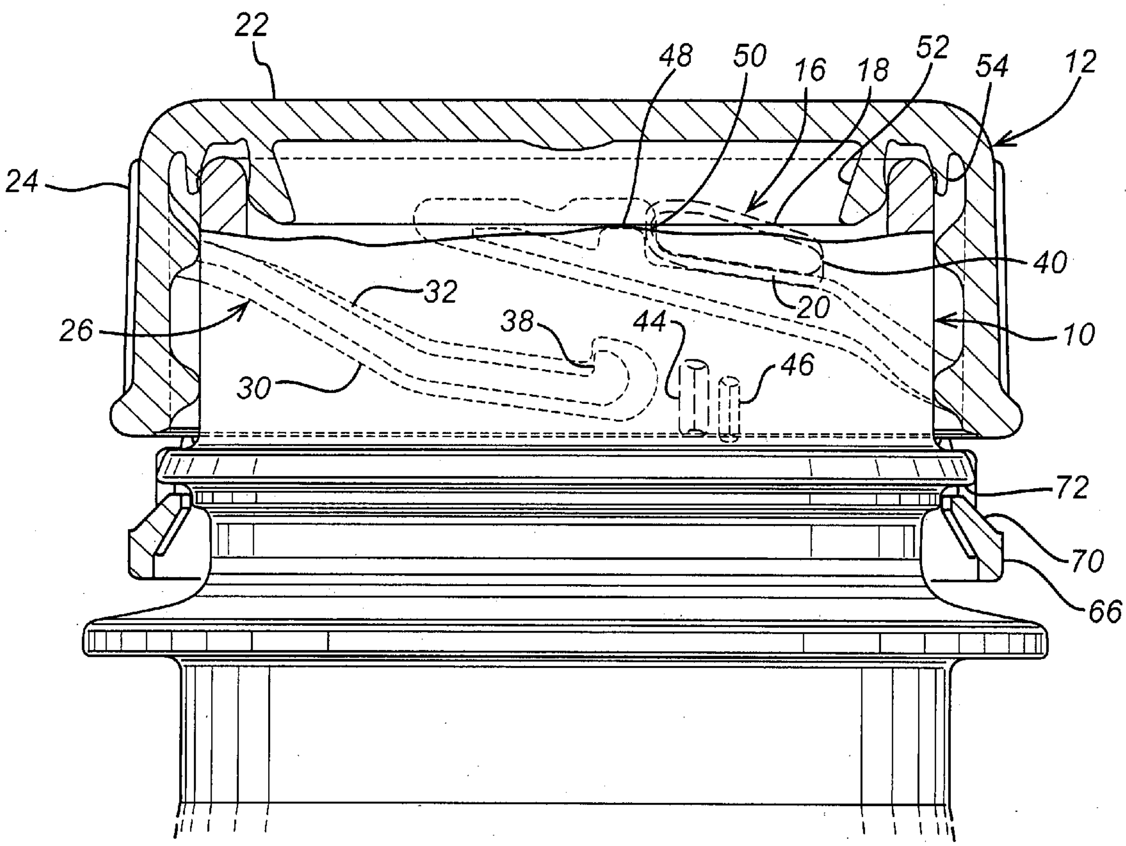


FIG. 1

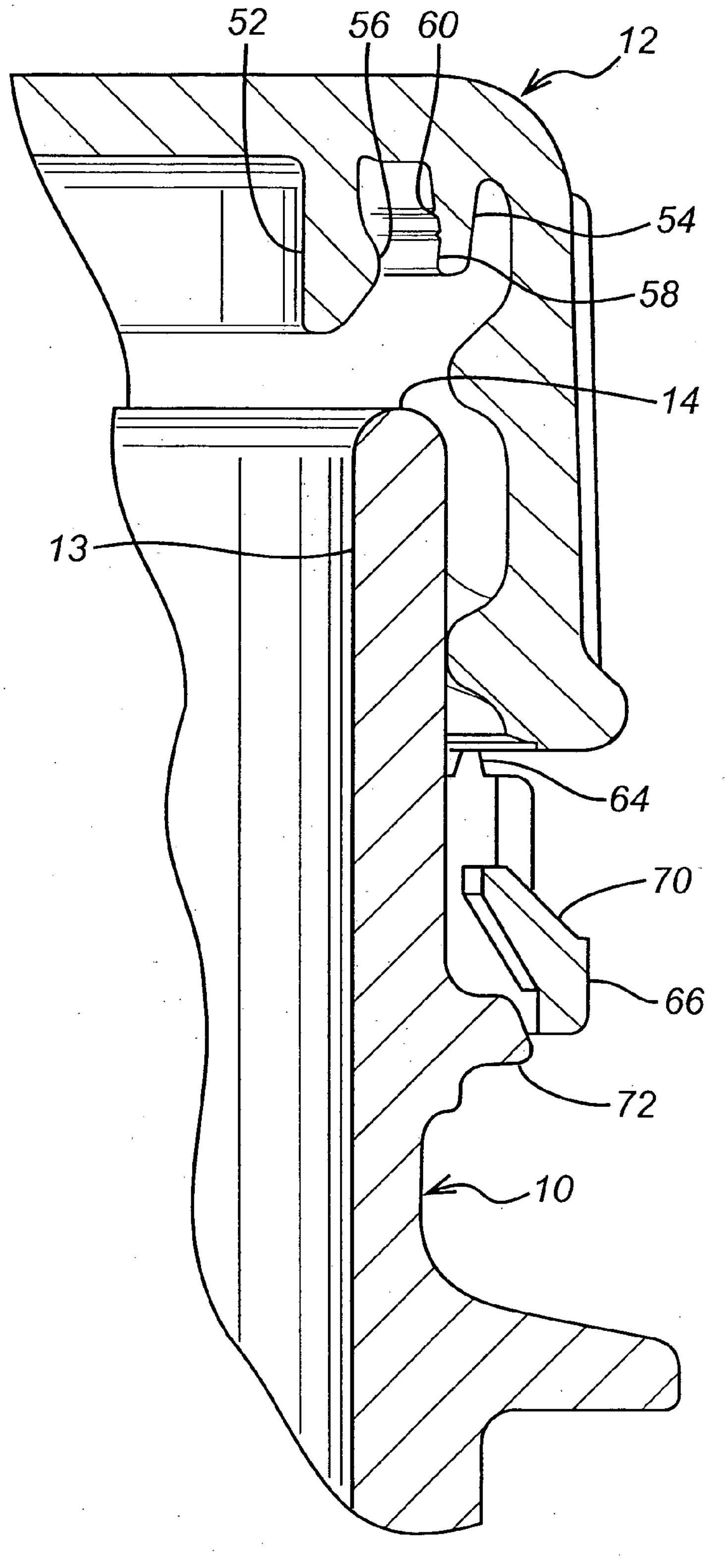


FIG. 2

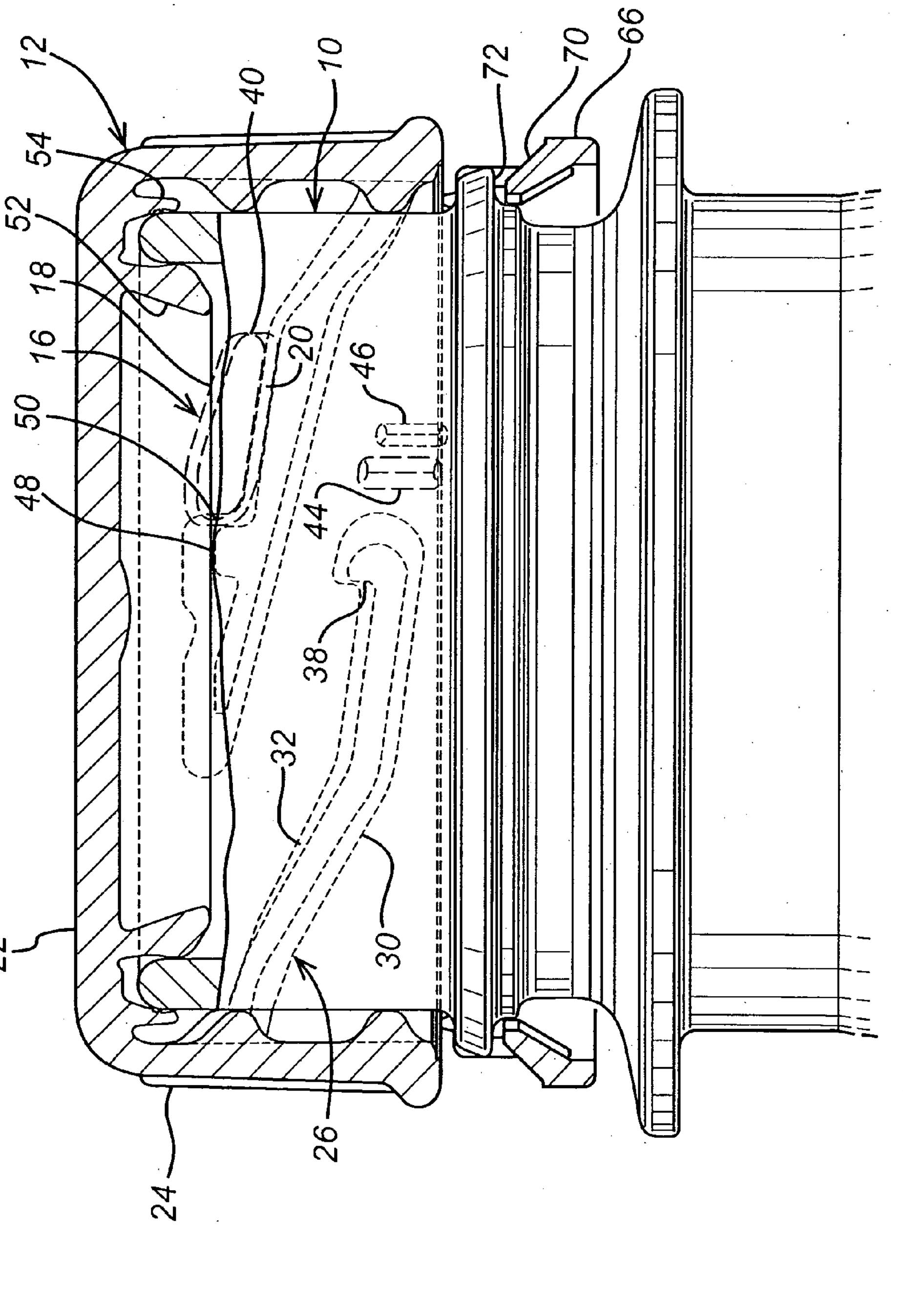
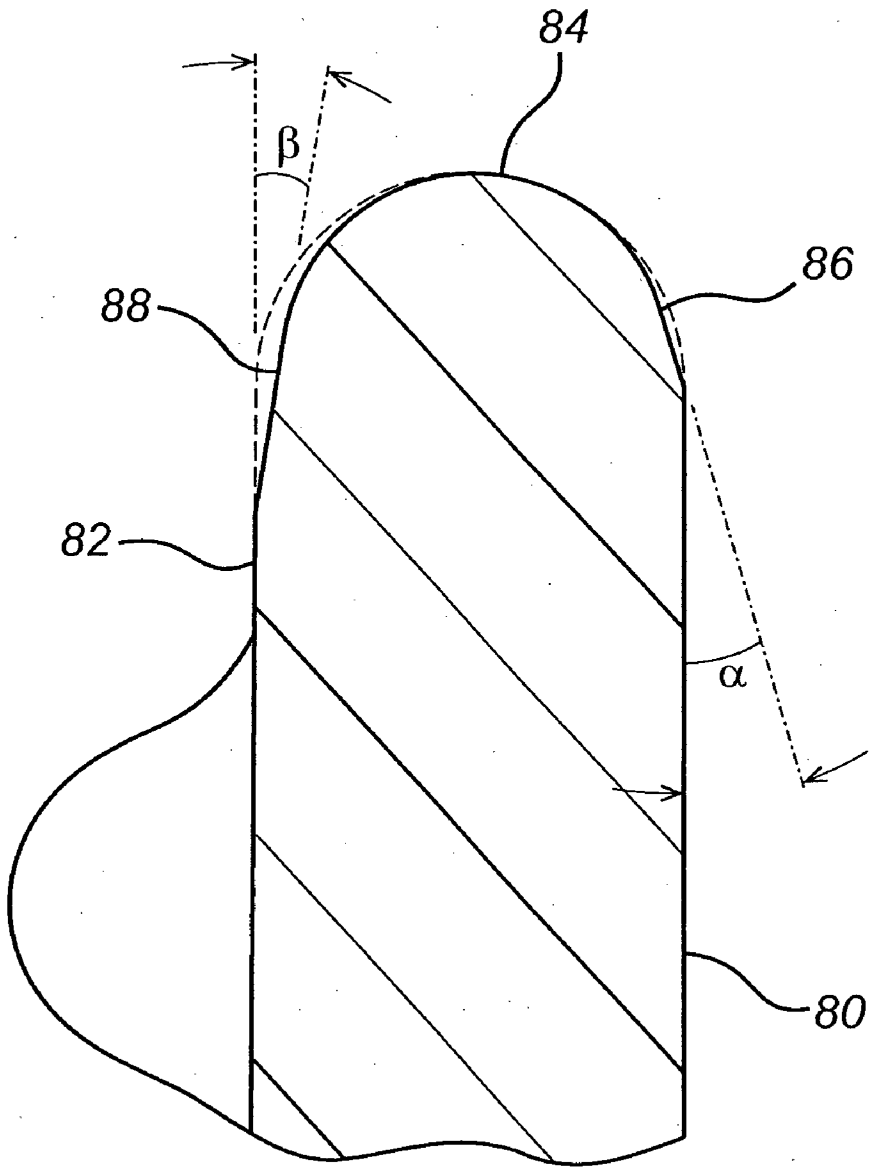


FIG. 3



CONTAINER CLOSURE ASSEMBLY WITH PRESSURE SEAL

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to improved seals for container closure assemblies. The invention is especially applicable to the sealing of containers in substantially gas-tight and liquid-tight fashion, such as the sealing of carbonated and non-carbonated beverage containers.

[0003] It is well known to provide beverage containers of glass, paper, card, metal or plastic having a screw top that can be resecured on the bottle neck. It is desirable to provide such containers with a screw top cap assembly that provides an airtight and liquid-tight seal to retain the quality of the beverage both during initial transport and storage, and after partial consumption of the contents when the cap has been resecured onto the container neck.

[0004] The present invention relates to improved seals for container closure assemblies. The invention is especially applicable to the sealing of containers in substantially gas-tight and liquid-tight fashion, such as the sealing of carbonated and non-carbonated beverage containers.

[0005] It is well known to provide beverage containers of glass, paper, card, metal or plastic having a screw top that can be resecured on the bottle neck. It is desirable to provide such containers with a screw top cap assembly that provides an airtight and liquid-tight seal to retain the quality of the beverage both during initial transport and storage, and after partial consumption of the contents when the cap has been resecured onto the container neck.

[0006] Certain existing container and cap assemblies make use of an elastomeric liner in the base of the cap. This liner is pressed against the lip of the bottle neck when the cap is screwed firmly onto the bottle neck, and the compression between the soft, deformable liner and the lip of the container provides a tight seal. Unfortunately, the manufacture and insertion of the liner into the cap are relatively costly additional process steps. Furthermore, care must be taken not to over-tighten such caps onto the container neck, since the liner can become brittle or damaged if excessive pressure is applied thereto.

[0007] It is also known to provide a cylindrical plug seal projecting downwardly from the base of the cap, such that the plug forms an interference fit with an inner surface of the bottle neck close to the lip of the bottle. Effective sealing by such plug seals requires the cap to be screwed down very tightly on the container neck in order to deform the base of the cap and thereby force the plug radially outwardly into a tight sealing engagement with the container neck. It is very often the case that such caps are under-tightened, especially by children and elderly users. Furthermore, a sufficient sealing force can only be achieved by the use of threads on the cap and the neck having a low pitch, such that the cap torque applied to the cap is leveraged into a very strong downward sealing force between the lip of the container and the cap base.

[0008] Certain existing container and cap assemblies make use of an elastomeric liner in the base of the cap. This liner is pressed against the lip of the bottle neck when the cap is screwed firmly onto the bottle neck, and the compression between the soft, deformable liner and the lip of the container provides a tight seal. Unfortunately, the manufacture and insertion of the liner into the cap are relatively costly additional process steps. Furthermore, care must be taken not to over-tighten such caps onto the container neck, since the liner can become brittle or damaged if excessive pressure is applied thereto.

[0009] It is also known to provide a cylindrical plug seal projecting downwardly from the base of the cap, such that the plug forms an interference fit with an inner surface of the bottle neck close to the lip of the bottle. Effective sealing by such plug seals requires the cap to be screwed down very tightly on the container neck in order to deform the base of the cap and thereby force the plug radially outwardly into a tight sealing engagement with the container neck. It is very often the case that such caps are under-tightened, especially by children and elderly users. Furthermore, a sufficient sealing force can only be achieved by the use of threads on the cap and the neck having a low pitch, such that the cap torque applied to the cap is leveraged into a very strong downward sealing force between the lip of the container and the cap base.

[0010] 2. Description of Related Art

[0011] WO02/42171 describes a container closure assembly comprising: a sealing plug extending from the base portion of the cap inside and substantially concentric with the skirt portion of the cap, wherein the sealing plug comprises a plurality of circumferential sealing ribs on an outer surface of the sealing plug for engagement with the inner surface of the container neck when the cap is secured on the container neck; at least one flexible sealing fin between the sealing plug and the cap skirt for engagement with the lip of the container when the cap is secured on the container neck; and at least one circumferential sealing rib on an inner surface of the cap skirt for engagement with an outer surface of the container neck proximate to the lip when the cap is secured on the container neck. In use, the lip of the container neck is pinched between the ribs on the outer surface of the sealing plug and the sealing rib on the inner surface of the cap skirt to form a pressure-tight seal.

[0012] WO2007/057706 describes a container closure assembly comprising: a sealing plug extending from the base portion of the cap inside and substantially concentric with the threaded skirt portion of the cap, wherein the sealing plug comprises two or more longitudinally spaced circumferential sealing ribs on an outer surface of the sealing plug for engagement with an inner surface of the container neck proximate to the lip when the cap is secured on the container neck. The cap further comprises a sealing skirt extending from the base portion of the cap intermediate the sealing plug and the threaded skirt portion of the cap and substantially concentric with the sealing plug and the threaded skirt portion of the cap, wherein the sealing skirt comprises two or more longitudinally spaced circumferential sealing ribs on an inner surface of the sealing skirt for engagement with an outer surface of the container neck proximate to the lip when the cap is secured on the container neck. In use two of the sealing ribs on the sealing plug are located at substantially the same longitudinal distances from the base portion of the cap as a two of the circumferential sealing ribs on the sealing skirt, whereby the lip of the container neck is pinched between the sealing ribs on the cap plug and the sealing skirt at two or more longitudinally spaced locations when the cap is in the secured position on the container neck.

[0013] Sealing arrangements for plastic container closures are also known that make use of a sealing olive extending from the base of the cap that forms an interference fit inside the container neck for sealing against an inside surface of the container neck proximate to the lip of the container neck. The sealing olive is a sealing plug that is characterized by having a smooth, bulbous circumferential projection (when viewed in longitudinal cross-section) on its radially outer surface. The olive seal is robust, easy to mould, and can maintain a good seal even when the base of the cap is distorted (domed) by pressure from inside the container. However, the olive seal on its own is not sufficient to provide a good, pressure-tight seal on carbonated beverage containers.

[0014] U.S. Pat. No. 5,871,111 and WO-A-9944896, US-A-20040060893, US-A-20020158037, GB-A-2131774, EP-A-0076778, WO-A-2007132254, US-A-20010027957 and WO2008012426 show arrangements in which a sealing olive or sealing plug is used together with one or more circumferential sealing ribs on the base of the cap that abut against the top of the container neck in the sealing position.

[0015] In a further development of closures of this type, WO98/35881 describes container closures in which a sealing olive is used together with a highly flexible sealing skirt that deforms to cover the lip of the container neck when the cap is secured on the neck. The contact area between the sealing skirt and the neck is quite large in the sealing position, which reduces problems caused by defects or dirt on the lip. Caps of this type, manufactured by Bericap GmbH, probably represent the most effective sealing caps on the market. However, the large contact area between the sealing skirt and the container neck in the sealing position results in an undesirably high sealing and opening torque. Furthermore, over-tightening of the cap can result in damage to the sealing skirt. WO2008/012426 describes a similar cap with an olive seal and a relatively short sealing skirt. However it appears that this cap further requires an elastomeric liner in the base of the cap and a further sealing rib near the bottom of the cap in order to produce a satisfactory seal.

BRIEF SUMMARY OF THE INVENTION

[0016] The present inventors have found that the above sealing arrangements in which a portion of the cap abuts directly against the top of the container lip present a problem, which is that the application of an axial force on the cap to displace it further towards the neck from the fully closed and sealing position results in permanent deformation and damage to the cap and impaired subsequent sealing. This excess axial displacement of the cap towards the neck can occur not only as a result of over-tightening of the cap on the neck (which can generally be prevented by means of suitable thread stops) but also as a result of the weight of superimposed containers when the containers are stacked, as is commonplace in the storage and transport of, for example, beverage containers.

[0017] A need remains for a screw-top container and cap arrangement that can provide an effective seal without the need for a liner, and also without the need for a strong axial sealing force between the container neck and the cap, and which furthermore is tolerant of high axial forces applied to the cap when it is in the closed and sealing position on the neck, for example the weight of superimposed containers when the containers are stacked.

[0018] The present invention provides a container closure assembly comprising: a container neck having side walls defining an opening at one end thereof and a lip extending around the opening; and a cap for said neck, the cap having a base portion and a threaded skirt portion; a first screw thread on the neck; a second screw thread on an inner surface of the threaded skirt of the cap; said first and second screw threads being configured to enable a user to secure, remove and resecure the cap into a sealing position on the neck by rotation of the cap on the neck; a sealing plug extending from said base portion of the cap inside and substantially concentric with said threaded skirt portion of the cap, wherein the sealing plug is an olive sealing plug for forming a seal against an inside surface of the container neck when the cap is secured on the container neck; and a sealing skirt extending from said base portion of the cap intermediate said sealing plug and said threaded skirt portion of the cap and substantially concentric with said sealing plug and said threaded skirt portion of the cap, wherein said cap can be displaced towards said neck from said sealing position by application of an axial force without rotation of the cap on the neck and substantially without plastic deformation of the cap.

[0019] Generally, the seal between the cap and the neck is maintained during said displacement. The ability to displace the cap by axial force provides improved performance of the closure assembly when containers equipped with the assembly are stacked so that the assemblies at the bottom of the stack are subjected to axial force due to the superimposed containers. Suitably, the displacement is a resilient displacement, whereby the closure tends to spring back to substantially the original sealing position when the axial force is removed even in the absence of any external restoring force such as pressure inside the container. This resilience can be primarily due to the elastic flexure of the sealing skirt. It goes without saying that the prior art closure assemblies currently in use, as described above, do not have this property, as they all require direct abutment between the top of the container lip and the cap at the sealing position that blocks further axial movement of the cap towards the neck under axial force and/or results in permanent, plastic deformation of the cap under the axial force that impairs the sealing properties of the assembly both during and after the axial force is applied. Suitably, the axial displacement of the cap in the assemblies of the present invention takes place substantially or completely without plastic (permanent) deformation of the cap. Suitably, the resilient axial deformation may be at least 0.1 mm, more suitably from about 0.2 mm to about 2 mm, typically from about 0.5 mm to about 1 mm. Suitably, the axial force may be from about 1N to about 1000N, for example from about 10N to about 100N.

[0020] In order to allow for the above axial displacement, the assemblies according to the invention suitably have a clearance (gap) between the top of the container lip and the axially adjacent point on the cap at the sealing position. Suitably, the clearance between the topmost point of the lip and the axially adjacent point on the base of the closure at the sealing position (in the absence of external applied axial force) should be at least about 0.1 mm, suitably about 0.2 mm to about 2 mm, for example about 0.5 mm to about 1 mm. Suitably no part of the cap should contact the top surface of the container lip at the sealing position. The term "top surface" in this context refers to any portion of the lip that is inclined (in longitudinal cross-section) at an angle of more than about 45 degrees to the main axis of the assembly, preferably about 30 degrees to the main axis of the assembly.

[0021] Suitably, a region of the radially inner surface of the sealing skirt is concave for engagement with an outer surface of the container neck proximate to said lip when the cap is secured on the container neck. Such a concave sealing skirt is well adapted to slide around the side of the lip to maintain effective sealing during the axial displacement.

[0022] The combination of olive sealing plug and concave sealing skirt is new, and provides surprisingly improved sealing at low sealing forces, in addition to the improved performance when subjected to axial force at the sealing position.

[0023] Suitably, the neck is molded in one piece from thermoplastic material, such as polyethylene terephthalate. The neck may form part of a beverage container, such as a molded plastic or glass carbonated beverage bottle.

[0024] Suitably, the container lip is substantially fully radiused in longitudinal cross-section. That is to say, the longitudinal cross-section of the lip surface presents a substantially continuous curve extending from the inside surface of the neck to the outside surface of the neck, so that the top of the lip is rounded, not flat. More suitably, the surface of the lip is shaped substantially as a segment of a circle in cross-section, for example it may be substantially semi-circular. The rounded lip provides for easy and comfortable drinking directly from the container neck. It is a further advantage of the present invention that the sealing arrangement is effective to provide a pressure-tight seal on a rounded container lip by engagement of the concave inner surface of the sealing skirt on the rounded surface of the lip.

[0025] Suitably, the inner and/or the outer surfaces of the container neck adjoining the lip are slightly tapered. That is to say, the internal diameter of the neck adjacent to the bottom of the lip may be slightly tapered inwardly providing a substantially conical surface wherein the internal diameter decreases slightly with increasing distance from the junction with the (radiused part of) the lip. Suitably, this region of taper extends for an axial distance from about 1 mm to about 10 mm, for example about 2 mm to about 5 mm. so that the olive seal abuts against the tapered inside surface as the sealing position is approached when screwing the cap onto the neck. Similarly, the outer diameter of the neck adjacent to the bottom of the lip may be slightly tapered outwardly so that the outer diameter increases slightly with increasing distance from the junction with the (radiused part of) the lip. Suitably, this region of taper extends for an axial distance from about 1 mm to about 10 mm, for example about 2 mm to about 5 mm, so that the sealing skirt abuts against the tapered inside surface as the sealing position of the cap on the neck is approached. The angle of each taper, measured in longitudinal cross-section, is suitably independently from about 1 degree to about 30 degrees, more suitably from about 5 degrees to about 20 degrees from the longitudinal axis of the assembly. The slight taper of the neck below the lip results in a more constant torque being required to secure the cap on the neck close to the sealing position. In other words, there is a less abrupt increase in screwing torque as the sealing plug and sealing skirt first engage the neck.

[0026] The assembly according to the invention further comprises a cap having a base portion and a threaded skirt portion. The cap is suitably molded in one piece from thermoplastic material, for example by injection molding or by compression molding. The cap includes a sealing plug and a sealing skirt depending from the base of the cap, as defined above.

[0027] The sealing plug is suitably in the form of a tube, typically projecting perpendicularly downwardly from the base of the cap and preferably substantially concentric with the threaded skirt and coaxial with the longitudinal axis of the cap. The height of the sealing plug (measured from the inside surface of the base of the cap) is suitably from about 1 mm to about 5 mm, for example about 1.5 mm to about 2.5 mm. The sealing plug is normally molded integrally with the base of the cap. The mean thickness of the tubular wall of the sealing plug is suitably from about 0.5 mm to about 2 mm, for example about 0.7 mm to about 1.2 mm. This gives the sealing plug the right degree of resilience and strength for the desired sealing function.

[0028] The sealing plug is in the form of an olive seal. That is to say, the plug has a circumferentially projecting radially outer surface having a bulbous shape (when viewed in longitudinal cross-section). The bulbous projection has a substantially smooth, continuous surface and a height suitably from about 10% to about 50% of the radial thickness of the plug. The minimum radius of curvature of the bulbous projection is suitably no less than about the mean radial thickness of the plug. Suitably, the minimum radius of curvature of the bulbous projection is from about 0.5 mm to about 1 mm. Such olive sealing plugs are relatively tolerant of small axial displacements of the plug, for example caused by doming of the cap base under pressure from inside the container, without loss of sealing effectiveness.

[0029] The container closure in the assembly according to the present invention further comprises a circumferential sealing skirt. The sealing skirt is separate and radially spaced from the threaded cap skirt that engages the thread on the outside of the container neck. Suitably, the sealing skirt is substantially tubular, and projects downwardly from the base of the cap intermediate the cap skirt and the sealing plug. The sealing skirt is preferably substantially concentric with the threaded skirt and the sealing plug, and coaxial with the longitudinal axis of the cap. The height of the sealing skirt is suitably from about 1 mm to about 5 mm, for example about 1.5 mm to about 2.5 mm. The height of the sealing skirt in certain embodiments (measured from the inside surface of the cap adjacent to the inside surface of the sealing skirt) is at least about 50%, for example at least about 75% of the height of the sealing plug. The sealing skirt is normally molded integrally with the base of the cap. The mean thickness of the tubular wall of the sealing skirt is suitably from about 0.5 mm to about 2 mm, for example about 0.7 mm to about 1.2 mm. This gives the sealing skirt the right degree of resilience and strength for the desired sealing function.

[0030] The sealing skirt in the arrangement of the present invention is suitably relatively thick relative to its height, and undergoes relatively little deformation upon sealing when compared to the sealing skirt of, for example, WO98/35881. Suitably, the sealing force applied by the skirt is provided by the resilience of the skirt itself, not by abutment of the outside of the sealing skirt against the inside of the threaded skirt or the cap base as taught in WO98/35881. The relatively thick and resilient sealing skirt is less likely to be damaged by repeated use, in particular by over-tightening. Suitably, the sealing skirt has a radial thickness at half-height (said height of the sealing skirt being measured from the base of the radially inner surface of the sealing skirt) equal to from about 40% to about 80% of the radial thickness of the sealing plug measured at the same height. Suitably, the sealing skirt has a radial thickness at half-height (said height of the sealing skirt being measured from the base of the radially inner surface of the sealing skirt) equal to from about 20% to about 50% of the height of the sealing skirt, for example from about 25% to about 40% of said height.

[0031] Suitably, the inside diameter of the sealing skirt at half-height is from about 0.05 mm to about 0.5 mm less than the outside diameter of the container neck. For example, it may be from about 0.1 mm to about 0.25 mm less than the outside diameter of the container neck. In other words, the inside diameter of the sealing skirt is only slightly less than the outside diameter of the container neck proximate to the rounded lip, whereby the skirt is only slightly deformed in the sealing position. However, the resilience of the sealing skirt is sufficient for a slight deformation to produce a strong sealing force against the lip. Moreover, the resilience of the sealing skirt allows the skirt to flex outwardly without plastic deformation and without loss of sealing effectiveness when the cap is forced axially downwardly beyond the normal sealing position by an external force, for example the weight of another container stacked on top of the assembly. The same resilience of the sealing skirt restores the original sealing position of the cap when the external axial force is removed.

[0032] The sealing effectiveness of the sealing skirt may be further enhanced by providing at least one circumferential sealing rib in said concave region of said sealing skirt. Suitably, there are two of the sealing ribs on the sealing skirt, but in some embodiments there could be from 3 to 10 of the ribs, and for example 4 to 6 ribs.

[0033] Suitably, at least one of the sealing ribs has a substantially triangular cross-section when the cap is viewed in longitudinal cross-section, for example substantially equilateral triangular. Suitably, the contact angle between the sides of the sealing ribs and the radially inside surface of the sealing skirt is from about 30 degrees to about 75 degrees, for example from about 45 degrees to about 60 degrees. This enables the sealing force to be concentrated in the tip of the sealing rib to maximize sealing effectiveness. Suitably, at least one of the sealing ribs has a height in the range of 10 to 250 micrometers, more suitably 20 to 150 micrometers, for example 50 to 150 micrometers. The height is defined as the maximum distance that the sealing rib projects above the adjacent surface of the sealing skirt, when the cap is viewed in longitudinal cross-section. Such micro sealing ribs are especially effective to concentrate the sealing force and achieve an effective seal with a substantially smooth sealing surface on the container neck. Furthermore, such micro ribs are especially easy to mold in high-speed cap molding equipment, and to bump off the mold mandrel of the equipment after molding.

[0034] An advantage of using multiple sealing ribs on the sealing skirt is that the plurality of sealing ribs may have more than one dimension in order to optimize sealing. For example, the size of the sealing rib closest to the base of the cap may be greater than the size of the sealing rib remote from the base of the cap. This allows the sealing rib closest to the base of the cap (i.e. closest to the lip of the container) to deform more that the sealing rib furthest from the base of the cap.

[0035] The use of multiple circumferential sealing ribs on the sealing skirt, which has a degree of radial flexibility, allows a pressure-tight seal to be formed between the container neck and the cap without application of excessive force to the cap, and without any need for a sealing liner in the base of the cap. Accordingly, the caps in the assemblies according to the present invention suitably do not include a liner, i.e. they are linerless caps. Furthermore, the cap assemblies do not require, and preferably do not include, any sealing elements on the cap other than the olive seal plug and the sealing skirt. In particular, as previously explained, and in contrast to almost all prior art closure assemblies for carbonated beverages, the assemblies according to the present invention do not require, and normally do not have, any sealing elements abutting against the top of the lip.

[0036] Suitably, the cap is a low-profile cap having an axial height from the top of the base to the bottom of the threaded skirt (i.e. excluding any tamper-evident ring attached to the bottom of the threaded skirt), of from about 10 mm to about 15 mm, for example about 12 mm to about 14 mm. The sealing arrangement of the present invention is especially suitable for use with low-profile caps, because the minimal distortion of the sealing skirt during sealing makes it possible to arrange the sealing skirt and plug so that they axially overlap the top of the threads on the cap skirt without interfering with the running of those threads.

[0037] It has been found that the assemblies according to the invention provide excellent sealing of carbonated beverage containers even under high pressure/high temperature conditions such as storage at 38° C. This is because the distortion (doming) of the base of the cap leverages increased sealing force onto the sealing skirt, while the olive seal on the inside of the container neck is more tolerant of deformation of the cap base compared to the sealing plugs described in WO02/42171 and WO2007/057706. However, the arrangements according to the present invention maintain the advantages of robustness, resistance to over-tightening, ease of molding, and low sealing/opening torque of those prior art assemblies.

[0038] The container closure assembly according to the present invention is especially suitable for use in conjunction with thread arrangements that are quick and easy to secure and resecure, wherein the cap can be secured and resecured on the container neck by a single smooth rotation through 360° or less, more suitably 180° or less, and most suitably about 90°.

[0039] Suitably, the first and second threads may be multiple start threads such as two-start threads or three-start threads, and more suitably they are four-start threads. This further assists securing of the cap on the neck, since the user needs to rotate the cap less in order to find a thread start. Suitably, the threads are substantially free-running or parallel threads. That is to say, the threads on the cap and the neck slide past each other freely without forming an interference fit between the thread segments on the cap and the neck. However, the present invention is also applicable to embodiments in which the first and second threads may be more conventional, single-start, low-pitch continuous threads.

[0040] Suitably, the first and second threads are continuous helical threads. That is to say, they are not bayonet-type threads that require a stepped motion of the cap to secure the cap on the neck, but rather they define a substantially continuous helical thread path having a thread gradient (pitch) less than 90 degrees substantially throughout. Suitably the threads have a mean thread pitch of from 5° to 25°, more suitably from 10° to 20°. Typically, the minimum vertical displacement of the cap between the fully secured position on the container neck and a fully disengaged position of the cap on the neck of from about 2 mm to about 10 mm, for example from about 4 mm to about 8 mm.

[0041] Steeply pitched threads provide advantages in terms of ease of use and more reliable separation of tamper-evident rings from the cap skirt. However, it will be appreciated that such steeply pitched threads result in a relatively small leverage of rotational force applied to the cap into downward force on the cap, and it is a feature of the sealing arrangement according to the invention that it can provide a reliable pressure-tight seal without strong downward force being applied to the cap as in previous sealing arrangements.

[0042] Suitably, the torque required to secure the cap in a sealing position on the container neck is less than 1.2 Nm, more suitably less than 1 Nm and most suitably from about 0.7 to about 0.9 Nm. This is the torque required to engage the complementary locking arrangement (where present) at the sealing position, and/or otherwise the force required to substantially eliminate gas leakage at normal carbonated beverage pressure differentials.

[0043] It is an advantage of the assemblies according to the present invention that they can provide a pressure tight seal without the need for additional circumferential flexible sealing fins between the sealing plug and the sealing skirt of the kind described in WO02/42171.

[0044] In certain embodiments, the container closure assembly according to the invention, the container further comprises mutually engageable elements on the neck and the closure to block or restrict rotation of the closure in an unscrewing direction beyond an intermediate position when the closure is under axial pressure in a direction emerging from the container neck. This is the so-called pressure safety feature that is intended to prevent the closure unscrewing uncontrollably or missiling as it is removed from a container neck under pressure. Preferably, the pressure safety feature is as described in WO95/05322, WO97/21602 and WO99/19228.

[0045] In these embodiments, the first and second screw threads are constructed and arranged to permit axial displacement of the closure relative to the neck at least when the closure is at the said intermediate position, and preferably the engageable elements are adapted to engage each other when the closure is axially displaced in a direction emerging from the neck, for example by axial pressure from inside the pressurized container. More preferably, the mutually engageable elements are constructed and arranged not to mutually engage each other when the closure is axially displaced in a direction inwardly towards the neck at the intermediate position, for example when the closure is being screwed down onto the container neck.

[0046] Preferably, the mutually engageable elements comprise a step or recess formed in the lower surface of one of the second screw thread segments to provide a first abutment surface against which a second abutment surface on one of the first screw thread segments abuts to block or restrict rotation of the closure in an unscrewing direction at the said intermediate position when the closure is under axial pressure in a direction emerging from the container neck, but which allows easy removal of the closure when the container is not unduly pressurized.

[0047] More preferably, the second thread segment comprises a first thread portion having a first longitudinal cross section and a second thread portion having a second longitudinal cross section narrower than the first cross section, whereby the first thread segment abuts against the second thread portion. The relatively broad first cross section is preferably adjacent to the circumferentially overlapping region of the second thread segments, resulting in a relatively narrow thread gap in that region.

[0048] Preferably, the first and second threads on the container neck and closure are variable pitch threads, preferably as described in WO97/21602. Preferably, the pitch of an unscrewing thread path defined by the first and the second thread segments is relatively lower in a first region and relatively higher in a second region displaced from the first region in an unscrewing direction. The pitch of the thread path in the first region is preferably substantially constant. The first region normally includes the position at which the closure is sealed on the container neck. Preferably, the first region extends for 20°-40° about the circumference of the container neck or the closure skirt. Preferably, the pitch of the lower thread surface in the first region is in the range of 1° to 12°, more preferably 2° to 8°.

[0049] Preferably, the second region is adjacent to the first region of the thread path. Preferably, the pitch of the helical thread path in the second region is substantially constant, and the second region preferably extends for 15° to 35° about the circumference of the container neck or the closure skirt. Preferably, the pitch of the thread path in the second region is in the range of 15° to 35°.

[0050] The use of a variable pitch thread renders it easier to combine fast-turn threads having a steep average pitch that are elderly- and child-friendly with pressure safety. A problem that could arise with fast-turn threads is that they are steeply pitched, which results in a tendency to back off from the fully secured position on the container neck when the container is pressurized. This problem can be overcome by using bayonet-type threads, but the use of bayonet-type threads results in a number of different problems, as described above. In contrast, the variable pitch threads solve the problem of backing off of the closure under pressure, whilst retaining all of the advantages of continuous, fast-turn threads.

[0051] Preferably, the helical unscrewing thread path further comprises a third region adjacent to the second region, wherein the third region has a relatively low pitch. Preferably, the third region has a relatively constant pitch, preferably in the range 1 to 12°, more preferably 2 to 8°. The third region preferably includes the position of the closure on the container neck when the closure is blocked at the intermediate gas venting position. The relatively low pitch of the third region reduces the tendency of the closure to override the blocking means at high gas venting pressures.

[0052] Suitably, the container and cap assemblies according to the present invention comprise complementary locking elements on the container neck and the cap that block or resist unscrewing of the cap from the sealing position on the container neck until a predetermined minimum opening torque is applied. For example, the locking elements may comprise a longitudinal locking rib on one of the container neck or the skirt portion of the cap, and a complementary locking ramp on the other of the container neck and the skirt portion of the cap, the locking rib abutting against the retaining edge of the locking ramp when the cap is fully secured on the container neck.

[0053] In certain embodiments, the first and second locking projections (side catches) longitudinally overlap the first and/or the second thread segments when the cap is in said fully engaged position on the container neck. In other words, the first and second locking projections are not located entirely above or below the threads (the terms above and below refer to relative positions along the longitudinal axis of the assembly), but are located, at least in part, circumferentially in-between the threads. The side catches are preferably located adjacent to an end of the threads. This enables the entire thread assembly to be made more compact in the longitudinal (vertical) direction, thereby reducing the total amount of molding material needed to make the assembly, and the space taken up by the assembly. In certain embodiments, it also enables the neck thread to be made more suitable for consumption directly from the neck.

[0054] Typically, the first and second locking elements are situated near the lower end of the threads when the cap is fully secured on the container. Preferably, the first and/or second locking projections do not extend below the lower edge of the first or second thread segments when the cap is in said fully engaged position on the container neck. The term "lower" refers to the part of the neck thread furthest from the opening of the container neck. In such assemblies, the locking projections are preferably located substantially completely circumferentially between the threads and not above or below the threads. Preferably, the locking projections on the neck are not joined at the lower edge to a circumferential flange or shoulder (e.g. the shoulder used to retain a tamper-evident band), thereby enhancing the flexibility of the locking projections and enhancing the "click-to-close" noise.

[0055] Further to the aforesaid, at least one, and preferably both of the complementary locking projections on the neck and/or the cap is substantially separate from the thread segments and can flex substantially independently of the thread segments in order to provide the snap-fitting and clearly audible click as the fully secured position of the cap on the neck is reached. In general, a radially innermost vertex of the second locking element on the cap skirt rides over a radially outermost vertex of the first locking element on the container neck as the fully secured position is approached. The second locking element then rides back over the outermost vertex of the first locking element when the cap is removed from the secured position, for example when opening the assembly.

[0056] At least one, and preferably both of the complementary locking projections on the neck and/or the cap has a length in the longitudinal direction (i.e. along the rotational axis of the cap assembly) of from about 1 mm to about 6 mm, for example from about 2 mm to about 4 mm. At least one, and preferably both of the complementary locking projections on the neck and/or the cap has a height of from about 0.25 mm to about 2 mm, for example from about 0.5 mm to about 1.5 mm. In any case the height of the locking projections is normally less than the average height of the respective thread segments. At least one, and preferably both of the complementary locking projections on the neck and/or the cap has a maximum width (i.e. around the circumference of the neck or cap skirt) of from about 0.5 mm to about 3 mm, for example from about 1 mm to about 2 mm. At least one, and preferably both of the complementary locking projections on the neck and/or the cap has a ratio of the maximum height to the maximum width of at least about 0.5, more preferably at least 1, for example from about 1 to about 5.

[0057] In suitable embodiments, the first locking projection is located longitudinally overlapping with and circumferentially spaced from an upper end of a first thread segment. In other embodiments, the second locking projection is located longitudinally overlapping with and circumferentially spaced from a lower end of a second thread segment. These latter embodiments are preferred, since the first locking projections are then located further from the opening of the container neck. The circumferential spacing between the projections and the respective thread segments in these embodiments is typically from about 1 mm to about 10 mm, for example from about 1 mm to about 4 mm. In these embodiments, the circumferentially spaced locking projections may abut against the thread segments of the other assembly component as the assembly is screwed together. That is to say, the circumferentially spaced projections may define a part of the thread path on the cap or neck. For example, in the case where there are relatively long thread segments on the cap skirt defining a thread path for relatively short thread segments on the container neck, the locking projections on the cap skirt may be circumferentially spaced from the lower end of the relatively long thread segments on the cap skirt and may thereby define an extension at the start of the thread path followed by the thread segments on the neck when the cap is applied to the neck. This method of using the locking projections to form an extension of the thread path on one of the neck or the cap solves the problem of providing larger locking projections that overlap with the threads, but do not interfere with the running of the threads. The locking projections are generally in the line of and, as it were, are extensions of the thread path on one of the neck or the cap. Suitably, the locking projections are as described in WO-A-2005058720.

[0058] The assemblies according to the present invention may comprise more than one pair of complementary locking projections on the container neck and the cap. Preferably there are at least two such complementary pairs radially spaced around the neck and cap skirt. There will normally be at least one pair for each thread start, for example there may be four pairs radially spaced around the neck and cap skirt.

[0059] The said sealing position of the cap on the neck is thus normally the first rotational position in the screwing direction at which the locking projections are in locking engagement, i.e. normally in abutment.

[0060] Suitably, the locking projections on the neck and the cap skirt are circumferentially positioned such that they are in abutment when the cap is at the said sealing position on the container neck. That is to say, the projection on the cap has ridden over one side of, and is resting in abutment with the opposite side of, the corresponding projection on the container neck at said fully closed and sealing position. This ensures that there is no play in the cap at said closed and sealing position that could allow leakage from the seal. Preferably, when the projections are in abutment at the closed and sealing position, the cap skirt and/or the projections are still slightly distorted such that a resilient force is exerted between the projections in abutment. This resilient force is leveraged by the abutment into a closing torque between the cap and the neck that urges the cap into the fully closed and sealing position. This can ensure that the respective sealing surfaces of the container neck and the cap are automatically seated against each other, even though the cap may not be screwed down especially tightly. Furthermore, the locking projections allow for considerably lower manufacturing tolerances in the molding of the assembly, since effective sealing is achieved over a broader range of rotational sealing positions due to the interaction between the locking projections and the radial deformation of the cap skirt.

[0061] The advantages of locking projections that urge the cap into the sealing position are discussed in detail in WO93/01098.

[0062] The complementary locking elements according to the present invention provide a number of other important advantages, besides urging the cap into the fully secured and sealing position as described above. Firstly, they prevent accidental backing off of the cap from the fully engaged and sealing position on the container neck due to pressure from inside the container. These elements enable more steeply pitched threads and free running (parallel) threads to be used without risk of the cap unscrewing spontaneously. The use of more steeply pitched threads in turn makes it easier to remove and resecure the cap.

[0063] In some embodiments, the locking elements according to the present invention may also provide a positive "click" when the fully engaged and sealing position of the cap on the container neck is reached, thereby giving the user a positive indication that the cap is in the closed (sealed) position. This system also ensures that exactly the right degree of compression is applied between the container and cap to achieve an effective airtight seal.

[0064] Suitably, the container closure assembly according to the present invention further comprises a projecting stop surface on one of the container neck and the cap skirt for abutment against a second stop or a thread on the other of the container neck or the cap to block over-tightening of the cap beyond a predetermined angular sealing position of the cap on the container neck. The stop elements act in conjunction with the locking arrangement to ensure that exactly the right degree of screwing of the cap is achieved in order to provide a pressure-tight seal with the sealing arrangement of the present invention. The stop surfaces may be in abutment at said sealing position of the cap on the neck, or they may be very close to abutment, for example within less than about 2 mm, suitably less than about 1 mm of abutment at said sealing position, to allow for manufacturing tolerances.

[0065] Suitable locking and stop arrangements are described in detail in WO 91/18799, WO 95/05322 and WO2005/058720.

[0066] The container closure assembly also suitably comprises a tamper-evident safety feature. The safety feature preferably includes a tamper-evident ring that is initially formed integrally with the skirt of the container closure and joined to the lower edge thereof by one or more frangible bridges. The tamper-evident ring is retained on the container neck when the cap is removed from the neck for the first time, suitably by abutment with the underside of a circumferential retaining lip provided on the container neck below the threads.

[0067] In certain embodiments, the tamper-evident ring comprises a plurality of integrally formed, flexible, radially inwardly pointing retaining tabs to retain the ring under the retaining lip. In these embodiments, ratchet projections may also be provided on the container neck below the circumferential retaining lip and radially spaced around the container neck to block rotation of the tamper-evident ring on the container neck in an unscrewing direction and thereby assist separation of the tamper-evident ring from the neck. The structure and operation of the tamper-evident ring feature according to these embodiments may be as described and claimed in our International Patent Publication WO94/11267.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0068] Embodiments of the present invention will now be described further by way of example with reference to the accompanying drawings, in which:

[0069] FIG. **1** shows a partial longitudinal cross-section through a container closure assembly according to the invention with the cap shown immediately prior to application to the neck;

[0070] FIG. **2** shows a view partially in longitudinal cross-section and partially in elevation of the container closure assembly of FIG. **1**, with the cap in the fully secured and sealing position on the container neck; and

[0071] FIG. **3** shows a partial longitudinal cross-section through the top region of the neck of a container closure assembly according to the invention

DETAILED DESCRIPTION OF THE INVENTION

[0072] Referring to FIGS. **1** and **2**, this embodiment is a container closure assembly especially adapted for a carbonated beverage container. Many features of this assembly resemble those of the assembly described and claimed in our International Patent Applications WO95/05322 and WO97/21602 and WO99/19228. However, it is important to note that the threads on the closure and the neck are reversed in the present invention relative to the closure assemblies described in those applications. That is to say, the earlier patent specifications describe in detail assemblies having short thread segments in the closure skirt and longer thread segments on the neck, whereas the present invention provides only short thread segments on the neck and longer thread segments on the closure skirt.

[0073] The assembly according to this embodiment includes a container neck **10** of a container for carbonated beverages, and a closure **12**. Both the container neck and the closure are formed from plastics material, but the container neck could also be made from glass. The container is preferably formed by injection molding and blow molding of polyethylene terephthalate in the manner conventionally known for carbonated beverage containers. The closure is preferably formed by injection molding or compression molding of polyethylene. The container neck has a cylindrical inner surface **13** terminating in rounded lip **14**.

[0074] Referring to FIG. **3**, an embodiment of the lip region of the container neck is shown in more detail. The neck has an internal surface **80**, an outside surface **82**, and a radiused lip **84**. A region **86** of the internal surface adjacent to the radiused lip **84** is tapered at an angle α of approximately 16 degrees. A region **88** of the outside surface adjacent to the radiused lip **84** is tapered at an angle β of approximately 9 degrees. These regions of taper provide that there is a less abrupt increase in screwing torque when the sealing plug and sealing skirt of the cap come into engagement with the neck as the sealing position of the cap on the neck is approached.

[0075] On the container neck **10** there is provided a four-start first screw thread made up of four first thread segments **16**, as shown in FIG. **2**. The first thread segments **16** are short thread segments extending about 33° around the neck and having a lower surface **18** with relatively low pitch of about 6° and an upper surface **20** with intermediate pitch of about 13.5°. The first thread segments present a substantially trapezoidal cross-section along the axis of the neck.

[0076] Referring to FIGS. **1** and **2**, the closure **12** comprises a base portion **22** and a skirt portion **24**. The closure skirt **24** is provided with a second screw thread formed from four elongate second thread segments **26**, each having a lower thread surface **30** and an upper thread surface **32**. (The term "upper" in this context means closer to the base of the closure, i.e. further from the open end of the closure). The upper and lower second thread surfaces **30**, **32** give the thread segments substantially trapezoidal side edges that are complementary to the shape of the first thread segments. A substantially continuous, approximately helical thread path for the first thread segments is defined between adjacent second thread segments **26**.

[0077] A feature of this assembly is the profiling of the upper surfaces **32** of the second thread segments **26**, which is described in more detail in our International patent application WO97/21602. The upper thread surfaces **32** in a first, upper region have a substantially constant pitch of only about 6°. The upper region adjoins an intermediate region having a substantially constant, much higher pitch of about 25°. The average pitch of the helical thread path defined by the second thread segments **26** is 13.5°.

[0078] The second thread segments **26** also include a pressure safety feature similar to that described and claimed in our International Patent Application WO95/05322. Briefly, the lowermost portion of the second thread segment **26** defines a step **38** to abut against a first end **40** of the first thread segments **16** and block unscrewing of the closure **12** from the neck **10** when the said first thread segments **16** are in abutment with the upper surface **32**, i.e. when there is a net force on the closure in an axial direction out of the container neck. A third region of the upper surfaces **32** of the second thread segments situated adjacent to the step **38** also has a low pitch of about 6°.

[0079] The container and closure assembly is also provided with complementary locking elements on the container neck and the closure to block unscrewing of the closure from the fully engaged position on the container neck unless a minimum unscrewing torque is applied. These locking elements comprise four equally radially spaced first locking projections **44** on the container neck, and four equally radially spaced second locking projections **46** on the inside of the closure skirt **24**. The projections on the container neck are located at the bottom of the thread, where they are least noticeable to a person drinking directly from the container neck. The locking projections **46** on the closure skirt are located level with, and radially spaced by about 2 mm from, the bottom of the threads **26** on the skirt. The locking projections on the closure skirt **24** are formed as a continuation of the closure thread segments **26**, whereby the thread segments **16** on the neck **10** can pass smoothly past the locking projections on the neck as the cap is secured on the neck.

[0080] Each of the locking projections **44**, **46** is substantially in the form of a triangular prism having its long axis aligned with the axis of the closure assembly. The height of each locking projection is about 1.5 mm, and the base width is about 1.5 mm. This ensures that the projections have sufficient strength to snap over each other without permanent deformation.

[0081] Each of the second thread segments **26** includes a longitudinally upwardly projecting portion **48** that defines a longitudinal stop surface against which a second end **50** of one of the first thread segments **16** may abut when the closure is fully secured on the neck to block overtightening of the closure on the neck.

[0082] The cap comprises a cylindrical sealing plug **52**. The cap further comprises a cylindrical sealing skirt **54** that is substantially concentric with the sealing plug. The sealing plug **52** and the sealing skirt **54** are concentric with the threaded skirt **24** and located inside the threaded skirt **24** for sealing abutment against opposite sides of the container neck proximate to the container lip **14**.

[0083] The sealing plug **52** is an olive sealing plug having a bulbous projection **56** on the radially outer surface thereof that forms a seal against the inside surface of the container neck in use.

[0084] The sealing skirt **54** has a concave region **58** on its radially inner surface. Two small circumferential sealing ribs **60** of substantially triangular cross-section project inwardly from the concave region. The circumferential sealing ribs on the sealing skirt have a substantially equilateral triangular cross-section, and are approximately 150 micrometers high, in the unstressed state. However, they deform when pressed against the harder material (glass or PET) of the container neck to form the pressure-tight seal. The small dimensions of the sealing ribs **60** enable a pressure tight seal to be achieved without substantial force having to be applied to the sealing skirt to form the seal.

[0085] The container closure assembly according to this embodiment also comprises a tamper-evident safety feature. This comprises a tamper-evident ring **66** that is initially formed integrally with the skirt **24** of the container closure **12** and joined thereto by frangible bridges **64**. The tamper-evident ring **66** comprises a plurality of integrally formed, flexible, radially inwardly pointing retaining tabs **70**. A circumferential retaining bead **72** is provided on the container neck **10**. Ratchet projections (not present in this embodiment) may also be provided on the container neck below the circumferential retaining bead **72** and radially spaced around the container neck to block rotation of the tamper-evident ring **66** on the container neck **10** in an unscrewing direction. However, it may be preferred to smooth or omit the ratchet projections in order to improve user-friendliness of the neck finish. The structure and operation of the tamper-evident ring feature are as described and claimed in our International Patent Application WO94/11267.

[0086] In use, the closure **12** is secured onto the container neck **10** by screwing down in conventional fashion. There are four thread starts, and the closure **12** can be moved from a fully disengaged position to a fully engaged position on the container neck **10** by rotation through about 90°. It can be seen that the thread segments **16** on the neck initially ride past the upper end of the locking projections **46** on the closure skirt, and are thereby guided into a helical thread path. In other words, the locking projections **46** on the skirt **24** define an initial extension of the helical thread path followed by the thread segments **16** on the neck. In this way, the locking projections on the skirt do not interfere or block the free running of the threads.

[0087] When the closure is being screwed down, there is normally a net axial force applied by the user on the closure into the container neck, and accordingly the first thread segments **16** on the neck abut against and ride along the lower surfaces **30** of the second thread segments **26** on the closure. It can thus be seen that the first thread segments **16** follow a substantially continuous path along a variable pitch helix. The first and second threads are free-running, which is to say that there is substantially no frictional torque between the thread segments until the fully engaged position is neared. These features of multiple thread starts, a 90° closure rotation, substantially continuous thread path, and free-running threads, all make the closure extremely easy to secure on the container neck, especially for elderly or arthritic persons, or children.

[0088] As the closure nears the fully engaged position on the container neck **10**, several things happen. Firstly, the tamper-evident ring **66** starts to ride over the retaining bead **72** on the container neck. The retaining tabs **70** on the tamper-evident ring **66** flex radially outwardly to enable the tamper-evident ring to pass over the retaining bead **72** without excessive radial stress on the frangible bridges **64**.

[0089] Secondly, the initial abutment between the sealing plug **52** and sealing skirt **54** in the container closure base and the sealing lip **14** on the container neck results in a net axial force on the closure in a direction out of the container neck. This pushes the thread segments **16** out of abutment with the lower surfaces **30** of the projecting portions of the second thread segments **26** and into abutment with the upper surfaces **32** of the projecting portions of the second thread segments **20**. More specifically, it brings the first thread segments **16** into abutment with the upper regions **34** of upper thread surfaces **32**. Continued rotation of the closure in a screwing-down direction causes the first thread segments **16** to travel along the upper regions **34** until the final, fully engaged position shown in FIGS. **1** and **4** is reached. The low pitch of the upper surfaces **34** means that this further rotation applies powerful leverage (camming) to compress the sealing plug **52** and sealing skirt **54** against the container lip **14** in order to achieve an effective gas-tight seal. The concave inner surface **58** of the sealing skirt **54** conforms to the curved container lip **14** to form an effective seal without substantial deformation of the sealing skirt **54**.

[0090] Thirdly, as the fully closed position is reached, the locking projections **46** on the closure skirt flex and ride over the complementary locking projections **44** on the container neck. At the fully closed position, the complementary locking projections remain in abutment, such that the closure skirt is still slightly deformed. The resilient restoring force exerted by the closure skirt is leveraged by the projections **44**, **46** into a closing torque on the assembly, which helps to ensure that sufficiently strong sealing force is applied to the various sealing surfaces of the assembly. It will be appreciated that this effect, coupled with the relatively large size of the projections **44**, **46**, enables effective sealing to be achieved even if the locking projections **44**, **46** are not molded to a very high tolerance.

[0091] Finally, as the fully engaged position of the closure **12** on the container neck **10** is reached or passed, the second ends **76** of the first thread segments **16** may come into abutment with the stop shoulders **50** projecting from the second thread segments **26**, thereby blocking further tightening of the closure that could damage the threads and/or distort the sealing fins and ribs on the closure.

[0092] When the closure **12** is in the fully engaged position on the container neck **10**, the lower surfaces **18** of the first thread segments **16** abut against the upper regions **34** of the upper thread surfaces **32** of the projecting portions of the second thread segments **26**, as shown in FIG. **2**. The lower surface **18** of the first thread segments **16** has a low pitch to match that of the upper regions **34**, so as to maximize the contact area between the projecting portions in the regions **34**, and thereby distribute the axial force exerted by the closure as evenly as possible around the container neck. Because of the low pitch in the regions **34**, relatively little of the axial force emerging from the container neck due to pressure inside the container is converted into unscrewing rotational force by the abutment between the thread surfaces in this position. This greatly reduces the tendency of the closure to unscrew spontaneously under pressure. Spontaneous unscrewing is also prevented by the abutment between the first and second locking projections **44**, **46**. An advantage of the assembly is that the reduced tendency to unscrew spontaneously due to the low pitch of the thread in the lower regions **34** means that the minimum opening torque of the locking projections **44**, **46** can be reduced without risk of the closure blowing off spontaneously. This makes the closure easier to remove by elderly or arthritic people, or by children, without reducing the pressure safety of the closure.

[0093] In the fully engaged and sealing position, the cap is secured on the container neck as shown in FIG. **2**. Both the sealing skirt **20** and the sealing plug **24** are radially slightly flexible to engage the sealing lip. The bulbous projection on the sealing plug and the circumferential sealing ribs on the sealing skirt engage opposite sides of the sealing lip **5**, and pinch the lip between them to form a highly effective seal. The overall effect is to provide a sealing jaw for gripping the top of the container neck.

[0094] In use, the closure is removed from the container neck by simple unscrewing. An initial, minimum unscrewing torque is required to overcome the resistance of the locking projections **44**, **46**. Once this resistance has been overcome, essentially no torque needs to be applied by the user to unscrew the closure. The internal pressure inside the container exerts an axial force on the closure in a direction emerging from the mouth of the container, as a result of which the first thread segments **16** ride along the upper surfaces **32** of the second thread segments **26** as the closure is unscrewed. The first thread segments **16** initially ride along the upper regions **34**, and then along the steeply pitched intermediate regions **36** of the upper surface of the second thread segments **20**. The first thread segments **16** then come into abutment with lower projecting portion **38** of the second thread segments **26**. In this position, further unscrewing of the closure is blocked while gas venting takes place along the thread paths. It should also be noted that, in this intermediate gas venting position, the first thread segments **16** abut primarily against the region **42** of the upper surface of the second thread segments **26**. The low pitch of this region **42** results in relatively little of the axial force on the closure being converted into unscrewing rotational torque, thereby reducing the tendency of the closure to override the pressure safety feature and blow off.

[0095] Once gas venting from inside the container neck is complete so that there is no longer axial upward force on the closure, the closure can drop down so as to bring the thread segments **16** into abutment with the lower surfaces **30** of the second thread segments **26**. In this position, unscrewing can be continued to disengage the closure completely from the container neck.

[0096] The sealing arrangement in the assemblies according to the present invention enables the cap to be secured and resecured on the container neck without the need for high torque or low pitched threads to force a seal. It can be seen that the assembly according to the invention provides at least two circumferential seals having a high sealing pressure over the whole range of temperature and pressure normally encountered in carbonated beverage containers. It can further be seen that the cap is suitable for application to container necks having rounded top lips, such as glass container necks and plastic container necks having a rounded lip to assist drinking directly from the neck. The drawbacks associated with the use of soft sealing liners in the cap are eliminated, in particular the caps according to the present invention can be resecured on the container neck repeatedly, without damage or loss of effectiveness.

[0097] The performance of the container closure assembly according to this embodiment applied to a PET carbonated beverage container was studied under extended storage at 38°

C. (high temperature/pressure test). The assembly met the most rigorous industry standard, set by the current Bericap closure according to WO98/35881, but with lower and more controllable opening and closing torque than the Bericap closure. Furthermore, the assembly according to the present invention significantly outperformed the closure of WO2007/057706 in this test.

[0098] The above embodiments have been described by way of example only. Many other embodiments falling within the scope of the accompanying claims will be apparent to the skilled reader.

[0099] All patent publications referred to in the foregoing specification are thereby incorporated by reference in their entirety.

1. A container closure assembly comprising:

a container neck having side walls defining an opening at one end thereof and a lip extending around the opening;

a cap for said neck, the cap having a base portion and a threaded skirt portion;

a first screw thread on the neck;

a second screw thread on an inner surface of the threaded skirt of the cap;

said first and second screw threads being configured to enable a user to secure, remove and resecure the cap into a sealing position on the neck by rotation of the cap on the neck;

a sealing plug extending from said base portion of the cap inside and substantially concentric with said threaded skirt portion of the cap, wherein the sealing plug is an olive sealing plug for forming a seal against an inside surface of the container neck when the cap is secured on the container neck; and a sealing skirt extending from said base portion of the cap intermediate said sealing plug and said threaded skirt portion of the cap and substantially concentric with said sealing plug and said threaded skirt portion of the cap, and wherein said cap can be displaced towards said neck from said sealing position by application of an axial force without rotation of the cap on the neck and substantially without plastic deformation of the cap.

2. A container closure assembly according to claim **1**, wherein the displacement from said sealing position is a resilient displacement.

3. A container closure assembly according to claim **1**, wherein no part of the cap contacts the top surface of the container lip at the sealing position.

4. A container closure assembly according to claim **1**, wherein the container lip is substantially fully radiused in longitudinal cross-section.

5. A container closure assembly according to claim **1**, wherein the inner and/or the outer surfaces of the container neck adjoining the lip is slightly tapered

6. A container closure assembly according to claim **1**, wherein the sealing skirt has a radial thickness at half-height equal to from about 40% to about 80% of radial thickness of the sealing plug measured at the same height.

7. A container closure assembly according to claim **1**, wherein a region of the radially inner surface of the sealing skirt is concave for engagement with an outer surface of the container neck proximate to said lip when the cap is secured on the container neck.

8. A container closure assembly according to claim **1**, wherein the inside diameter of the sealing skirt at half-height is from about 0.05 mm to about 0.5 mm less than the outside diameter of the container neck.

9. A container closure assembly according to claim **1**, wherein an outer surface of the sealing skirt does not abut against an internal surface of the threaded skirt or the cap base when the cap is in the secured and sealing position on the neck.

10. A container closure assembly according to claim **1**, wherein at least one circumferential sealing rib is provided in said concave region of said sealing skirt.

11. A container closure assembly according to claim **10**, wherein at least one said circumferential sealing rib has a substantially triangular cross-section.

12. A container closure assembly according to claim **11**, wherein at least one of the sealing ribs has a height in the range of from about 10 to about 250 micrometers.

13. A container closure assembly according to claim **1**, wherein the cap is a low-profile cap having an axial height from the top of the base to the bottom of the threaded skirt, but excluding any tamper-evident ring attached to the cap, of from about 10 mm to about 15 mm.

14. A container closure assembly according to claim **1**, wherein the cap can be secured and resecured on the container neck by a single smooth rotation through 360° or less, preferably through 180° or less, and more preferably through about 90°.

15. A container closure assembly according to claim **1**, wherein the first and second threads are multiple start threads.

16. A container closure assembly according to claim **1**, wherein the first and second threads are substantially continuous helical threads.

17. A container closure assembly according to claim **1**, wherein the container and cap further comprise complementary locking elements on the container neck and the cap that block or resist unscrewing of the cap from the fully secured position on the container neck until a predetermined minimum opening torque is applied.

18. A container closure assembly according to claim **17**, wherein said complementary locking elements comprise first and second locking projections on the container neck and the threaded cap skirt, and either said first locking projection is located longitudinally overlapping with and circumferentially spaced from an upper end of a first thread segment, or said second locking projection is located longitudinally overlapping with and circumferentially spaced from a lower end of a second thread segment, whereby the said first or second locking projection defines an extension of the thread path defined by the thread segments on the neck or the cap.

19. A container closure assembly according to claim **1**, further comprising a projecting stop surface on one of the container neck and the cap skirt for abutment against a second stop or a thread on the other of the container neck or the cap to block over-tightening of the cap beyond a predetermined angular sealing position of the cap on the container neck.

20. A container closure assembly according to claim **1**, wherein the torque required to secure the cap in a sealing position on the container neck is from about 0.7 Nm to about 0.9 Nm.

21. A beverage container sealed with a container closure assembly according to claim **1**.

22. A beverage container according to claim **21** which contains a carbonated beverage.

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