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Haumont

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(54) **SCREWCAP AND BOTTLE ASSEMBLY**

(71) Applicant: **AMCOR FLEXIBLES NORTH AMERICA, INC.**, Neenah, WI (US)

(72) Inventor: **Paul Haumont**, Dijon (FR)

(73) Assignee: **AMCOR FLEXIBLES NORTH AMERICA, INC.**, Neenah, WI (US)

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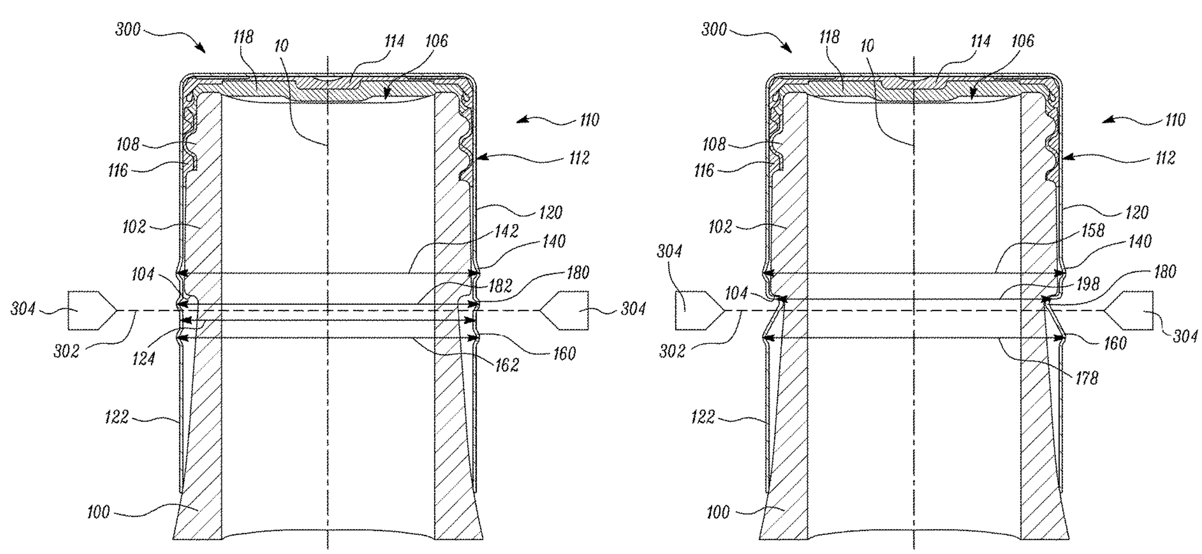
Primary Examiner — Orlando E Aviles
Assistant Examiner — Brijesh V. Patel

(57) **ABSTRACT**

A screwcap and a bottle assembly are disclosed. The screwcap seals a neck of a bottle. The screwcap includes a shell extending along a longitudinal axis and configured to be disposed on the neck. The shell includes a head, and a skirt having a nominal outer diameter and detachable connected to the head along a bridge line. The skirt includes a first support ring disposed proximal to the bridge line, a second support ring disposed distal to the bridge line, and a third support ring disposed between the first support ring and the second support ring relative to the longitudinal axis. The first support has a first maximum outer diameter greater than the nominal outer diameter. The second support ring has a second maximum outer diameter greater than the nominal outer diameter. The third support ring has a third maximum outer diameter greater than the nominal outer diameter.

19 Claims, 8 Drawing Sheets



(58) **Field of Classification Search**
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USPC 215/252–253, 320, 325, 341, 343–344, 215/349–350, 354, 43–44, 256, 258, 230, 215/270, 277; 220/266, 319, 288, 906; 277/637
See application file for complete search history.

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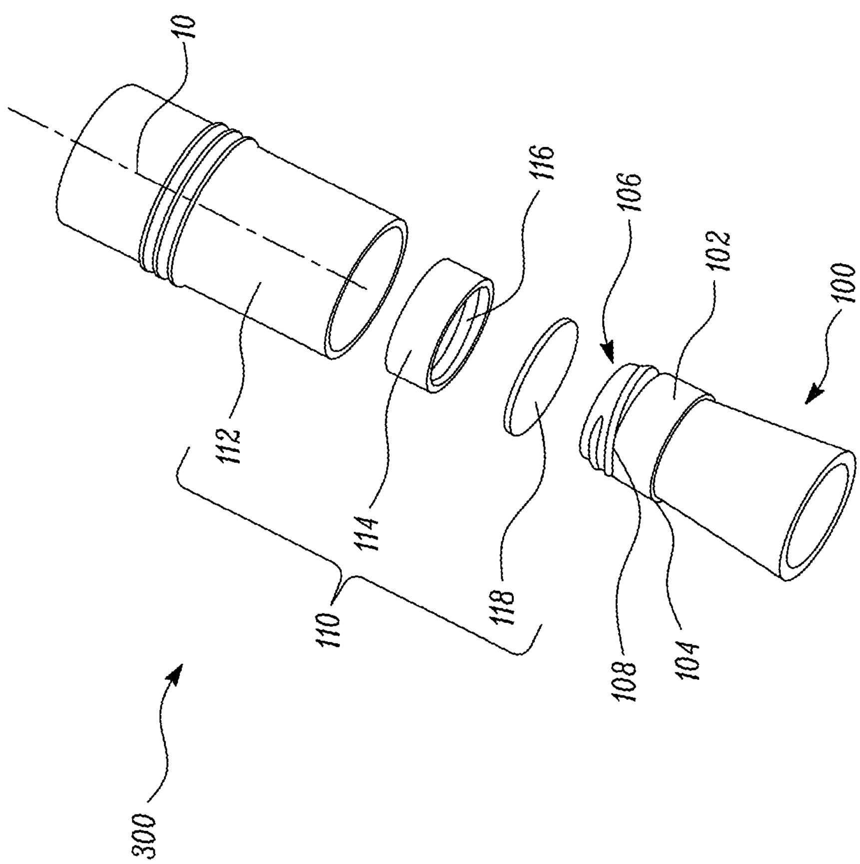


FIG. 1

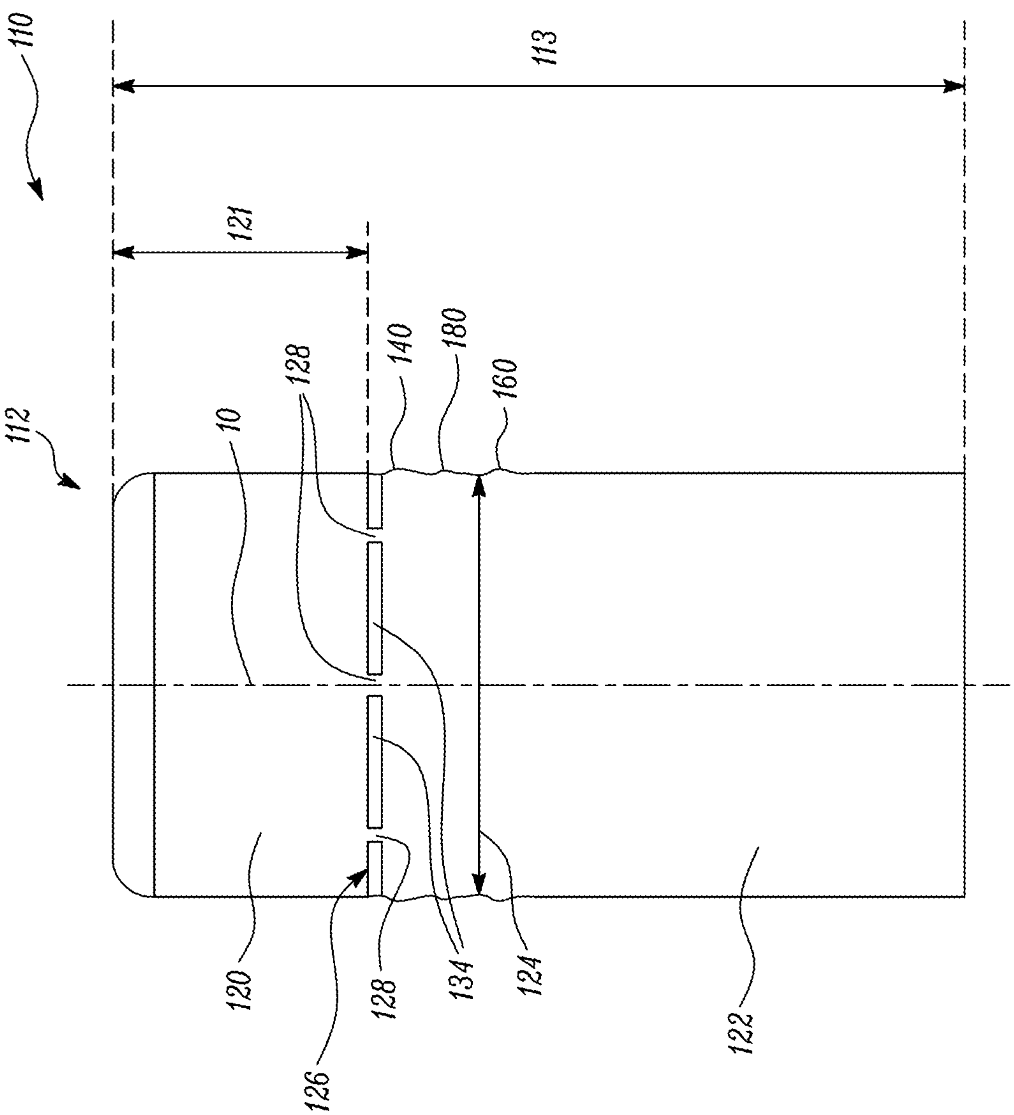


FIG. 2A

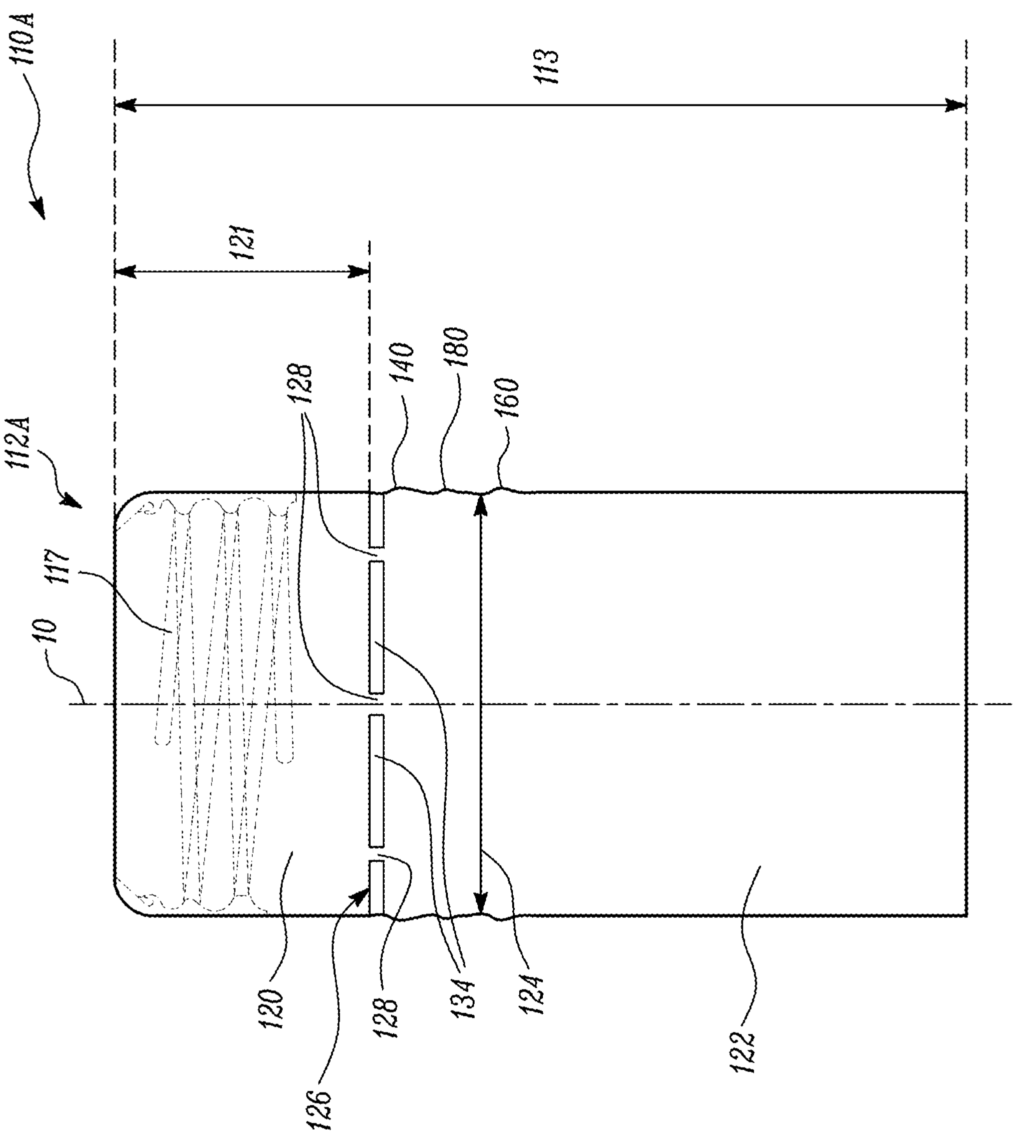
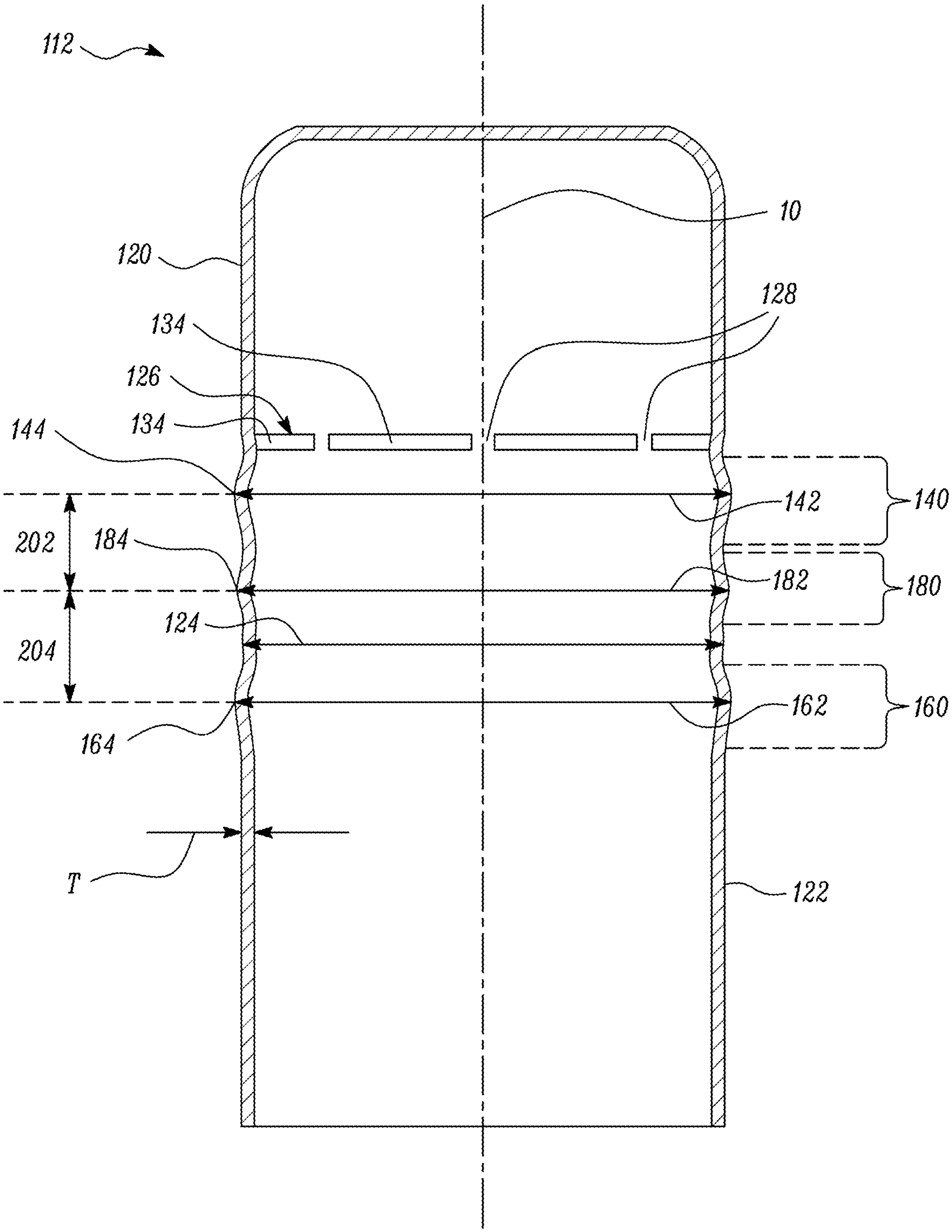


FIG. 2B


112
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120
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FIG. 3

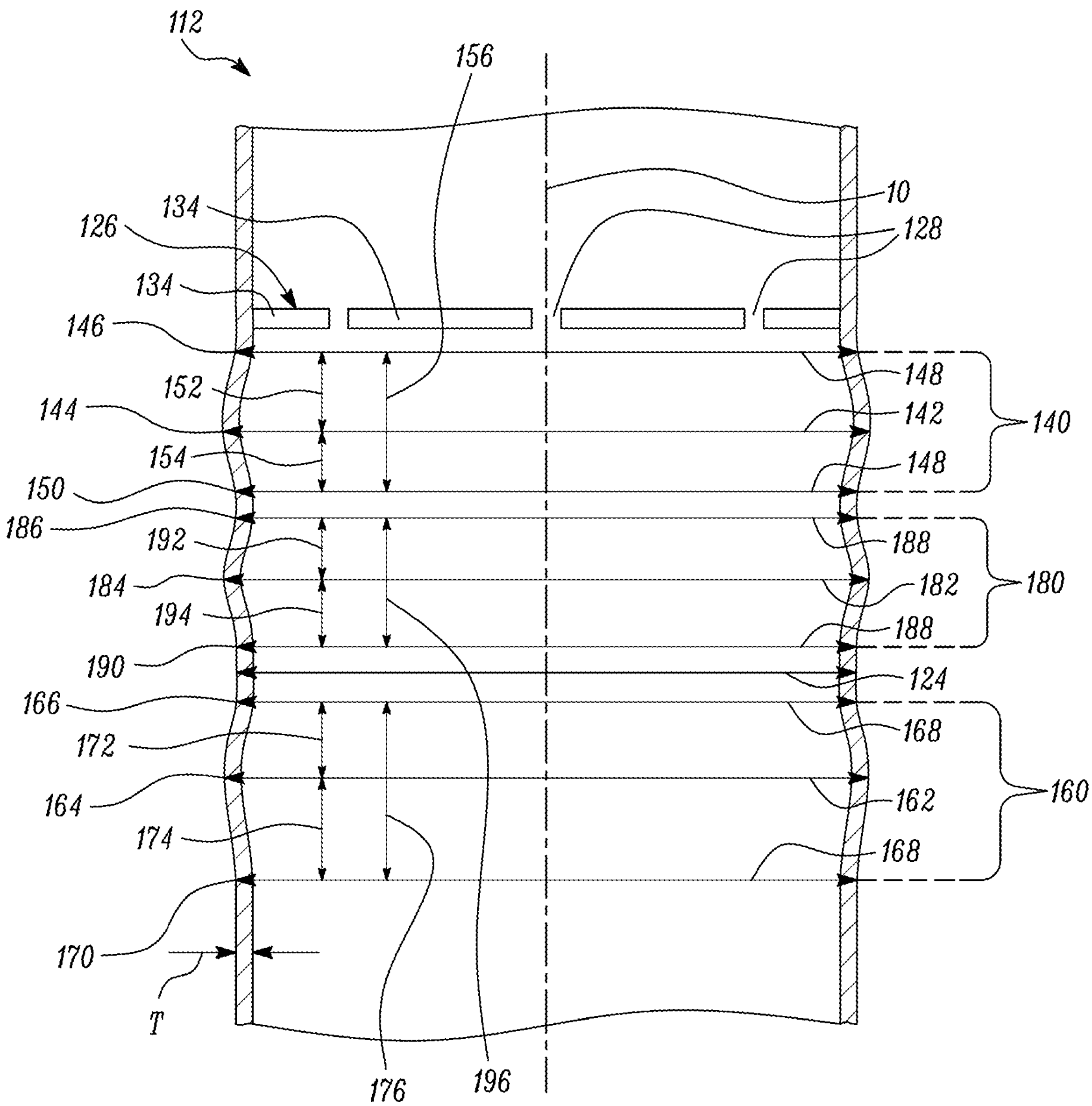
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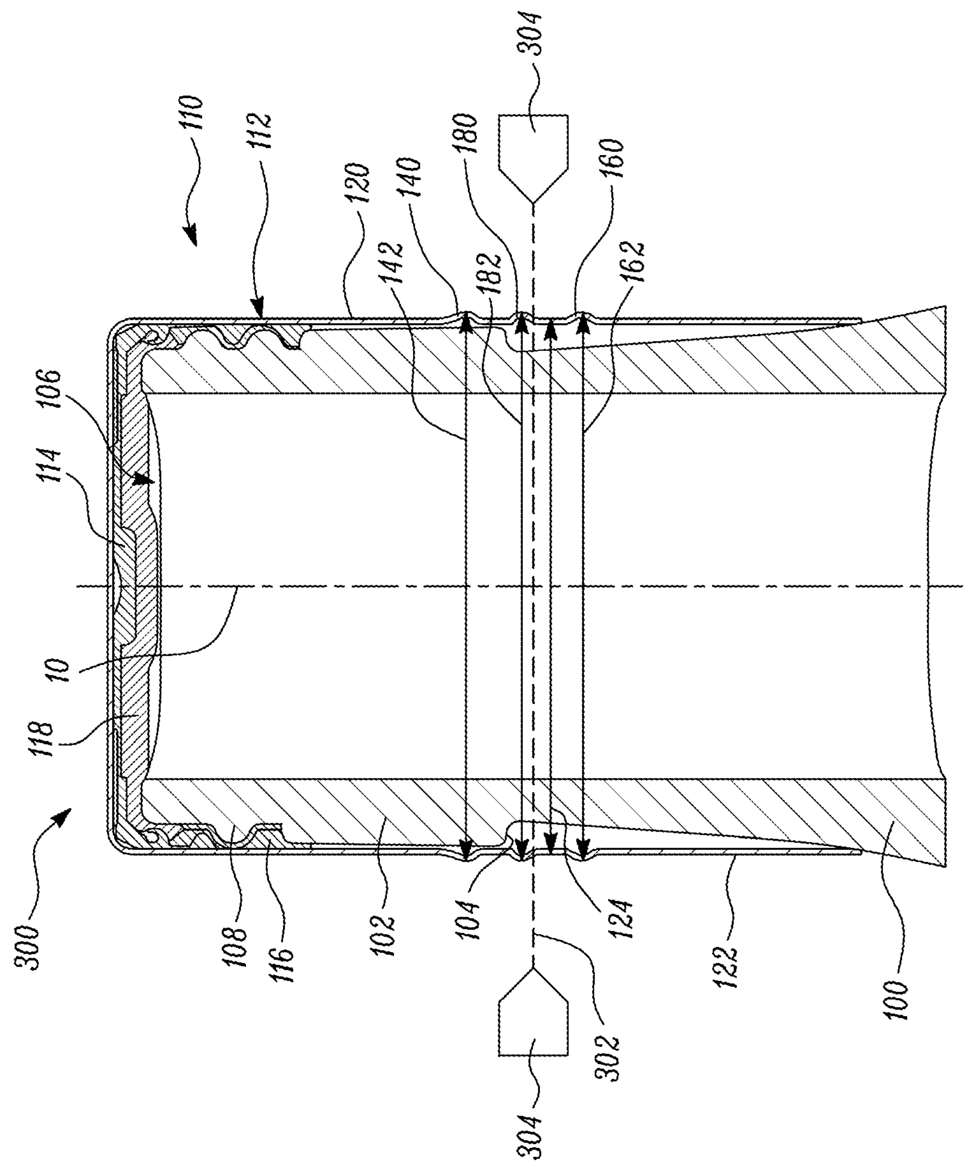
FIG. 4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100
302
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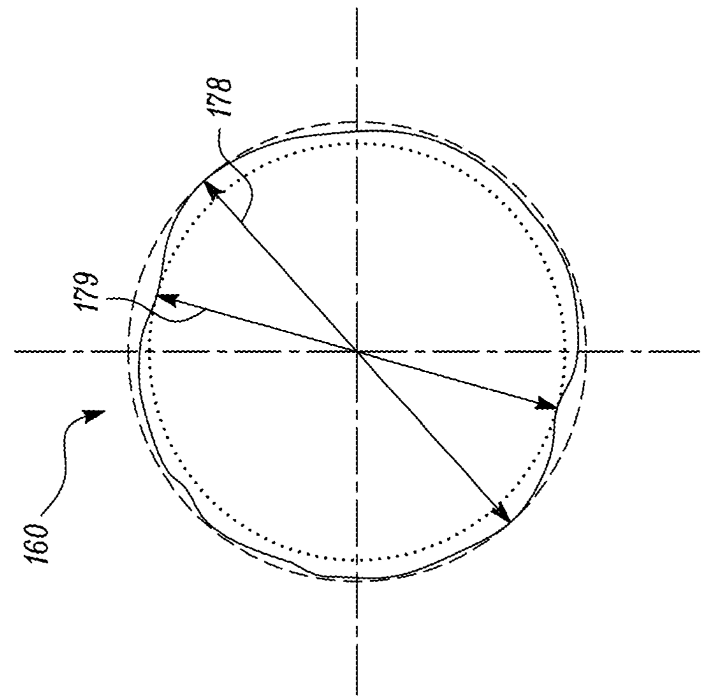
FIG. 5A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179
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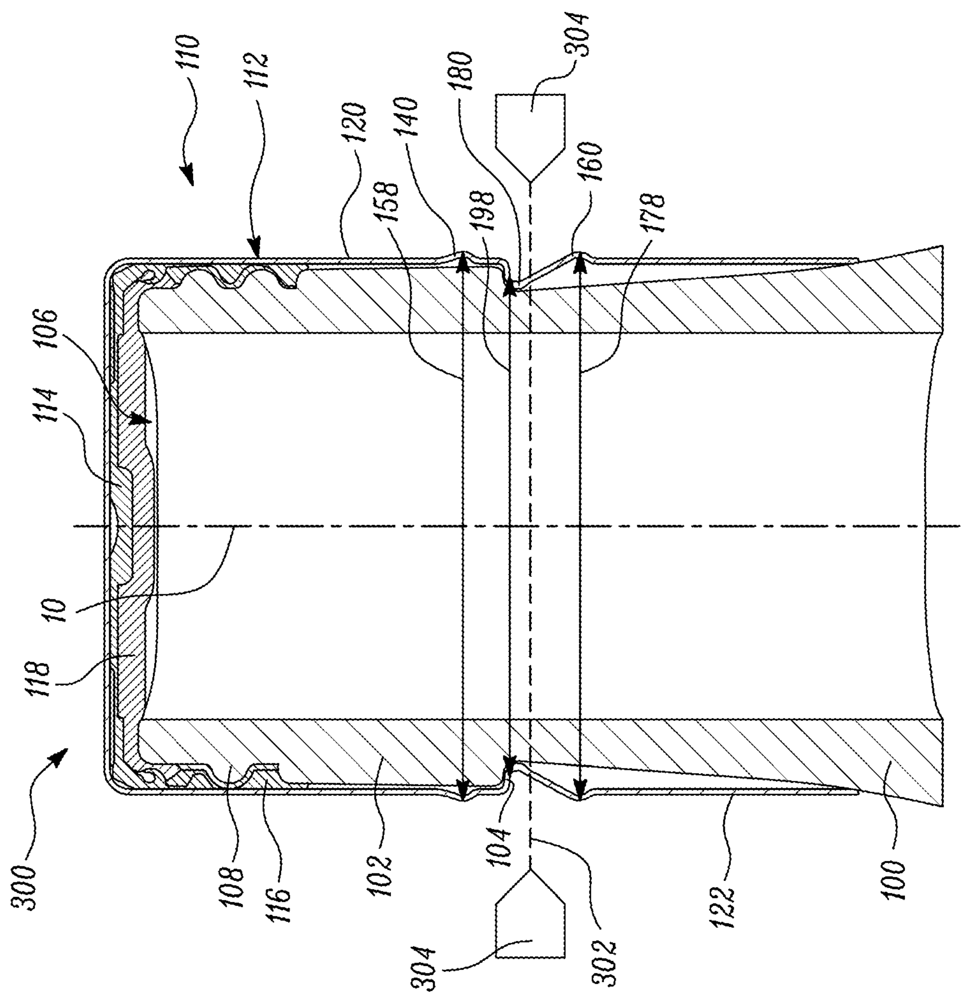
FIG. 5C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118
300
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116
102
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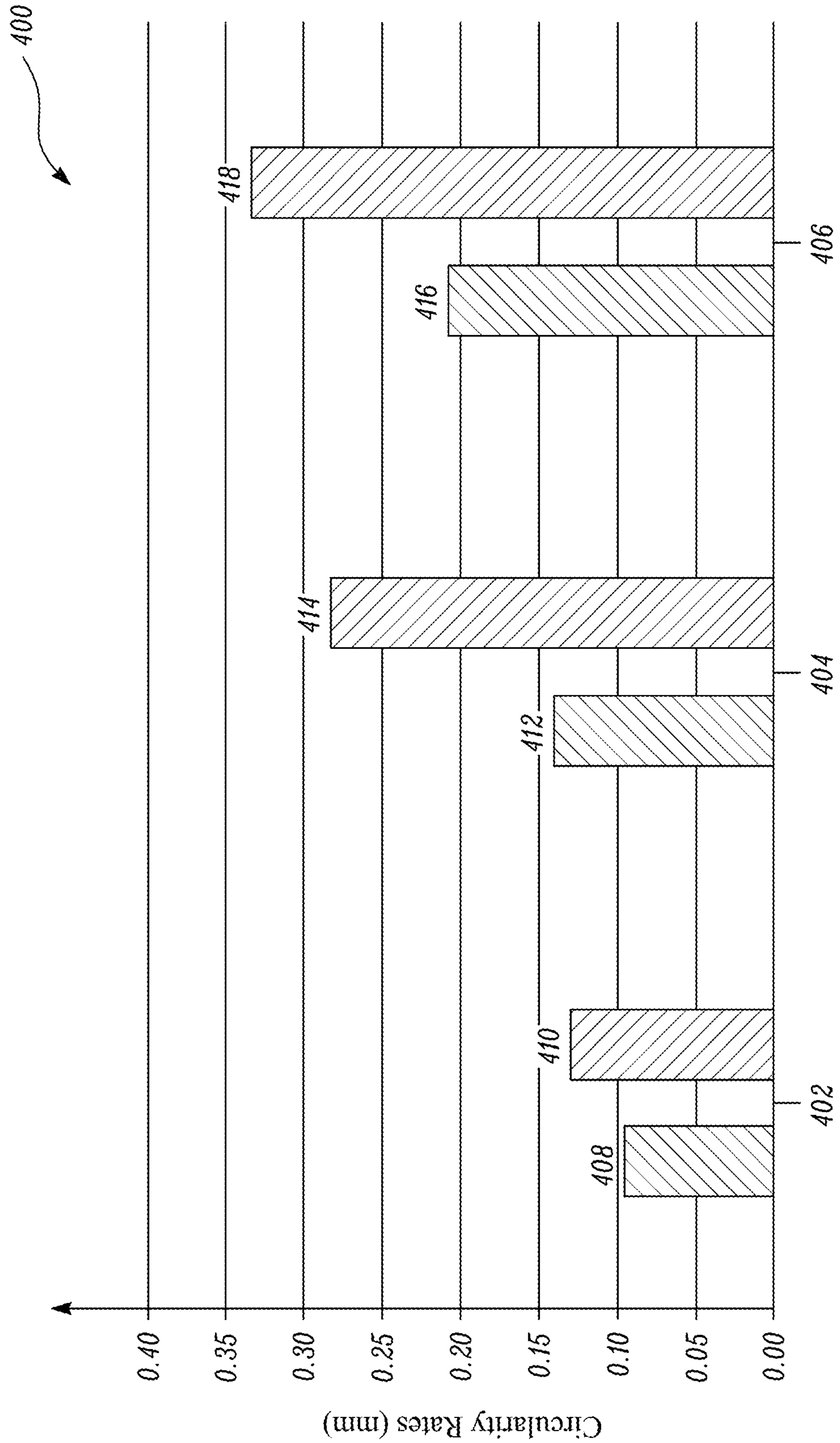
302
304
122
100

FIG. 5B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406
408
410
412
414
416
418
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Circularity Rates (mm)

FIG. 6

SCREWCAP AND BOTTLE ASSEMBLY

TECHNICAL FIELD

The present application relates generally to a screwcap and a bottle assembly, and in particular to a screwcap for sealing a neck of a bottle, and a bottle assembly including the screwcap.

BACKGROUND

Screwcaps are generally used to seal a bottle. However, conventional screwcaps may undergo distortion during a capping process and experience various defects due to the distortion. In some cases, the defects may result in leakage of a product stored in the bottle. Further, the defects may cause the product stored in the bottle to deteriorate. In some other cases, the defects may result in undesired pull-offs of the conventional screwcaps from the bottle. Thus, the defects may also promote tampering of the product stored in the bottle. Moreover, the defects may negatively affect an appearance of the bottle.

SUMMARY

A screwcap for sealing a neck of a bottle has been developed. The screwcap may reduce or eliminate various defects that may occur during a capping process. Further, the screwcap may improve an appearance of the bottle after the capping process.

One embodiment of the present disclosure is a screwcap for sealing a neck of a bottle. The screwcap includes a shell extending along a longitudinal axis and configured to be disposed on the neck. The shell includes a head. The shell further includes a skirt having a nominal outer diameter and detachably connected to the head along a bridge line. The skirt includes a first support ring disposed proximal to the bridge line. The first support ring has a first maximum outer diameter greater than the nominal outer diameter of the skirt. The skirt further includes a second support ring disposed distal to the bridge line. The second support ring has a second maximum outer diameter greater than the nominal outer diameter of the skirt. The skirt further includes a third support ring disposed between the first support ring and the second support ring relative to the longitudinal axis. The third support ring has a third maximum outer diameter greater than the nominal outer diameter of the skirt.

The first support ring may be configured to protect the bridge line during crimping of the shell. The second support ring may be configured to improve an appearance of the screwcap after crimping of the shell.

The third support ring may reduce distortion of the first and second support rings during crimping of the shell to the neck of the bottle. Therefore, the third support ring may prevent various defects, such as bird beaks and facets, that may occur during the capping process.

The third support ring may allow improved crimping of the shell to the neck of the bottle, thereby enhancing securement of the screwcap with the bottle. Specifically, the third support ring may enable reduction of a crimped diameter of the shell on the neck. Thus, the third support ring may prevent undesired pull-offs of the screwcap from the bottle.

The third support ring may further allow lowering a position of the second support ring, thereby increasing a distance between the first support ring and the second support ring along the longitudinal axis. This may further reduce distortion of the second support ring during crimping

of the shell. Moreover, the third support ring may not be visible after crimping. Consequently, the screwcap may improve an appearance of the bottle after the capping process.

In some embodiments, the first support ring includes a first peak having the first maximum outer diameter. The second support ring includes a second peak having the second maximum outer diameter. The third support ring includes a third peak having the third maximum outer diameter. A first distance between the first peak and the third peak is less than a second distance between the second peak and the third peak.

In some embodiments, the second distance is greater than the first distance by a factor of at least 1.3.

In some embodiments, the first distance is about 3 millimeters (mm), and the second distance is about 4 mm.

In some embodiments, the first support ring further includes a first proximal end proximal to the bridge line and having a first minimum outer diameter of the first support ring. The first support ring further includes a first distal end distal to the bridge line and having the first minimum outer diameter of the first support ring. The first peak is disposed between the first proximal end and the first distal end along the longitudinal axis. A first proximal peak distance between the first proximal end and the first peak along the longitudinal axis is greater than a first distal peak distance between the first distal end and the first peak along the longitudinal axis.

In some embodiments, the first proximal peak distance is greater than the first distal peak distance by a factor of at least about 1.3.

In some embodiments, the second support ring further includes a second proximal end proximal to the bridge line and having a second minimum outer diameter of the second support ring. The second support ring further includes a second distal end distal to the bridge line and having the second minimum outer diameter of the second support ring. The second peak is disposed between the second proximal end and the second distal end along the longitudinal axis. A second proximal peak distance between the second proximal end and the second peak along the longitudinal axis is less than a second distal peak distance between the second distal end and the second peak along the longitudinal axis.

In some embodiments, the second distal peak distance is greater than the second proximal peak distance by a factor of at least about 1.9.

In some embodiments, the third support ring further includes a third proximal end proximal to the bridge line and having a third minimum outer diameter of the third support ring. The third support ring further includes a third distal end distal to the bridge line and having the third minimum outer diameter of the third support ring. The third peak is disposed between the third proximal end and the third distal end along the longitudinal axis. A third proximal peak distance between the third proximal end and the third peak along the longitudinal axis is substantially equal to a third distal peak distance between the third distal end and the third peak along the longitudinal axis.

In some embodiments, the third maximum outer diameter is greater than the nominal outer diameter by at least 0.5 mm.

In some embodiments, the first maximum outer diameter, the second maximum outer diameter, and the third maximum outer diameter are substantially equal to one another.

In some embodiments, the first support ring has a first length along the longitudinal axis. The second support ring has a second length along the longitudinal axis. The third support ring has a third length along the longitudinal axis. The third length is less than each of the first length and the second length.

In some embodiments, the first length is greater than the third length by a factor of at least 1.16.

In some embodiments, the second length is greater than the third length by a factor of at least 1.45.

In some embodiments, the first length is about 2.8 mm, the second length is about 3.5 mm, and the third length is about 2.4 mm.

In some embodiments, the third support ring has a symmetric shape along the longitudinal axis.

In some embodiments, the third support ring has a V-shaped cross-section along the longitudinal axis.

In some embodiments, each of the first and second support rings has a curved cross-sectional shape.

In some cases, the second support ring may have an asymmetric cross-sectional shape along the longitudinal axis. The asymmetric cross-sectional shape of the second support ring may provide increased rigidity to the second support ring during crimping.

In some embodiments, at least a portion of the third support ring is configured to deform and engage a shoulder of the neck after crimping.

In some embodiments, the shell has an average thickness of about 0.25 mm.

In some embodiments, the head of the screwcap includes at least one internal thread configured to engage with at least one external thread of the neck of the bottle.

In some embodiments, the screwcap further including an insert disposed between the shell and the neck. The insert includes at least one internal thread configured to engage with at least one external thread of the neck.

In some embodiments, the screwcap further including a plurality of bridges disposed along the bridge line and detachably connecting the head to the skirt. The plurality of bridges defines a plurality of perforations therebetween.

As discussed above, the third support ring may reduce distortion of the first support ring during crimping of the shell. Consequently, the third support ring may prevent breakage or rupture of the plurality of bridges disposed along the bridge line during crimping. Thus, the third support ring may prevent leakage of a product stored in the bottle.

In some embodiments, the screwcap further including a sealing arrangement disposed between the shell and the neck. The sealing arrangement is configured to seal an opening of the neck.

The sealing arrangement may provide an air-tight seal between the screwcap and the opening of the bottle.

Another embodiment of the present disclosure is a bottle assembly. The bottle assembly includes a bottle and the screwcap. The bottle includes a neck. The neck includes a shoulder and an opening. The shell is crimped to the neck, such that at least a portion of the third support ring deforms and engages the shoulder of the neck after crimping. The third support ring has a third maximum crimped outer diameter after crimping. The third maximum crimped outer diameter is less than the nominal outer diameter of the skirt.

The third support ring may reduce distortion of the first and second support rings during crimping of the shell to the neck of the bottle.

In some embodiments, the second support ring has a second maximum crimped outer diameter after crimping and a second minimum crimped outer diameter after crimping. A difference between the second maximum crimped outer diameter and the second minimum crimped outer diameter is less than about 0.25 mm.

In some embodiments, the first support ring has a first maximum crimped outer diameter after crimping. The first maximum crimped outer diameter is substantially equal to the first maximum outer diameter.

There are several other aspects of the present subject matter which may be embodied separately or together. These aspects may be employed alone or in combination with other aspects of the subject matter described herein, and the description of these aspects together is not intended to preclude the use of these aspects separately or the claiming of such aspects separately or in different combinations.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure may be more completely understood in consideration of the following detailed description of various embodiments of the disclosure in connection with the accompanying drawings, in which:

FIG. **1** illustrates a schematic exploded perspective view of a bottle assembly in accordance with an embodiment of the present disclosure;

FIG. **2**A illustrates a schematic front view of a screwcap in accordance with an embodiment of the present disclosure;

FIG. **2**B illustrates a schematic front view of a screwcap in accordance with another embodiment of the present disclosure;

FIG. **3** illustrates a schematic cross-sectional view of a shell in accordance with an embodiment of the present disclosure;

FIG. **4** illustrates an enlarged cross-sectional view of a portion of the shell of FIG. **3**;

FIG. **5**A illustrates a schematic cross-sectional view of a bottle assembly before crimping in accordance with an embodiment of the present disclosure;

FIG. **5**B illustrates a schematic cross-sectional view of the bottle assembly after crimping in accordance with an embodiment of the present disclosure;

FIG. **5**C illustrates a schematic plan view of a second support ring after crimping in accordance with an embodiment of the present disclosure; and

FIG. **6** illustrates a graph comparing a circularity rate of a second support ring of the present disclosure and a second support ring of conventional screwcaps after crimping with respect to different positions of crimping rollers.

The figures are not necessarily to scale. Like numbers used in the figures refer to like components. It will be understood, however, that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labeled with the same number.

The drawings show some but not all embodiments. The elements depicted in the drawings are illustrative and not necessarily to scale, and the same (or similar) reference numbers denote the same (or similar) features throughout the drawings.

DETAILED DESCRIPTION

The present disclosure relates to a screwcap for sealing a neck of a bottle. The screwcap may reduce or eliminate various defects that may occur during a capping process. Further, the screwcap may improve an appearance of the bottle after the capping process.

The screwcap includes a shell extending along a longitudinal axis and configured to be disposed on the neck. The shell includes a head. The shell further includes a skirt having a nominal outer diameter and detachably connected to the head along a bridge line. The skirt includes a first support ring disposed proximal to the bridge line. The first support ring has a first maximum outer diameter greater than the nominal outer diameter of the skirt. The skirt further includes a second support ring disposed distal to the bridge line. The second support ring has a second maximum outer diameter greater than the nominal outer diameter of the skirt. The skirt further includes a third support ring disposed between the first support ring and the second support ring relative to the longitudinal axis. The third support ring has a third maximum outer diameter greater than the nominal outer diameter of the skirt.

The first support ring may be configured to protect the bridge line during crimping of the shell. The second support ring may be configured to improve an appearance of the screwcap after crimping of the shell.

The third support ring may reduce distortion of the first and second support rings during crimping of the shell to the neck of the bottle. Therefore, the third support ring may prevent various defects, such as bird beaks and facets, that may occur during the capping process.

The third support ring may allow improved crimping of the neck to the shell of the bottle, thereby enhancing securement of the screwcap with the bottle. Specifically, the third support ring may enable reduction of a crimped diameter of the shell on the neck. Thus, the third support ring may prevent undesired pull-offs of the screwcap from the bottle.

The third support ring may further allow lowering a position of the second support ring, thereby increasing a distance between the first support ring and the second support ring along the longitudinal axis. This may further reduce distortion of the second support ring during crimping of the shell. Moreover, the third support ring may not be visible after crimping. Consequently, the screwcap may improve an appearance of the bottle after the capping process.

As used in the present application, the term "crimping" may refer to any suitable process of joining two parts by mechanically deforming one or both of the two parts to hold the other, and the term "crimp" may refer a region of deformation that may result from crimping.

As used in the present application, the term "bridge line" may refer to a line of weakness including continuous or non-continuous series of holes, vents, slits, slots, perforations, notches, punctures, orifices, openings, inlets, channels, etc., in the surface of or throughout a shell. Its depth may extend from a first surface of the shell to a second surface of the shell (i.e., throughout an entire thickness of the shell). Alternatively, its depth may extend from about 50% to about 95% of the thickness of a shell.

As used in the present application, the term "nominal outer diameter" may refer to a minimum outer diameter of a body prior to undergoing a metalworking process, such as crimping.

As used in the present application, the terms "circularity" or "roundness" may refer to a degree of deviation of an object from a geometrically perfect circle. The terms "circularity" or "roundness" may further refer to a tolerance zone defined between two concentric circles.

As used in the present application, the term "circularity rate" may refer to a difference between a maximum outer diameter and a minimum outer diameter of an object.

FIG. **1** shows a schematic exploded perspective view of a bottle assembly **300** in accordance with an embodiment of the present disclosure.

Bottle assembly **300** includes a bottle **100**. Bottle **100** is partially shown in FIG. **1**. Bottle **100** includes a neck **102**. Neck **102** includes a shoulder **104** and an opening **106**. Neck **102** further includes at least one external thread **108**.

In some embodiments, bottle **100** may be made of glass. Bottle **100** may be used to store any suitable product. In some cases, bottle **100** may be used to store liquid products. For example, bottle **100** may be used to store alcoholic drinks, such as wines, aperitifs, liqueurs, and alcohols. In another example, bottle **100** may be used to store juices, carbonated drinks, and the like.

Bottle assembly **300** further includes a screwcap **110** for sealing neck **102** of bottle **100**. Screwcap **110** includes a shell **112** extending along a longitudinal axis **10** and configured to be disposed on neck **102**.

Shell **112** may be made from any suitable metal. In some embodiments, shell **112** may be made of aluminum. Shell **112** may be formed using a suitable drawing process, by drawing a sheet of metal into a cylindrical shape that is open on one side.

In the illustrated embodiment of FIG. **1**, screwcap **110** further includes an insert **114** disposed between shell **112** and neck **102**. In some embodiments, insert **114** includes at least one internal thread **116** configured to engage with at least one external thread **108** of neck **102**. Insert **114** may be made of any suitable plastic, such as Polyethylene Terephthalate (PET), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Polypropylene (PP), and the like.

In the illustrated embodiment of FIG. **1**, screwcap **110** further includes a sealing arrangement **118** disposed between shell **112** and neck **102**. In some embodiments, sealing arrangement **118** is configured to seal opening **106** of neck **102**. In some embodiments, sealing arrangement **118** may facilitate providing an air-tight seal between neck **102** and screwcap **110** to seal opening **106**. In some embodiments, sealing arrangement **118** may include a liner. In some embodiments, the liner of sealing arrangement **118** may be made from a composition including a thermoplastic elastomer, polyisobutylene, and polybutylene. In some other embodiments, the liner of sealing arrangement **118** may include a multilayer liner including a layer of expanded polyethylene (EPE), a layer of white kraft, a layer of tin, a layer of polyvinylidene chloride (PVDC), and the like.

FIG. **2**A shows a schematic front view of screwcap **110** in accordance with an embodiment of the present disclosure.

As shown in FIG. **2**A, shell **112** has a shell length **113**. Shell length **113** may depend upon design and dimensions of bottle **100** (shown in FIG. **1**). Shell length **113** is measured along longitudinal axis **10**. In some embodiments, shell length **113** may be from about 50 millimeters (mm) to about 70 mm. In some embodiments, shell length **113** may be about 60 mm.

Shell **112** includes a head **120**. As shown in FIG. **2**A, head **120** has a head length **121**. Head length **121** is measured along longitudinal axis **10**. Head length **121** may depend upon design and dimensions of neck **102** (shown in FIG. **1**). In some embodiments, head length **121** may be from about 10 mm to about 30 mm. In some embodiments, head length **121** may be about 18 mm.

Shell **112** further includes a skirt **122**. Skirt **122** is detachably connected to head **120** along a bridge line **126**. In the illustrated embodiment of FIG. **2**A, screwcap **110** further includes a plurality of bridges **128** disposed along bridge line **126** and detachably connecting head **120** to skirt **122**. Further, in the illustrated embodiment of FIG. **2**A, plurality of bridges **128** defines a plurality of perforations **134** therebetween. Thus, in some cases, bridge line **126** may provide a line of weakness about which head **120** may be detachable from skirt **122**. Head **120** may be detached from skirt **122** about bridge line **126** to access a product stored in the bottle **100** (shown in FIG. **1**). Bridge line **126** may also act as a tamper-proof feature.

In some embodiments, a width of each bridge **128** substantially normal to longitudinal axis **10** may be from about 1.25 mm to about 1.35 mm. In some embodiments, a number of plurality of bridges **128** may be from about 5 to about 15. In some embodiments, the number of plurality of bridges **128** may be 8, and plurality of bridges **128** may define 8 perforations **134** therebetween.

Skirt **122** further includes a first support ring **140**, a second support ring **160**, and a third support ring **180**.

As shown in FIG. **2**A, first support ring **140** is disposed proximal to bridge line **126**. Further, second support ring **160** is disposed distal to bridge line **126**. Moreover, third support ring **180** is disposed between first support ring **140** and second support ring **160** relative to longitudinal axis **10**.

In some embodiments, at least a portion of third support ring **180** is configured to deform and engage shoulder **104** (shown in FIG. **1**) of neck **102** (shown in FIG. **1**) after crimping. In other words, in some embodiments, shell **112** may be crimped, such that at least a portion of third support ring **180** may deform and engage shoulder **104**. Therefore, it may be noted that a position of first, second, and third support rings **140**, **160**, **180** may depend upon a profile of neck **102**.

In some embodiments, first support ring **140** may be configured to protect bridge line **126** during crimping of shell **112**. In some embodiments, second support ring **160** may be configured to improve an appearance of screwcap **110** after crimping of shell **112**. In some embodiments, third support ring **180** may be configured to reduce or eliminate distortion of the first and second support rings **140**, **160** during crimping of shell **112**.

As shown in FIG. **2**A, skirt **122** has a nominal outer diameter **124**. Nominal outer diameter **124** of skirt **122** may be defined as a minimum outer diameter of skirt **122**. Specifically, nominal outer diameter **124** of skirt **122** may be defined as a minimum outer diameter of skirt **122** before crimping. In some embodiments, nominal outer diameter **124** is defined between third support ring **180** and second support ring **160** relative to longitudinal axis **10**. Nominal outer diameter **124** of skirt **122** may depend upon the design and dimensions of bottle **100** (shown in FIG. **1**). In some embodiments, nominal outer diameter **124** of skirt **122** may be from about 25 mm to about 35 mm. In some embodiments, nominal outer diameter **124** of skirt **122** may be from about 29.5 mm to about 30 mm.

FIG. **2**B shows a schematic front view of a screwcap **110**A in accordance with another embodiment of the present disclosure. Screwcap **110**A is substantially similar to screwcap **110** of FIG. **2**A, with like elements designated by like numbers. However, screwcap **110**A includes a shell **112**A having a different configuration as compared to shell **112** of screwcap **110**.

Referring to FIGS. **1** and **2**B, in some embodiments, head **120** includes at least one internal thread **117** (shown by dashed lines) configured to engage with at least one external thread **108** of neck **102**. Therefore, insert **114** may be omitted from screwcap **110**A.

FIG. **3** shows a schematic cross-sectional view of shell **112** in accordance with an embodiment of the present disclosure.

Shell **112** has an average thickness T. Average thickness T of shell **112** may depend upon desired application attributes and a material of shell **112**. In some embodiments, shell **112** may have average thickness T of about 0.20 mm to about 0.30 mm. In some embodiments, shell **112** has average thickness T of about 0.25 mm.

First support ring **140** has a first maximum outer diameter **142** greater than nominal outer diameter **124** of skirt **122**. In the illustrated embodiment of FIG. **3**, first support ring **140** includes a first peak **144** having first maximum outer diameter **142**. In other words, in the illustrated embodiment of FIG. **3**, first maximum outer diameter **142** is a maximum outer diameter of first support ring **140** at first peak **144**.

Second support ring **160** has a second maximum outer diameter **162** greater than nominal outer diameter **124** of skirt **122**. In the illustrated embodiment of FIG. **3**, second support ring **160** includes a second peak **164** having second maximum outer diameter **162**. In other words, in the illustrated embodiment of FIG. **3**, second maximum outer diameter **162** is a maximum outer diameter of second support ring **160** at second peak **164**.

As shown in FIG. **3**, in some embodiments, each of first and second support rings **140**, **160** has a curved cross-sectional shape. However, first and second support rings **140**, **160** may have any suitable cross-sectional shape depending on desired aesthetics and application attributes. In some embodiments, each of first and second support rings **140**, **160** may have an asymmetric shape. The asymmetric shape may increase rigidity of first and second support rings **140**, **160** during crimping of shell **112**. In some cases, second support ring **160** may be positioned lower to further reduce distortion of second support ring **160** during crimping of shell **112**. This may further reduce defects such as facets on screwcap **110**.

Third support ring **180** has a third maximum outer diameter **182** greater than nominal outer diameter **124** of skirt **122**. In the illustrated embodiment of FIG. **3**, third support ring **180** includes a third peak **184** having third maximum outer diameter **182**. In other words, in the illustrated embodiment of FIG. **3**, third maximum outer diameter **182** is a maximum outer diameter of third support ring **180** at third peak **184**. In some embodiments, third maximum outer diameter **182** is greater than nominal outer diameter **124** by at least 0.5 mm. In some embodiments, third maximum outer diameter **182** may be greater than nominal outer diameter **124** by at least 0.2 mm, at least 0.3 mm, at least 0.4 mm, at least 0.6 mm, at least 0.7 mm, or at least 0.8 mm.

In some embodiments, third support ring **180** has a symmetric shape along longitudinal axis **10**. However, in some other embodiments, third support ring **180** may have an asymmetric shape along longitudinal axis **10**. In the illustrated embodiment of FIG. **3**, third support ring **180** has a V-shaped cross-section along longitudinal axis **10**.

In some embodiments, first maximum outer diameter **142**, second maximum outer diameter **162**, and third maximum outer diameter **182** are substantially equal to one another. However, in some other embodiments, first maximum outer diameter **142**, second maximum outer diameter **162**, and third maximum outer diameter **182** may be different from one another. For example, in some embodiments, third maximum outer diameter **182** of third support ring **180** may be greater than both first maximum outer diameter **142** of first support ring **140** and second maximum outer diameter **162** of second support ring **160**.

In some embodiments, first peak **144** and third peak **184** define a first distance **202** therebetween. Further, in some embodiments, second peak **164** and third peak **184** define a second distance **204** therebetween. In some embodiments, first distance **202** between first peak **144** and third peak **184** is less than second distance **204** between second peak **164** and third peak **184**. In some embodiments, second distance **204** is greater than first distance **202** by a factor of at least 1.3. In other words, in some embodiments, second distance **204** is greater than or equal to 1.3 times of first distance **202**. In some embodiments, first distance **202** is about 3 mm, and second distance **204** is about 4 mm. Therefore, second support ring **160** is positioned relatively lower in skirt **122** along longitudinal axis **10**.

FIG. **4** shows an enlarged cross-sectional view of skirt **122** in accordance with an embodiment of the present disclosure.

In the illustrated embodiment of FIG. **4**, first support ring **140** further includes a first proximal end **146** proximal to bridge line **126**. In the illustrated embodiment of FIG. **4**, first support ring **140** further includes a first distal end **150** distal to bridge line **126**. In some embodiments, first peak **144** is disposed between first proximal end **146** and first distal end **150** along longitudinal axis **10**.

In the illustrated embodiment of FIG. **4**, first proximal end **146** has a first minimum outer diameter **148** of the first support ring **140**. Further, in the illustrated embodiment of FIG. **4**, first distal end **150** has first minimum outer diameter **148** of first support ring **140**. In other words, in the illustrated embodiment of FIG. **4**, first proximal end **146** and first distal end **150** have a substantially equal outer diameter, that is, first minimum outer diameter **148**.

In some embodiments, first proximal end **146** and first peak **144** define a first proximal peak distance **152** therebetween along longitudinal axis **10**. In some embodiments, first distal end **150** and first peak **144** define a first distal peak distance **154** therebetween along longitudinal axis **10**.

In some embodiments, first proximal peak distance **152** between first proximal end **146** and first peak **144** along longitudinal axis **10** is greater than first distal peak distance **154** between first distal end **150** and first peak **144** along longitudinal axis **10**. In some cases, first proximal peak distance **152** being greater than first distal peak distance **154** may improve rigidity of first support ring **140** during crimping of shell **112**.

In some embodiments, first proximal peak distance **152** is greater than first distal peak distance **154** by a factor of at least about 1.3. In other words, in some embodiments, first proximal peak distance **152** is greater than or equal to 1.3 times of first distal peak distance **154**. In some embodiments, first proximal peak distance **152** may be about 1.6 mm, and first distal peak distance **154** may be about 1.2 mm.

Further, in the illustrated embodiment of FIG. **4**, first support ring **140** has a first length **156** along longitudinal axis **10**. In some embodiments, first length **156** may be defined as a sum of first proximal peak distance **152** and first distal peak distance **154**. In some embodiments, first length **156** is about 2.8 mm. However, in some other embodiments, first length **156** may be about 2.5 mm, about 2.6 mm, about 2.7 mm, about 2.9 mm, or about 3 mm.

In the illustrated embodiment of FIG. **4**, second support ring **160** further includes a second proximal end **166** proximal to bridge line **126**. In the illustrated embodiment of FIG. **4**, second support ring **160** further includes a second distal end **170** distal to bridge line **126**. In some embodiments, second peak **164** is disposed between second proximal end **166** and second distal end **170** along longitudinal axis **10**.

In the illustrated embodiment of FIG. **4**, second proximal end **166** has a second minimum outer diameter **168** of second support ring **160**. In the illustrated embodiment of FIG. **4**, second distal end **170** has second minimum outer diameter **168** of second support ring **160**. In other words, in the illustrated embodiment of FIG. **4**, second proximal end **166** and second distal end **170** have a substantially equal outer diameter, that is, second minimum outer diameter **168**.

In some embodiments, second proximal end **166** and second peak **164** define a second proximal peak distance **172** therebetween along longitudinal axis **10**. Further, in some embodiments, second distal end **170** and second peak **164** define a second distal peak distance **174** therebetween along longitudinal axis **10**.

In some embodiments, second proximal peak distance **172** between second proximal end **166** and second peak **164** along longitudinal axis **10** is less than second distal peak distance **174** between second distal end **170** and second peak **164** along longitudinal axis **10**. In some cases, second proximal peak distance **172** being less than second distal peak distance **174** may improve rigidity of second support ring **160** during crimping of shell **112**.

In some embodiments, second distal peak distance **174** is greater than second proximal peak distance **172** by a factor of at least about 1.9. In other words, in some embodiments, second distal peak distance **174** is greater than or equal to about 1.9 times of second proximal peak distance **172**. In some embodiments, second proximal peak distance **172** may be about 1.2 mm, and first distal peak distance **154** may be about 2.3 mm.

In the illustrated embodiment of FIG. **4**, second support ring **160** has a second length **176** along longitudinal axis **10**. In some embodiments, second length **176** may be defined as a sum of second proximal peak distance **172** and second distal peak distance **174**. In some embodiments, second length **176** is about 3.5 mm. However, in some other embodiments, second length **176** may be about 3.3 mm, about 3.4 mm, about 3.6 mm, about 3.7 mm, or about 3.8 mm.

In the illustrated embodiment of FIG. **4**, third support ring **180** further includes a third proximal end **186** proximal to bridge line **126**. In the illustrated embodiment of FIG. **4**, third support ring **180** further includes a third distal end **190** distal to bridge line **126**. In some embodiments, third peak **184** is disposed between third proximal end **186** and third distal end **190** along longitudinal axis **10**.

In the illustrated embodiment of FIG. **4**, third proximal end **186** has a third minimum outer diameter **188** of third support ring **180**. Further, in the illustrated embodiment of FIG. **4**, third distal end **190** has third minimum outer diameter **188** of third support ring **180**. In other words, in the illustrated embodiment of FIG. **4**, third proximal end **186** and third distal end **190** have a substantially equal outer diameter, that is, third minimum outer diameter **188**.

In some embodiments, third proximal end **186** and third peak **184** define a third proximal peak distance **192** therebetween along longitudinal axis **10**. Further, in some embodiments, third distal end **190** and third peak **184** define a third distal peak distance **194** therebetween along longitudinal axis **10**.

In some embodiments, third proximal peak distance **192** between third proximal end **186** and third peak **184** along longitudinal axis **10** is substantially equal to third distal peak distance **194** between third distal end **190** and third peak **184** along longitudinal axis **10**. Specifically, in some embodiments, third support ring **180** may be symmetric about third peak **184** along longitudinal axis **10**. In some embodiments, third proximal peak distance **192** may be about 1.2 mm and third distal peak distance **194** may be about 1.2 mm.

However, in some other embodiments, third proximal peak distance **192** between third proximal end **186** and third peak **184** along longitudinal axis **10** may be different from third distal peak distance **194** between third distal end **190** and third peak **184** along longitudinal axis **10**. In other words, in some embodiments, third support ring **180** may be asymmetric about third peak **184** along longitudinal axis **10**.

Further, in the illustrated embodiment of FIG. **4**, third support ring **180** has a third length **196** along longitudinal axis **10**. In some embodiments, third length **196** may be defined as a sum of third proximal peak distance **192** and third distal peak distance **194**. In some embodiments, third length **196** is about 2.4 mm. However, in some other embodiments, third length **196** may be about 2.2 mm, about 2.3 mm, about 2.5 mm, about 2.6 mm, or about 2.7 mm.

In some embodiments, third length **196** is less than each of first length **156** and second length **176**. That is, in some embodiments, third support ring **180** may be smaller than each of first support ring **140** and second support ring **160** along longitudinal axis **10**.

In some embodiments, first length **156** is greater than third length **196** by a factor of at least 1.16. In other words, in some embodiments, first length **156** is greater than or equal to about 1.16 times of third length **196**.

Further, in some embodiments, second length **176** is greater than third length **196** by a factor of at least 1.45. In other words, in some embodiments, second length **176** is greater than or equal to about 1.45 times of third length **196**.

FIGS. **5**A and **5**B show schematic cross-sectional views of bottle assembly **300** in accordance with an embodiment of the present disclosure. Specifically, FIG. **5**A shows a schematic cross-sectional view of bottle assembly **300** before crimping of shell **112**, and FIG. **5**B shows a schematic cross-sectional view of bottle assembly **300** after crimping of shell **112**.

As discussed above, bottle assembly **300** includes bottle **100** and screwcap **110**.

Referring to FIGS. **5**A and **5**B, in some embodiments, crimping rollers **304** may be used to crimp shell **112** to neck **102** of bottle **100**. In some cases, shell **112** may be crimped to neck **102** by crimping rollers **304** at an optimal position **302**. Optimal position **302** may reduce defects and improve sealing of opening **106** of bottle **100** by screwcap **110**. In some embodiments, optimal position **302** may be about 0.3 mm below neck **102** of bottle **100**. Specifically, in some embodiments, optimal position **302** may be about 0.3 mm below shoulder **104** of neck **102**.

In some embodiments, shell **112** is crimped to neck **102**, such that at least a portion of third support ring **180** deforms and engages shoulder **104** of neck **102** after crimping. Third support ring **180** has a third maximum crimped outer diameter **198** after crimping. Third maximum crimped outer diameter **198** is less than nominal outer diameter **124** of skirt **122**.

Advantageously, third support ring **180** may allow crimping of shell **112** at a greater penetration by crimping rollers **304** on neck **102** to reduce third maximum crimped outer diameter **198**. Reduction of third maximum crimped outer diameter **198** may prevent the undesired pull-off of screwcap **110** from bottle **100**.

Further, third support ring **180** may allow second support ring **160** of skirt **122** to be positioned lower as compared to a conventional screwcap. This may further reduce distortion of second support ring **160** during crimping, thereby preventing several defects such as bird beaks and facets.

Further, in the illustrated embodiment of FIG. **5**B, first support ring **140** has a first maximum crimped outer diameter **158** after crimping. In some embodiments, first maximum crimped outer diameter **158** is substantially equal to first maximum outer diameter **142**. In other words, in some embodiments, first maximum outer diameter **142** of first support ring **140** may remain substantially unchanged after crimping.

FIG. **5**C shows a plan view of second support ring **160** depicting a circularity of second support ring **160** after crimping. Referring to FIGS. **5**A to **5**C, second support ring **160** has a second maximum crimped outer diameter **178** (shown by a dashed circle in FIG. **5**C) after crimping and a second minimum crimped outer diameter **179** (shown by a dotted circle in FIG. **5**C) after crimping. In some embodiments, second maximum crimped outer diameter **178** may be substantially equal to second maximum outer diameter **162**. In other words, in some embodiments, second maximum outer diameter **162** may remain substantially unchanged after crimping.

In some embodiments, a difference between second maximum crimped outer diameter **178** and second minimum crimped outer diameter **179** is less than about 0.25 mm. That is, in some embodiments, second maximum crimped outer diameter **178**—second minimum crimped outer diameter **179**<0.25 mm. In some embodiments, the difference between second maximum crimped outer diameter **178** and second minimum crimped outer diameter **179** may be in a range between about 0 mm and about 0.25 mm.

Thus, third support ring **180** may improve the circularity of second support ring **160**. This may further improve an appearance of screwcap **110** on bottle **100**.

FIG. **6** shows a graph **400**. Referring to FIGS. **5**A to **6**, graph **400** represents a circularity rate with respect to different positions of crimping rollers **304**. The circularity rate may be defined as a difference between a maximum crimped outer diameter and a minimum crimped outer diameter.

Specifically, graph **400** represents the circularity rate of second support ring **160** with respect to the different positions of crimping rollers **304** during crimping of shell **112**. The circularity rate of second support ring **160** may be defined as a difference between second maximum crimped outer diameter **178** and second minimum crimped outer diameter **179**. Graph **400** further represents the circularity rate of a second support ring of a conventional screwcap with respect to the different positions of crimping rollers **304** during crimping of the conventional screwcap.

Graph **400** depicts the circularity rate (in mm) on the ordinate (Y-axis), and the different positions of the crimping rollers **304** during crimping on the abscissa (X-axis). The different positions of the crimping rollers **304** during crimping include a first position **402**, a second position **404**, and a third position **406**. First position **402** is optimal position **302** of the crimping rollers **304** during crimping. Second position **404** is about 0.5 mm below optimal position **302**. Third position **406** is about 1 mm below optimal position **302**.

Graph **400** includes a first bar **408** and a second bar **410** representing the circularity rates of second support ring **160** of screwcap **110** and the second support ring of the conventional screwcap, respectively, at first position **402**. As depicted by first and second bars **408**, **410**, second support ring **160** has a smaller circularity rate (about 0.09 mm vs. about 0.13 mm) than the conventional screwcap at first position **402**. Consequently, second support ring **160** has a greater circularity than the second support ring of the conventional screwcap at first position **402**. Thus, when crimped at first position **402**, screwcap **110** of the present disclosure may have a better appearance than the conventional screwcap.

Graph **400** further includes a third bar **412** and a fourth bar **414** representing the circularity rates of second support rings of screwcap **110** and the second support ring of the conventional screwcap, respectively, at second position **404**. As depicted by third and fourth bars **412**, **414**, second support ring **160** has a substantially smaller circularity rate (about 0.14 mm vs. about 0.28 mm) than the conventional screwcap at second position **404**. Consequently, second support ring **160** has a substantially greater circularity than the second support ring of the conventional screwcap at second position **404**. Thus, when crimped at second position **404**, screwcap **110** of the present disclosure may have a substantially better appearance than the conventional screwcap. Further, screwcap **110** may prevent bird beaks when crimped at second position **404**, while the conventional screwcap may experience bird beaks when crimped at second position **404**.

Graph **400** further includes a fifth bar **416** and a sixth bar **418** representing the circularity rates of second support rings of screwcap **110** and the conventional screwcap, respectively, at third position **406**. As depicted by fifth and sixth bars **416**, **418**, second support ring **160** has a substantially smaller circularity rate (about 0.20 mm vs. about 0.33 mm) than the conventional screwcap at third position **406**. Consequently, second support ring **160** has a substantially greater circularity than the second support ring of the conventional screwcap at third position **406**. Thus, when crimped at third position **406**, screwcap **110** of the present disclosure may have a substantially better appearance than the conventional screwcap. Further, screwcap **110** may prevent facets when crimped at third position **406**, as compared to the conventional screwcap that may experience facets when crimped at third position **406**.

As depicted by graph **400**, the circularity rates of second support ring **160** of screwcap **110** are lower than the circularity rates of the second support ring of the conventional screwcap. The circularity rates of second support ring **160** of screwcap **110** at the different positions are less than 0.25 mm. Therefore, second support ring **160** of screwcap **110** may not experience defects, such as bird beaks and facets, during crimping, and improve the appearance of the bottle **100**.

Comparative Examples

The screwcap of the present disclosure (hereinafter referred to as "the new screwcap") was crimped to a neck of a bottle at different positions and under different lateral loads (about 8.5 kilograms (kg) and about 9.5 kg) by crimping rollers. Similarly, a conventional screwcap was crimped to the neck of the bottle at the different positions and under the different lateral loads by the crimping rollers.

The crimping of the new screwcap and the conventional screwcap was repeated 10 times for each of the different positions and lateral loads. Defects were observed for the different lateral loads applied at the different positions by the crimping rollers on the new screwcap and the conventional screwcap.

Case 1:

The new screwcap and the conventional screwcap were crimped to the neck of the bottle at an optimal position under the different lateral loads by the crimping rollers. The optimal position was about 0.3 mm below the neck of the bottle.

Percentage occurrence of defects in the new screwcap and the conventional screwcap due to crimping at the optimal position under the different lateral loads was determined and is tabulated in Table 1 below.

TABLE 1

Details of Defect Occurrence in Percentage				
Screwcap Type	Lateral Load	Bird Beaks	Facets	Pull-off
New Screwcap	8.5 Kg	0%	0%	0%
Conventional Screwcap		0%	0%	100%
New Screwcap	9.5 Kg	0%	0%	0%
Conventional Screwcap		0%	0%	30%

Referring to Table 1, it was determined that when crimped at the optimal position and under 8.5 kg lateral load, the conventional screwcap experienced a pull-off defect (i.e., undesirable removal of a screwcap from the bottle upon application of a force) 100% of the times. Further, at the optimal position and under 9.5 kg lateral load, the conventional screwcap experienced the pull-off defect 30% of the times. On the other hand, the new screwcap did not experience the pull-off defect when crimped at the optimal position and under both 8.5 kg and 9.5 kg lateral loads. It was observed that the new screwcap clenched better to the bottle after crimping.

Case 2:

The new screwcap and the conventional screwcap were crimped to the neck of the bottle at a second position about 0.25 mm below the optimal position under the different lateral loads by the crimping rollers.

Percentage occurrence of defects in the new screwcap and the conventional screwcap due to crimping at the second position under the different lateral loads was determined and is tabulated in Table 2 below.

TABLE 2

Details of Defect Occurrence in Percentage				
Screwcap Type	Lateral Load	Bird Beaks	Facets	Pull-off
New Screwcap	8.5 Kg	0%	0%	0%
Conventional Screwcap		100%	0%	100%
New Screwcap	9.5 Kg	0%	0%	0%
Conventional Screwcap		100%	0%	30%

Referring to Table 2, it was determined that when crimped at the second position and under 8.5 kg lateral load, the conventional screwcap experienced the pull-off defect as well as bird beaks 100% of the times. Further, when crimped at the second position and under 9.5 kg lateral load, the conventional screwcap experienced the bird beaks 100% of the time, and the pull-off defect 30% of the times.

However, the new screwcap did not experience the pull-off defect and the bird beaks at the second position and under both 8.5 kg and 9.5 kg lateral loads. The new screwcap prevented both the pull-off defect and the bird beaks when crimped at the second position under the different lateral loads.

Case 3:

The new screwcap and the conventional screwcap were crimped to the neck of the bottle at a third position about 0.375 mm below the optimal position under the different lateral loads by the crimping rollers.

Percentage occurrence of defects in the new screwcap and the conventional screwcap due to crimping at the third position under the different lateral loads was determined and is tabulated in Table 3 below.

TABLE 3

Details of Defect Occurrence in Percentage				
Screwcap Type	Lateral Load	Bird Beaks	Facets	Pull-off
New Screwcap	8.5 Kg	0%	0%	0%
Conventional Screwcap		100%	100%	100%
New Screwcap	9.5 Kg	0%	0%	0%
Conventional Screwcap		100%	100%	0%

Referring to Table 3, it was determined that when crimped at the third position and under 8.5 kg lateral load, the conventional screwcap experienced the pull-off defect, facets, as well as bird beaks 100% of the times. Further, when crimped at the third position and under 9.5 kg lateral load, the conventional screwcap experienced the bird beaks and the facets 100% of the times.

However, the new screwcap did not experience the pull-off defect, the facets, and the bird beaks at the third position and under both 8.5 kg and 9.5 kg lateral loads. The new screwcap prevented all three of the defects at the third position under the different lateral loads.

Thus, it was concluded that the new screwcap overcame the defects, such as the bird beaks, facets, and pull-off, regardless of the different lateral loads and the different positions of the crimping rollers.

Each and every document cited in this present application, including any cross referenced, is incorporated in this present application in its entirety by this reference, unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any embodiment disclosed in this present application or that it alone, or in any combination with any other reference or references, teaches, suggests, or discloses any such embodiment. Further, to the extent that any meaning or definition of a term in this present application conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this present application governs.

Unless otherwise indicated, all numbers expressing sizes, amounts, ranges, limits, and physical and other properties used in the present application are to be understood as being preceded in all instances ay the term "about". Accordingly, unless expressly indicated to the contrary, the numerical parameters set forth in the present application are approximations that can vary depending on the desired properties sought to be obtained by a person of ordinary skill in the art without undue experimentation using the teachings disclosed in the present application.

As used in the present application, the singular forms "a", "an", and "the" encompass embodiments having plural referents, unless the context clearly dictates otherwise. As used in the present application, the term "or" is generally employed in its sense including "and/or", "unless" the context clearly dictates otherwise.

Spatially related terms, including but not limited to, "lower", "upper", "beneath", "below", "above", "bottom" and "top", if used in the present application, are used for ease of description to describe spatial relationships of an element(s) to another. Such spatially related terms encompass different orientations of the device in use or operation, in addition to the particular orientations depicted in the figures and described in the present application. For example, if an object depicted in the drawings is turned over or flipped over, elements previously described as below, or beneath other elements would then be above those other elements.

The drawings show some but not all embodiments. The elements depicted in the drawings are illustrative and not necessarily to scale, and the same or similar) reference numbers denote the same (or similar) features throughout the drawings.

The description, examples, embodiments, and drawings disclosed are illustrative only and should not be interpreted as limiting. The present invention includes the description, examples, embodiments, and drawings disclosed; but it is not limited to such description, examples, embodiments, or drawings. As briefly described above, the reader should assume that features of one disclosed embodiment can also be applied to all other disclosed embodiments, unless expressly indicated to the contrary. Modifications and other embodiments will be apparent to a person of ordinary skill in the packaging arts, and all such modifications and other embodiments are intended and deemed to be within the scope of the present invention.

The invention claimed is:

1. A screwcap for sealing a neck of a bottle, the screwcap comprising:
- a shell extending along a longitudinal axis and configured to be disposed on the neck, the shell comprising:
  - a head; and
  - a skirt having a nominal outer diameter and detachably connected to the head along a bridge line, the skirt comprising:
    - a first support ring disposed proximal to the bridge line, the first support ring having a first maximum outer diameter greater than the nominal outer diameter of the skirt;
    - a second support ring disposed distal to the bridge line, the second support ring having a second maximum outer diameter greater than the nominal outer diameter of the skirt; and
    - a third support ring disposed between the first support ring and the second support ring relative to the longitudinal axis, the third support ring having a third maximum outer diameter greater than the nominal outer diameter of the skirt, and wherein at least a portion of the third support ring is configured to deform and engage a shoulder of the neck after crimping.

2. The screwcap of claim **1**, wherein:
- the first support ring comprises a first peak having the first maximum outer diameter;
- the second support ring comprises a second peak having the second maximum outer diameter;
- the third support ring comprises a third peak having the third maximum outer diameter; and
- a first distance between the first peak and the third peak is less than a second distance between the second peak and the third peak.

3. The screwcap of claim **2**, wherein the second distance is greater than the first distance by a factor of at least 1.3.

4. The screwcap of claim **2**, wherein the first distance is 3 millimeters (mm), and the second distance is 4 mm.

5. The screwcap of claim **1**, wherein the first support ring further comprises:
- a first proximal end proximal to the bridge line and having a first minimum outer diameter of the first support ring; and
- a first distal end distal to the bridge line and having the first minimum outer diameter of the first support ring;
- wherein the first peak is disposed between the first proximal end and the first distal end along the longitudinal axis; and

wherein a first proximal peak distance between the first proximal end and the first peak along the longitudinal axis is greater than a first distal peak distance between the first distal end and the first peak along the longitudinal axis.

6. The screwcap of claim **1**, wherein the second support ring further comprises:

a second proximal end proximal to the bridge line and having a second minimum outer diameter of the second support ring; and

a second distal end distal to the bridge line and having the second minimum outer diameter of the second support ring;

wherein the second peak is disposed between the second proximal end and the second distal end along the longitudinal axis; and

wherein a second proximal peak distance between the second proximal end and the second peak along the longitudinal axis is less than a second distal peak distance between the second distal end and the second peak along the longitudinal axis.

7. The screwcap of claim **1**, wherein the third support ring further comprises:

a third proximal end proximal to the bridge line and having a third minimum outer diameter of the third support ring; and

a third distal end distal to the bridge line and having the third minimum outer diameter of the third support ring;

wherein the third peak is disposed between the third proximal end and the third distal end along the longitudinal axis; and

wherein a third proximal peak distance between the third proximal end and the third peak along the longitudinal axis is equal to a third distal peak distance between the third distal end and the third peak along the longitudinal axis.

8. The screwcap of claim **1**, wherein the third maximum outer diameter is greater than the nominal outer diameter by at least 0.5 mm.

9. The screwcap of claim **1**, wherein the first maximum outer diameter, the second maximum outer diameter, and the third maximum outer diameter are equal to one another.

10. The screwcap of claim **1**, wherein:

the first support ring has a first length along the longitudinal axis;

the second support ring has a second length along the longitudinal axis;

the third support ring has a third length along the longitudinal axis; and

the third length is less than each of the first length and the second length.

11. The screwcap of claim **1**, wherein the third support ring has a symmetric shape along the longitudinal axis.

12. The screwcap of claim **1**, wherein the third support ring has a V-shaped cross-section along the longitudinal axis.

13. The screwcap of claim **1**, wherein each of the first and second support rings has a curved cross-sectional shape.

14. The screwcap of claim **1**, wherein the shell has an average thickness of 0.25 mm.

15. The screwcap of claim **1**, wherein the head comprises at least one internal thread configured to engage with at least one external thread of the neck.

16. The screwcap of claim **1**, further comprising an insert disposed between the shell and the neck, wherein the insert comprises at least one internal thread configured to engage with at least one external thread of the neck.

17. The screwcap of claim **1**, further comprising a plurality of bridges disposed along the bridge line and detachably connecting the head to the skirt, wherein the plurality of bridges defines a plurality of perforations therebetween.

18. The screwcap of claim **1**, further comprising a sealing arrangement disposed between the shell and the neck, wherein the sealing arrangement is configured to seal an opening of the neck.

19. A bottle assembly comprising:

a bottle comprising a neck, the neck comprising a shoulder and an opening; and

a screwcap, the screwcap comprising:

a shell extending along a longitudinal axis and configured to be disposed on the neck, the shell comprising:

a head; and

a skirt having a nominal outer diameter and detachably connected to the head along a bridge line, the skirt comprising:

a first support ring disposed proximal to the bridge line, the first support ring having a first maximum outer diameter greater than the nominal outer diameter of the skirt;

a second support ring disposed distal to the bridge line, the second support ring having a second maximum outer diameter greater than the nominal outer diameter of the skirt; and

a third support ring disposed between the first support ring and the second support ring relative to the longitudinal axis, the third support ring having a third maximum outer diameter greater than the nominal outer diameter of the skirt;

wherein the shell is crimped to the neck, such that at least a portion of the third support ring deforms and engages the shoulder of the neck after crimping, wherein the third support ring has a third maximum crimped outer diameter after crimping, and wherein the third maximum crimped outer diameter is less than the nominal outer diameter of the skirt.

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