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(54) **OFFSET WAVE GROOVE BOTTLE**

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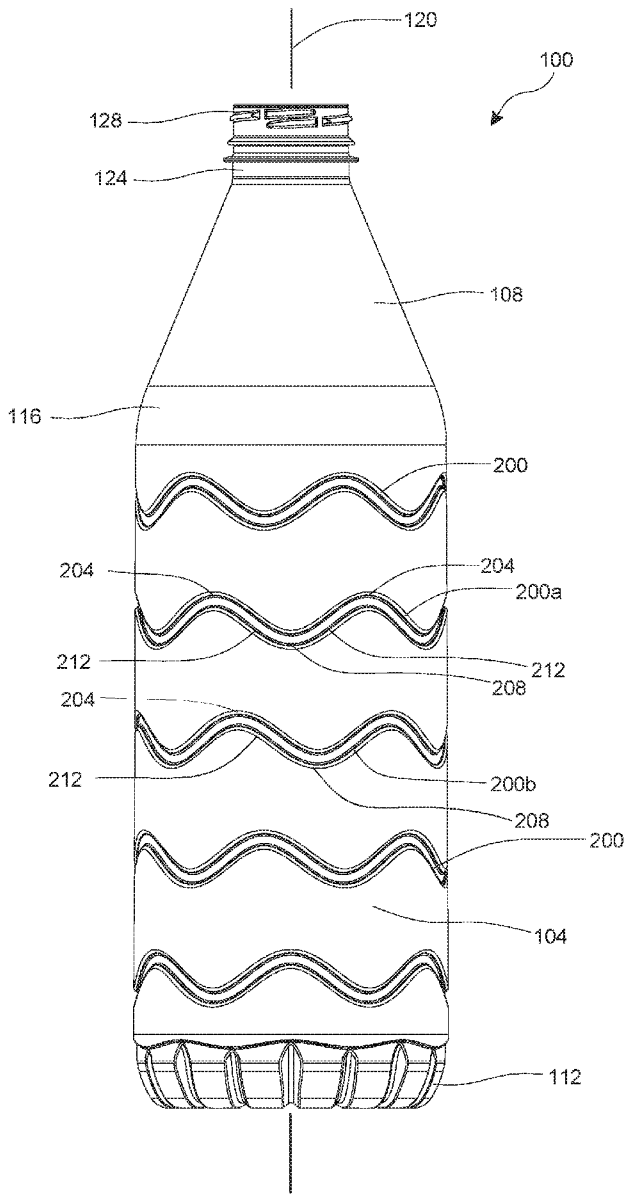
CPC ........ ***B65D 1/44*** (2013.01); *B65D 2501/0036* (2013.01); ***B65D 1/0284*** (2013.01); ***B65D 1/0246*** (2013.01)

(57) **ABSTRACT**

A bottle includes a finish defining a bottle opening, a bell carrying the finish, a base, a central axis extending from the finish to the base, a sidewall extending between the bell and the base, and at least two grooves that circumferentially extend around the sidewall and spaced apart relative to the central axis, the grooves being circumferentially offset from one another.



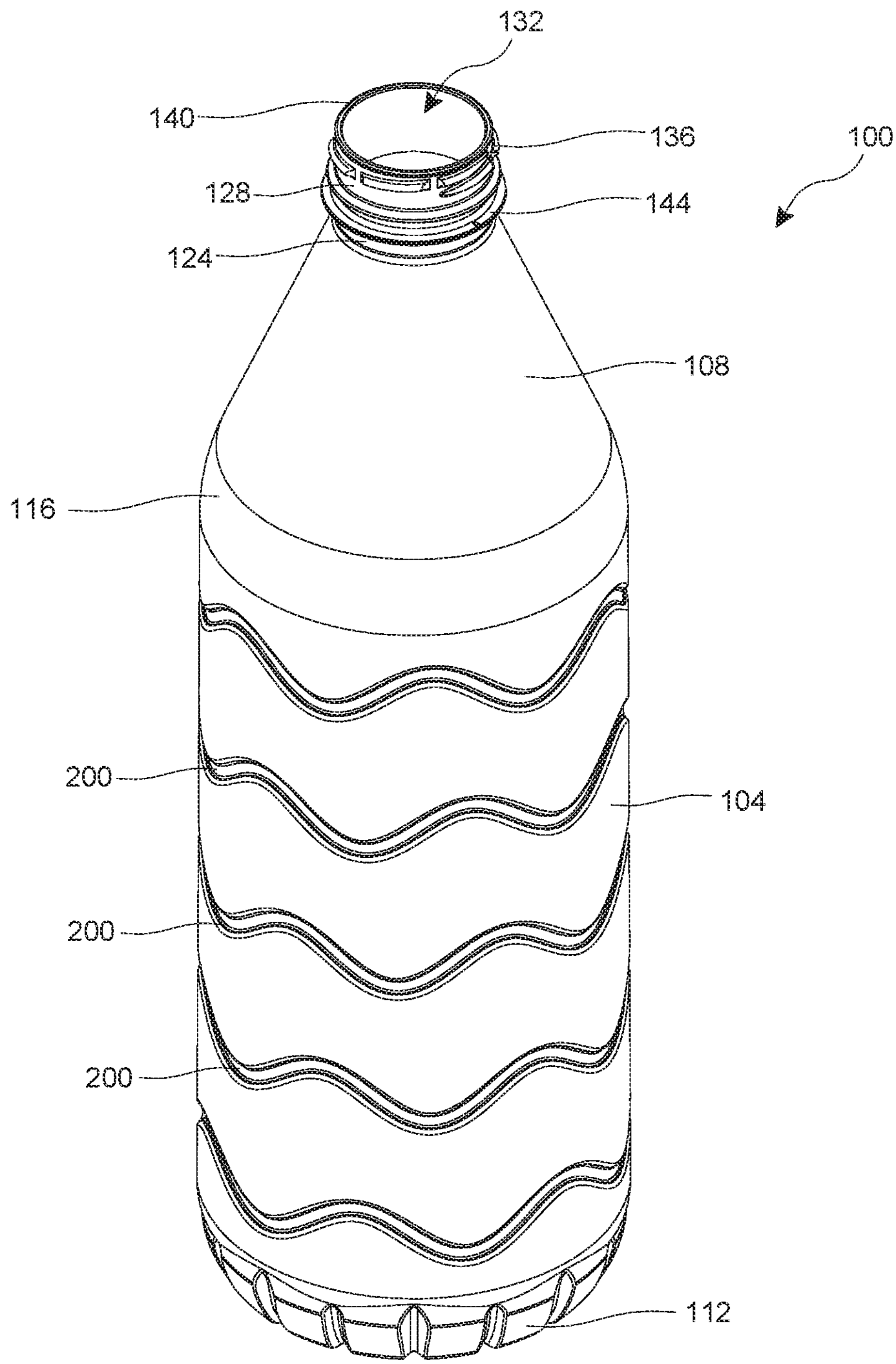



FIG. 1

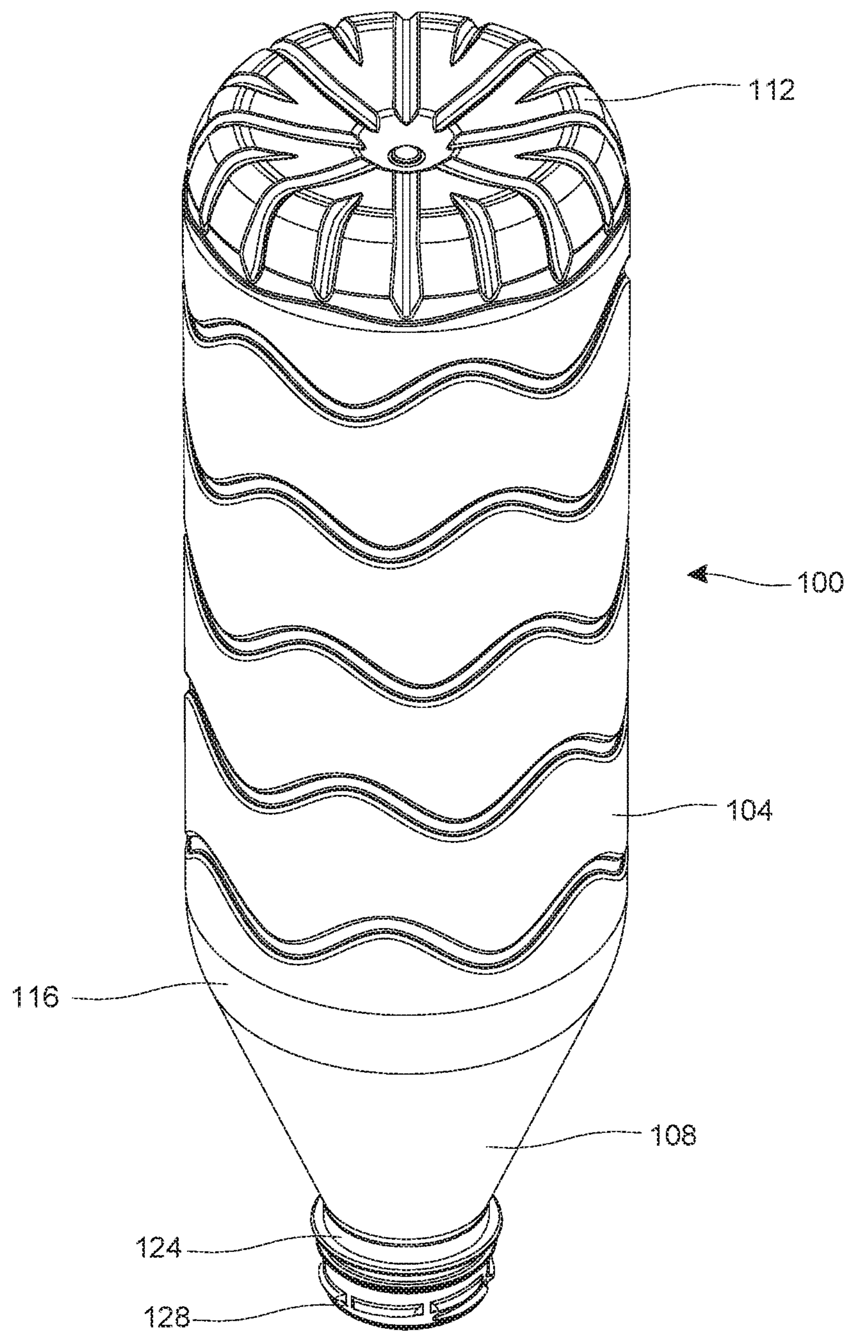



FIG. 2

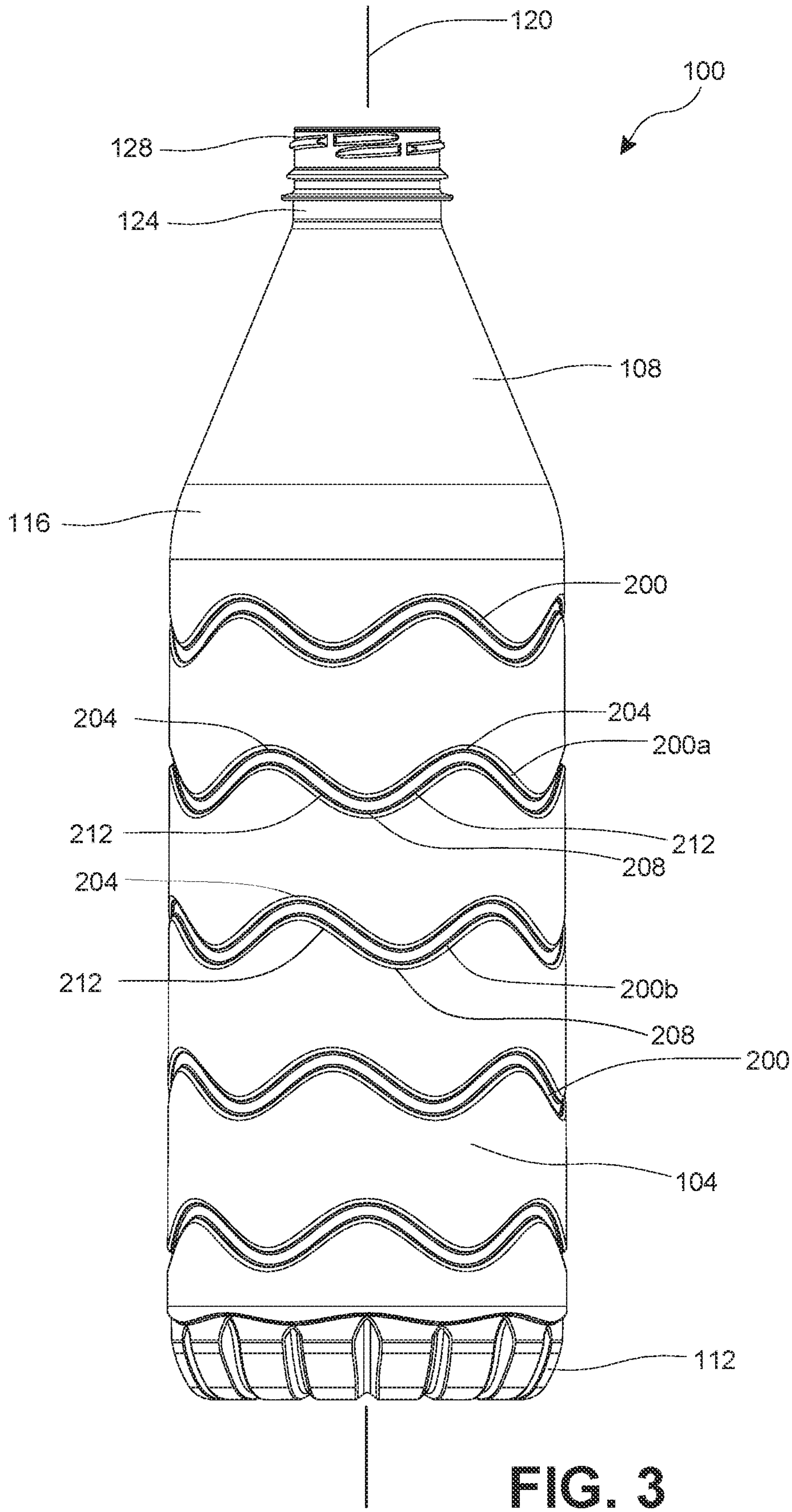

120
100
128
124
108
116
200
204
204
200a
212
212
208
204
212
200b
208
200
104
112

FIG. 3

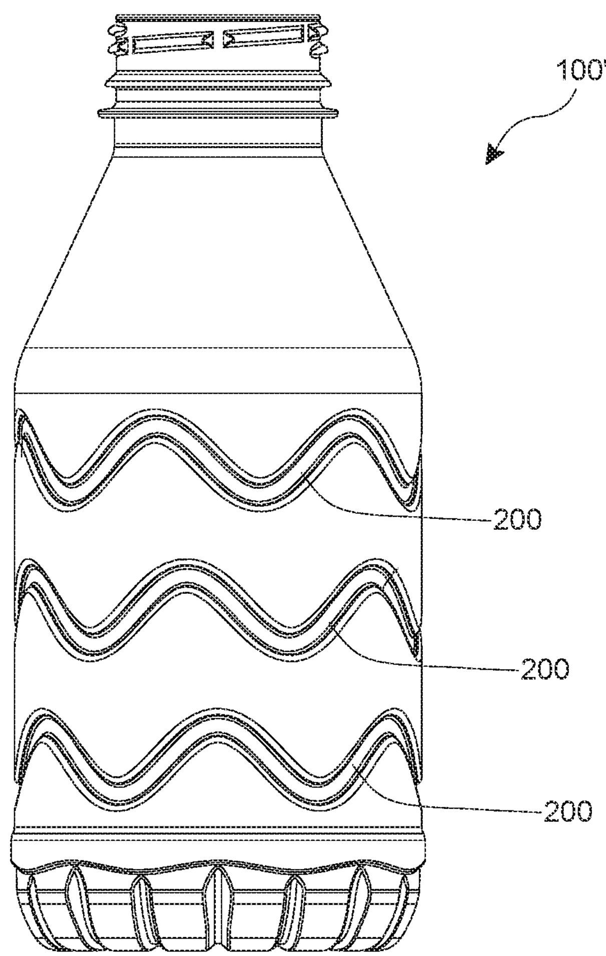



FIG. 3A

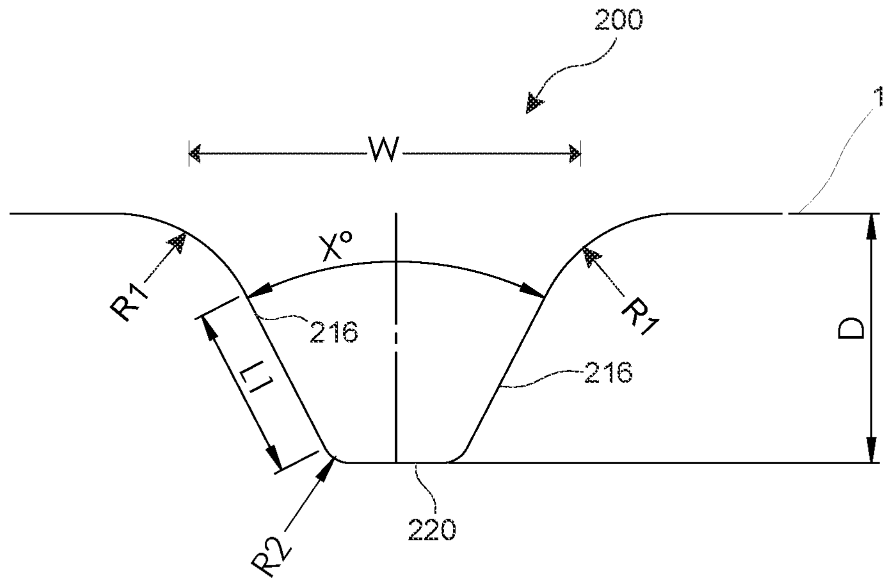

200
104
W
X°
R1
R1
216
216
L1
D
R2
220

FIG. 4

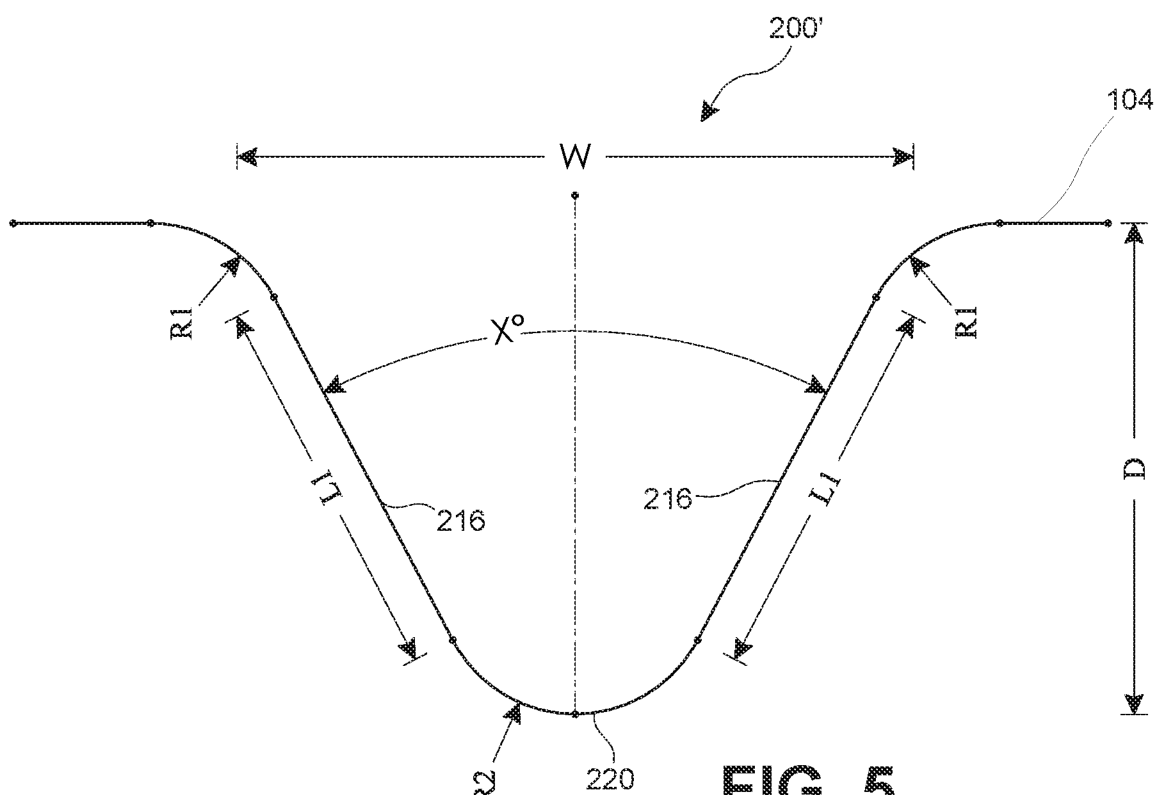

200'
104
W
X°
R1
R1
L1
L1
216
216
D
R2
220

FIG. 5

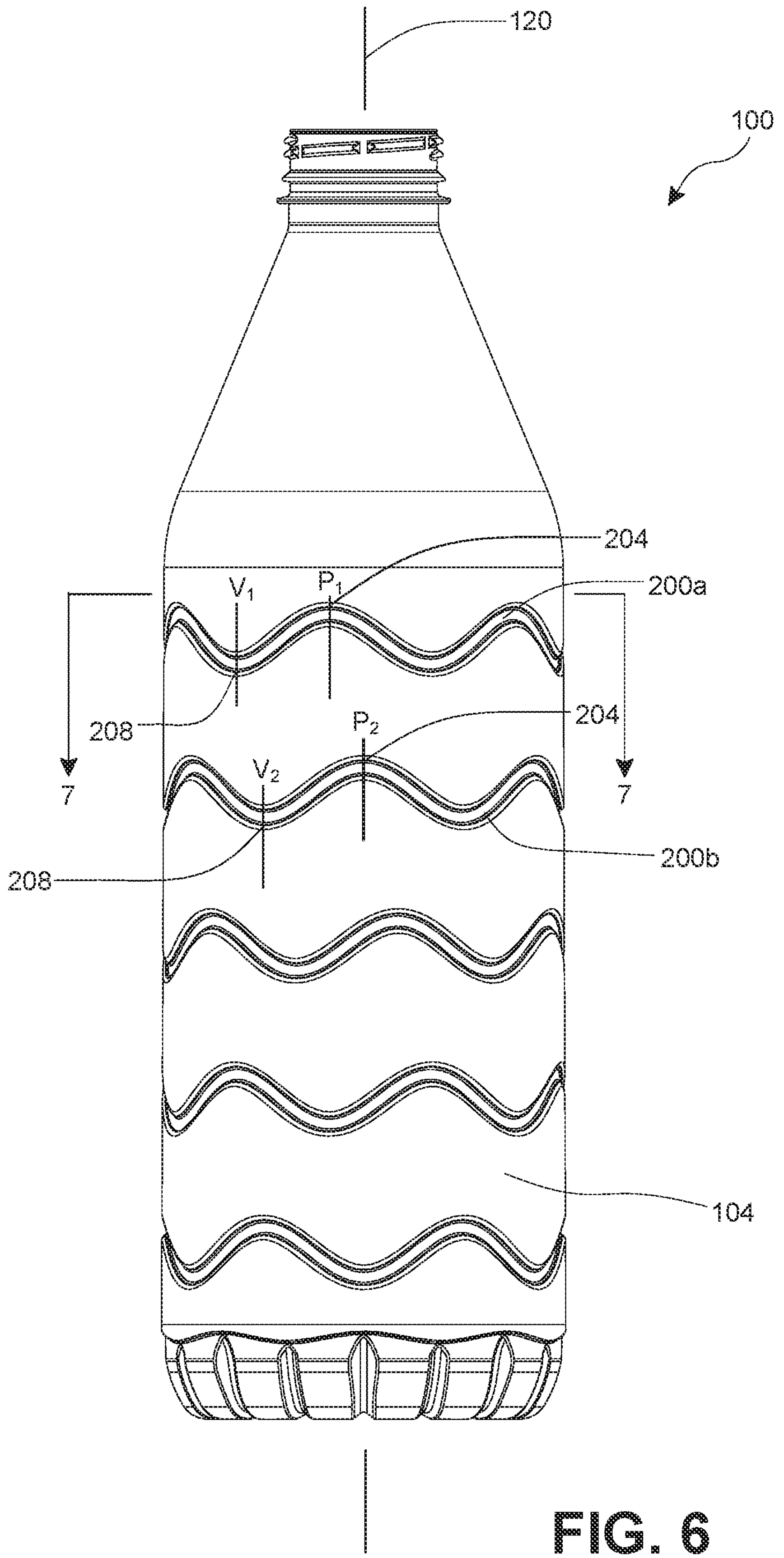



FIG. 6

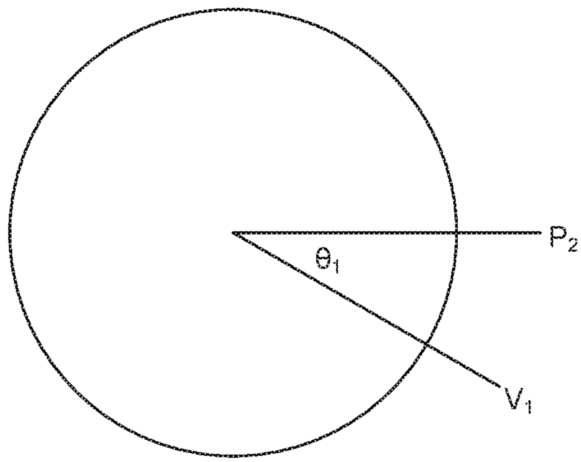



FIG. 7A

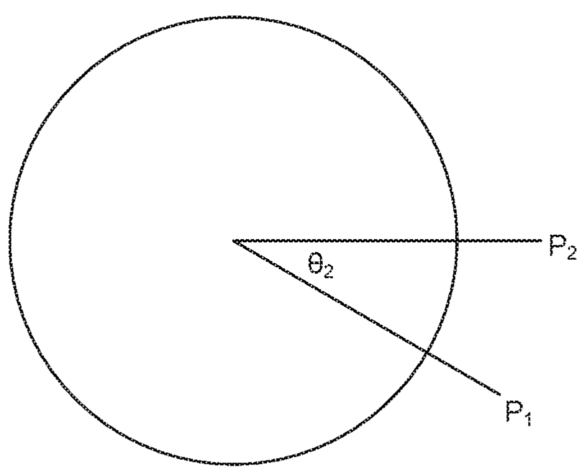



FIG. 7B

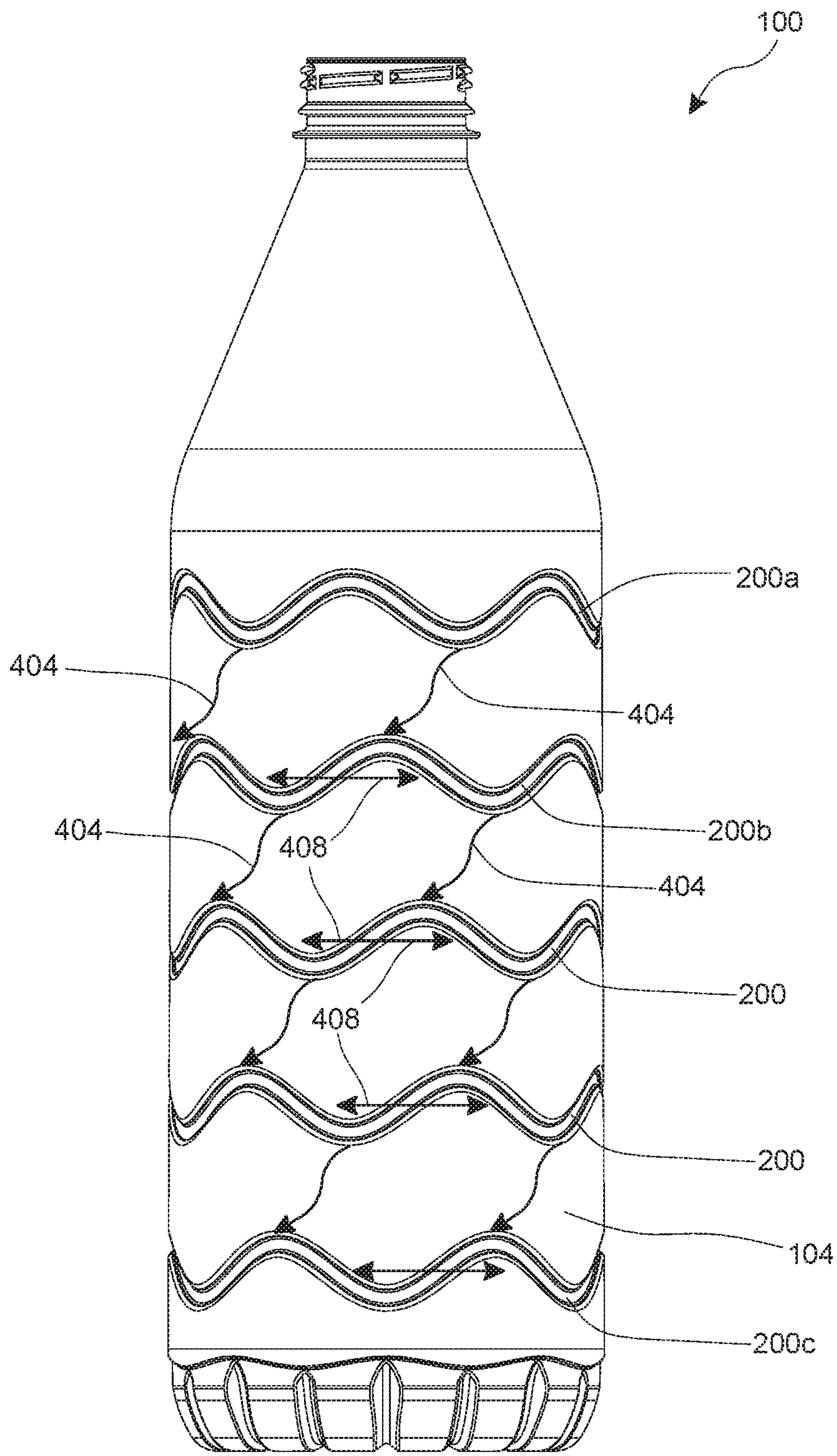



FIG. 8

# OFFSET WAVE GROOVE BOTTLE

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application claims priority to U.S. Provisional Patent Application No. 62/988,003, filed on Mar. 11, 2020, and entitled Offset Wave Groove Bottle, the entire contents of which is herein incorporated by reference in its entirety.

## FIELD

**[0002]** The present disclosure relates to plastic containers. More specifically, the present disclosure relates to a plastic container that includes a groove pattern around an outer circumference that provides improved strength attributes of the plastic container.

## BACKGROUND

**[0003]** Plastic containers are an alternative to glass or metal containers. A common plastic used in the manufacture of plastic containers is polyethylene terephthalate (or PET). Containers made of PET are generally transparent, thin walled, and can maintain their shape in response to force exerted on the walls by the contents of the container.

## SUMMARY

**[0004]** In one embodiment, a bottle includes a finish defining a bottle opening, a bell carrying the finish, a base, a central axis extending from the finish to the base, a sidewall extending between the bell and the base, and at least two grooves that circumferentially extend around the sidewall and spaced apart relative to the central axis, the grooves being circumferentially offset from one another.

**[0005]** In another embodiment, a bottle includes a finish defining a bottle opening, a neck coupled to the finish, a bell coupled to the neck, a base, a sidewall extending between the bell and the base, a central axis extending from the finish to the base, a first groove extending around the sidewall, the first groove having a wave shape defined by at least one peak and at least one valley, and a second groove extending around the sidewall, the second groove having a wave shape defined by at least one peak and at least one valley, the second groove being circumferentially offset from the first groove, and spaced from the first groove along the central axis.

**[0006]** In another embodiment, a bottle includes a neck defining a bottle opening, a bell coupled to the neck, a base, a sidewall extending between the bell and the base, a central axis extending from the neck to the base, a first groove extending around an outer circumference of the sidewall, the first groove having a wave shape defined by alternating first peaks and first valleys, and a second groove extending around an outer circumference of the sidewall, the second groove having a wave shape defined by alternating second peaks and second valleys, the second groove being circumferentially offset from the first groove such that the alternating second peaks and second valleys of the second groove are positioned out of vertical alignment with the alternating first peaks and first valleys of the first groove.

**[0007]** Other aspects of the disclosure will become apparent by consideration of the detailed description and accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** FIG. **1** is a perspective view of an example of an embodiment of a bottle illustrating a plurality of offset wave grooves.

**[0009]** FIG. **2** is a bottom perspective view of the bottle shown in FIG. **1**.

**[0010]** FIG. **3** is a side view of the bottle shown in FIG. **1**.

**[0011]** FIG. **3**A is a side view of another example of an embodiment of a bottle illustrating a plurality of offset wave grooves, and more specifically three total grooves.

**[0012]** FIG. **4** is a cross-sectional view of a groove of the bottle shown in FIG. **1**.

**[0013]** FIG. **5** is a cross-sectional view of another example of an embodiment of the groove of the bottle shown in FIG. **1**.

**[0014]** FIG. **6** is a side view of the bottle shown in FIG. **1** illustrating a plurality of circumferentially offset grooves.

**[0015]** FIG. **7**A is a cross-sectional view of the bottle shown in FIG. **6**, taken along line **7-7** of FIG. **6**, illustrating an angular distance between a valley of a first groove and a peak of an adjacent second groove.

**[0016]** FIG. **7**B is a cross-sectional view of the bottle shown in FIG. **6**, taken along line **7-7** of FIG. **6**, illustrating an angular distance between a first peak of the first groove and a closest second peak of the adjacent second groove.

**[0017]** FIG. **8** is a side view of the bottle shown in FIG. **1** illustrating a diverted load path and improved hoop-wise strength generated by the plurality of circumferentially offset grooves.

**[0018]** Before embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the accompanying drawings. The disclosure can support other embodiments and of being practiced or of being carried out in various ways.

## DETAILED DESCRIPTION

**[0019]** The present disclosure illustrates a container **100** that includes a plurality of offset wave grooves that improve structural strength of the container **100**, which can reduce risk of damage, leakage, bending, or undue stresses on the container **100**. The container **100** illustrated in the figures is a bottle **100**, and further an approximately one-liter bottle. It should be appreciated that the bottle **100**, and specifically the one-liter bottle, is provided for purposes of illustration and is not limiting. The bottle **100** can be any suitable or desired size and/or volume. For example, the bottle **100** can be, for example, 250 milliliters (mL), 1.0 Liter (L), 2.0 L, 8 ounces (oz.), 12 oz., 16.9 oz., 20 oz., 24 oz., or any other suitable or desired size or volume. In addition, the bottle **100** can be formed of a plastic or a polymer. For example, the bottle **100** can be formed of polyethylene terephthalate (PET), or any other suitable material or combination of materials. The plurality of offset wave grooves described herein can be used with any type of suitable container or vessel, or any size of suitable bottle that benefits from improved strength properties, including improved structural strength.

**[0020]** Now with reference to the figures, FIGS. **1-5** illustrate the container **100** (also referred to as the bottle **100**). With specific reference to FIGS. **1-3**, the bottle **100** includes a sidewall **104**, a bell **108** and a base **112**. The sidewall **104** (also referred to as a body **104**) extends between the bell **108** and the base **112**. A shoulder **116** can be provided between the sidewall **104** and the bell **108** to provide a transition between the sidewall **104** and the bell **108**. The bell **108** extends upward and inward relative to a central axis **120** (shown in FIG. **3**) from the sidewall **104** to a neck **124** and a finish **128**. As shown in FIG. **3**, the central axis **120** extends from the finish **128** to the base **112**. Referring back to FIGS. **1-3**, the neck **124** is coupled to the bell **108**, and the finish **128** is coupled to the neck **124**. The finish **128** defines a bottle opening **132** (or an opening **132** or an orifice **132**) (shown in FIG. **1**) that leads to an interior of the bottle **100**. As shown in FIG. **1**, the finish **128** includes a thread **136** and a sealing surface **140**. The thread **136** is configured to engage a closure (or a cap) (not shown). The sealing surface **140** defines a circumferential perimeter end of the opening **132**. The sealing surface **140** is configured to engage with a portion of the closure (not shown) to seal the opening **132**. A neck ring **144** (also referred to as a transfer bead **144**) circumferentially extends around the neck **124** and is positioned between the finish **128** and the neck **124**. The interior of the bottle **100** is configured to contain a beverage, a liquid, and/or any other suitable contents. In the illustrated embodiment, the bell **108** has a frustoconical cross-sectional shape, with the bell **108** having a first, smaller cross-sectional diameters adjacent the neck **124**, and a second, wider cross-sectional diameter adjacent the sidewall **104**. In other examples of embodiments, the bell **108** can have any suitable cross-sectional shape or geometry (e.g., arcuate, domed, semi-spherical, cupola-like, etc.) desired for the bottle **100**. In addition, the sidewall **104** is illustrated as generally cylindrical. However, in other embodiments, the sidewall **104** can be any suitable or desired cross-sectional shape or geometry (e.g., sloped with an increasing cross-sectional diameter, sloped with a decreasing cross-sectional diameter, form an hourglass-like cross-sectional shape where a portion of the sidewall has a cross-sectional diameter that is smaller than a portion above and/or a portion below, etc.). In addition, the sidewall **104** can include additional or different features, including curvatures, tapers, handles, grips, etc.

**[0021]** With reference to FIGS. **1** and **3**, the sidewall **104** includes a plurality of grooves **200** (otherwise referred to as ribs **200**). Each groove **200** extends around a circumference of the sidewall **104**. In other examples of embodiments, each groove **200** can extend around a portion of the circumference of the sidewall **104**, or partially extend around the circumference of the sidewall **104**. For example, each groove **200** can be defined by a plurality of groove sections to form an intermittent or broken groove around the circumference of the sidewall **104**. In the illustrated embodiment, the bottle **100** includes five total grooves **200**. In other embodiments, the bottle **100** can include any suitable number of grooves **200** (e.g., two, three, four, six, seven, eight, nine, or ten or more). As a nonlimiting example, FIG. **3**A illustrates a bottle **100'**, shown as a 250 mL bottle, that includes three grooves **200**. Generally, the bottle **100** includes at least two grooves **200**. In other embodiments, the bell **108** and/or the base **112** can also include at least one groove **200**.

**[0022]** With specific reference to FIG. **3**, the plurality of grooves **200** are vertically separated (or vertically spaced) along the central axis **120**. Stated another way, the grooves **200** are longitudinally separated (or spaced) along the longitudinally extending central axis **120**. In the illustrated embodiment, the grooves **200** are stacked, but spaced apart. The grooves **200** are equally spaced apart, such that a vertical distance between consecutive grooves **200** (or adjacent grooves) is the same along the central axis **120**. In other embodiments, the grooves **200** can be unequally spaced apart, such that a vertical distance between two consecutive grooves **200** of the plurality of grooves **200** can be greater than or less than a vertical distance between two other consecutive grooves **200** of the plurality of grooves **200**. It should be appreciated that the plurality of grooves **200** includes at least two grooves **200*a***, **200*b***.

**[0023]** Each groove **200** defines a wavelike pattern that extends around the circumference of the sidewall **104**. Each wave includes a plurality of peaks **204**, a plurality of valleys **208**, and a plurality of transition sections **212**. Each transition section **212** extends between each adjacent peak **204** and valley **208** (or each adjacent valley **208** and peak **204**). The peaks **204** are generally positioned closer to the bell **108** than the base **112**, while the valleys **208** are generally positioned closer to the base **112** than the bell **108**. In the illustrated embodiment, each groove **200** is sinusoidal in that the peaks **204** and the valleys **208** have the same amplitude (or extend the same distance from a common origin). In addition, the peaks **204** and the valleys **208** of each groove **200** are rounded (or U-shaped). In other examples of embodiments, the peaks **204** and the valleys **208** of each groove **200** can be angled (or V-shaped), or can be generally flat (i.e., can have a surface parallel to the circumference of the sidewall **104**. The plurality of grooves **200** have an identical pattern of peaks **204**, valleys **208**, and transition sections **212**, such that the plurality of grooves **200** have the same general shape, the same amplitude, the same wavelength, and/or have the same dimensions between consecutive peaks **204**. However, as discussed in additional detail below, each groove **200** of the plurality of grooves **200** is offset from the adjacent groove **200**. In other embodiments, each of the plurality of grooves **200** can have a different pattern of peaks **204**, valleys **208**, and transition sections **212**, while still being offset from the adjacent groove **200**. Each groove **200** includes a total of six peaks **204** and six valleys **208**. In other examples of embodiments, each groove **200** can include any suitable number of peaks **204** (e.g., two, three, four, seven, eight, nine, or ten or more), and any suitable number of valleys **208** (e.g., two, three, four, seven, eight, nine, or ten or more). In other examples of embodiments, the peaks **204** of a groove **200** can have the same amplitude (or extend the same vertical distance towards the bell **108**) or can have different amplitudes (or extend different vertical distances towards the bell **108**). Similarly, in other examples of embodiments, the valleys **208** of a groove **200** can have the same amplitude (or extend the same vertical distance towards the base **112**) or can have different amplitudes (or extend different vertical distances towards the base **112**). In yet other examples of embodiments, a groove **200** can have peaks **204** and valleys **208** that each have different amplitudes. For example, the peaks **204** can have a different amplitude than the valleys **208**. In addition, the peaks **204** can have different amplitudes between peaks **204**, and the valleys **208** can have different amplitudes between valleys **208**. Further, the amplitudes of the peaks **204** can be different than the amplitudes of the valleys **208**.

**[0024]** With reference now to FIG. **4**, a cross-sectional view of the groove **200** is illustrated. The groove **200** includes opposing groove sidewalls **216** and a bottom wall

**220**. Each groove sidewall **216** is inclined (or sloped) from the sidewall **104** (of the bottle **100**) to the bottom wall **220**. The bottom wall **220** is flat (or substantially flat). The groove **200** has a depth D, as measured from the sidewall **104** to the bottom wall **220**. In the illustrated embodiment, the depth D is in the range of approximately 0.8 millimeters (mm) to approximately 5.0 mm. In other embodiments, the depth D can be approximately 0.8 mm, 0.9 mm, 1.0 mm, 1.5 mm, 2.0 mm, 2.5 mm, 3.0 mm, 3.5 mm, 4.0 mm, 4.5 mm, or 5.0 mm. In yet other embodiments, the depth D can be any suitable or desired depth.

**[0025]** The groove **200** has a maximum width W, as measured between ends of the groove sidewalls **216** proximate the sidewall **104** (of the bottle **100**). In the illustrated embodiment, the width W is in the range of approximately 2.0 mm to approximately 6.0 mm. In other embodiments, the width W can be approximately 2.0 mm, 3.0 mm, 4.0 mm, 5.0 mm, or 6.0 mm. In yet other embodiments, the width W can be any suitable or desired width. In addition, the maximum width is greater than a width of the bottom wall **220**. As such, the groove **200** has a cross-sectional geometry similar to a trapezoid (or a trapezoidal cross-sectional shape).

**[0026]** The groove **200** has a first radius R**1** between the sidewall **104** (of the bottle **100**) and each of the groove sidewalls **216**. In the illustrated embodiment, the first radius R**1** is approximately 1.0 mm. In other embodiments, the first radius R**1** can be any suitable or desired radius length.

**[0027]** The groove has a second radius R**2** between each groove sidewall **216** and the bottom wall **220**. In the illustrated embodiment, the second radius R**2** is less than the first radius R**1**. In other examples of embodiments, the second radius R**2** is greater than the first radius R**1**. In yet other examples of embodiments, the second radius R**2** is the same as the first radius R**1**.

**[0028]** Each groove sidewall **216** has a length L**1**. In the illustrated embodiment, the length L**1** of the groove sidewalls **216** are approximately 1.51 mm. In other embodiments, the length L**1** of the groove sidewalls **216** can be any suitable or desired length.

**[0029]** An angle X° can extend between the groove sidewalls **216**. In the illustrated embodiment, the angle X° can be approximately 55 degrees. In other embodiments, the angle X° can be less than 55 degrees, can be more than 55 degrees, or can be any suitable or desired angle.

**[0030]** With reference to FIG. **5**, a cross-sectional view of another example of the groove **200'** is illustrated. The groove **200'** is substantially the same as groove **200**, with like number identifying like components, and like variables identifying like ranges. The groove **200'** differs in that the bottom wall **220** is curved (or arcuate), instead of flat (or substantially flat) as shown in groove **200**.

**[0031]** With reference now to FIGS. **3** and **6**, the plurality of grooves **200** are circumferentially offset from one another. More specifically, each groove **200** of the plurality of grooves **200** is circumferentially offset from an adjacent groove **200**. As such, the peaks **204**, the valleys **208**, and/or the transition sections **212** of one groove **200** are not in vertical alignment (or are not vertically aligned relative to the central axis **120**) with the peaks **204**, the valleys **208**, and/or the transition sections **212** of the adjacent groove **200**. It should be appreciated that the term adjacent groove **200** can include the immediately next groove **200** above and/or below one of the grooves **200**.

**[0032]** With reference to FIG. **6**, a first groove **200***a* of the plurality of grooves **200** includes a plurality of peaks **204** and a plurality of valleys **208**. A second groove **200***b* of the plurality of grooves **200**, which is adjacent the first groove **200***a*, also includes a plurality of peaks **204** and a plurality of valleys **208**. To illustrate the circumferentially offset arrangement of adjacent grooves **200**, the first groove **200***a* includes a first valley $V_1$ and a first peak $P_1$. The second groove **200***b* includes a second valley $V_2$ and a second peak $P_2$. The second valley $V_2$ of the second groove **200***b* corresponds to the first valley $V_1$ of the first groove **200***a*. Stated another way, the first and second valleys $V_1$, $V_2$ are the same valleys in different grooves **200***a*, **200***b*. The second valley $V_2$ is horizontally translated (or shifted) around an outer perimeter of the sidewall **104** (or circumferentially offset) relative to the first valley $V_1$. Stated another way, the first valley $V_1$ is horizontally translated (or shifted) around an outer perimeter of the sidewall **104** (or circumferentially offset) relative to the second valley $V_2$. Similarly, the second peak $P_2$ of the second groove **200***b* corresponds to the first peak $P_1$ of the first groove **200***a*. Stated another way, the first and second peaks $P_1$, $P_2$ are the same peaks in different grooves **200***a*, **200***b*. The second peak $P_2$ is horizontally translated (or shifted) around an outer perimeter of the sidewall **104** (or circumferentially offset) relative to the first peak $P_1$. Stated yet another way, the first peak $P_1$ is horizontally translated (or shifted) around an outer perimeter of the sidewall **104** (or circumferentially offset) relative to the second peak $P_2$. It should be appreciated that the first groove **200***a* can be any one of the plurality of grooves **200**, and the second groove **200***b* can be any groove **200** that is adjacent the first groove **200***a* (i.e., a groove **200** above or below the first groove **200***a*).

**[0033]** With reference to FIG. **7**A, the circumferentially offset arrangement of the first and second grooves **200***a*, **200***b* is illustrated by a first angle $\theta_1$. The first angle this defined as the angular distance (in degrees) between the first valley $V_1$ of the first groove **200***a* and the second peak $P_2$ of the second groove **200***b* (shown in FIG. **6**). This can also be referred to as an angular distance measured from valley to peak of adjacent grooves **200***a*, **200***b*. The first angle $\theta_1$ can be in the range of approximately 5 degrees to approximately 80 degrees. More specifically, the first angle $\theta_1$ can be in the range of approximately 25 degrees to approximately 60 degrees. More specifically, the first angle $\theta_1$ can be in the range of approximately 25 degrees to approximately 50 degrees. More specifically, the first angle $\theta_1$ can be in the range of approximately 35 degrees to approximately 55 degrees. More specifically, the first angle $\theta_1$ can be in the range of approximately 35 degrees to approximately 45 degrees. More specifically, the first angle $\theta_1$ can be in the range of approximately 40 degrees to approximately 50 degrees. More specifically, the first angle $\theta_1$ can be approximately 40 degrees. More specifically, the second angle $\theta_2$ can be approximately 25, 26, 27, 28, 229, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, or 50 degrees. All of the above approximations can be plus or minus approximately 5 degrees.

**[0034]** With reference to FIG. **7**B, the circumferentially offset arrangement of the first and second grooves **200***a*, **200***b* is illustrated by a second angle $\theta_2$. The second angle $\theta_2$ is defined as the angular distance (in degrees) between the first peak $P_1$ of the first groove **200***a* and the second peak $P_2$ of the second groove **200***b* (shown in FIG. **6**). This can also be referred to as an angular distance measured from peak to peak of adjacent grooves **200***a*, **200***b* (or the angular distance between the first peak $P_1$ of the first groove **200***a* and the angularly closest peak $P_2$ of the adjacent second groove **200***b*). The second angle $\theta_2$ can be in the range of approximately 5 degrees to approximately 45 degrees. More specifically, the second angle $\theta_2$ can be approximately 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, or 45 degrees. All of the above approximations can be plus or minus approximately 5 degrees. It should be appreciated that in embodiments where the adjacent grooves **200***a*, **200***b* have the same general shape and are circumferentially offset from each other, the angular distance as measured from peak to peak (or from the first peak $P_1$ to the second peak $P_2$) will be the same as the angular distance as measured from valley to valley (or between the first valley $V_1$ of the first groove **200***a* and the angularly closest, second valley $V_2$ of the second groove **200***b* (shown in FIG. **6**)).

**[0035]** The plurality of circumferentially offset grooves **200** advantageously improve load strengthening. More specifically, the grooves **200** disrupt a downward load path to provide additional strength to the bottle **100**. With reference to FIG. **8**, the circumferentially offset grooves **200** of the bottle **100** divert (or break up) a load path, illustrated by arrows **404**. The curved, downward arrows **404** indicate a path of load disruption caused by the plurality of circumferentially offset grooves **200**. More specifically, the circumferentially offset grooves **200** directs a downward force from a valley **208** of one groove **200** (or **200***a*) towards the closest peak **204** of an adjacent groove **200** (or **200***b*) positioned on the base side of the groove **200** (or **200***a*). The additional strength reduces a risk of buckling (or failure) of the sidewall **104** as compared to aligned grooves, where the downward load path is generally parallel to the central axis **120** (shown in FIG. **6**). In addition, the circumferentially offset grooves **200** provided improved hoop strength (or hoop-wise strength, or circumferential strength, or strength in a circumferential direction), shown by arrows **408**. The increase in hoop-wise strength is achieved as the load is diverted (or broken up) in the longitudinal/axial direction. Thus, advantageously, the downward load is provided partially downwards and partially in a twisting action.

**[0036]** Table I below illustrates the load effectiveness of disruption/strengthening (as a percentage or %). The angle described in Table I below illustrates the first angle $\theta_1$ shown in FIG. **7**A, defined as the angular distance (in degrees) between the first valley $V_1$ of the first groove **200***a* and the second peak $P_2$ of the adjacent second groove **200***b*. The effectiveness strengthening of Table I is measured by the first major drop in torsional resistive force, which signifies the first major failure of the sidewall **104**.

TABLE I

Effectiveness Values for Wave Alignment

| Angle (degrees) | Effectiveness of disruption/ strengthening (%) |
|---|---|
| 0 | 0 |
| 10 | 18 |
| 20 | 22 |
| 30 | 31 |
| 40 | 42 |
| 50 | 35 |
| 60 | 28 |
| 70 | 21.6 |

**[0037]** Table II below illustrates how changing the circumferential offset (or alignment) of adjacent grooves **200***a*, **200***b* can improve load performance. The angle described in Table II below illustrates the first angle $\theta_1$ shown in FIG. **7**A, defined as the angular distance (in degrees) between the first valley $V_1$ of the first groove **200***a* and the second peak $P_2$ of the adjacent second groove **200***b*. The top load increase is measured as a percentage change from zero degrees of angular offset (or vertically aligned grooves), as measured by the first major drop in downward resistive force, which signifies the first major failure of the sidewall **104**.

TABLE II

Load Values for Wave Alignment

| Angle (degrees) | Top Load Increase (%) |
|---|---|
| 0 | 0 |
| 10 | 3.5 |
| 20 | 4.7 |
| 30 | 6.6 |
| 40 | 8.5 |
| 50 | 8.0 |
| 60 | 6.1 |
| 70 | 5.2 |

**[0038]** Based on the results listed in Table II, embodiments of the bottle **100** that incorporate a plurality of circumferentially offset grooves **200** can have a load strength increase in the range of approximately 3.0% to approximately 8.5% as compared to a bottle without offset grooves (such as a bottle with circumferentially aligned grooves). More specifically, the bottle **100** can have a load strength increase of at least approximately 3.0%, 4.0%, 5.0%, 6.0%, 7.0%, 8.0%, or 8.5% as compared to a bottle without offset grooves (such as a bottle with circumferentially aligned grooves). In other embodiments, the load strength increase of the bottle that incorporates a plurality of circumferentially offset grooves **200** can be greater than 8.5% or less than 3.0% based on the size, dimensions, material, geometry, and/or other variables associated with bottle design.

**[0039]** The illustrated embodiment of the bottle **100** presents a plurality of circumferentially offset grooves **200**, where each groove **200**, **200***a* includes a plurality of peaks **204** and a plurality of valleys **208** that are not in vertical alignment with (or are circumferentially offset from) the plurality of peaks **204** and the plurality of valleys **208** in an adjacent groove **200**, **200***b*. It should be appreciated that in other examples of embodiments, the plurality of grooves **200** can include a groove **200**, **200***a* that includes at least one peak **204** that is not in vertical alignment with (or is circumferentially offset from) at least one peak **204** in an adjacent groove **200**, **200***b*. In yet other examples of embodiments, the plurality of grooves **200** can include a groove

**200**, **200***a* that includes at least one valley **208** that is not in vertical alignment with (or is circumferentially offset from) at least one valley **208** in an adjacent groove **200**, **200***b*.

**[0040]** It should be appreciated that the bottle **100** includes at least two grooves **200***a*, **200***b*, and the at least two grooves **200***a*, **200***b* are circumferentially offset (or not vertically aligned relative to the central axis **120**. In other examples of embodiments, the bottle **100** includes a plurality of grooves **200**, and each groove **200** is circumferentially offset relative to the adjacent groove **200**. Each groove **200** of the plurality of grooves **200** can be circumferentially offset relative to the adjacent groove **200** by the same angular distance (e.g., as illustrated in FIGS. **1-3**), or a different angular distance (e.g., within the plurality of grooves **200**, a first pair of adjacent grooves **200** is circumferentially offset a different angular distance than a second pair of adjacent grooves **200**, etc.).

**[0041]** In yet other examples embodiments, the plurality of grooves **200** can have an alternating circumferentially offset geometry. For example, every other groove **200** of the plurality of grooves **200** can be vertically aligned relative to the central axis **120**, however, any two adjacent grooves **200** are circumferentially offset. Stated another way, and as a nonlimiting example, in an embodiment of a bottle **100** having a plurality of grooves **200** that includes at least four grooves **200** vertically spaced along the central axis **120**, a second groove **200** can be circumferentially offset from an adjacent first groove **200**, the first groove being closer to the bell **108** than the second groove **200**. A third groove **200** can be circumferentially offset from the adjacent second groove **200**, the second groove being closer to the bell **108** than the third groove **200**. A fourth groove **200** can be circumferentially offset from the adjacent third groove **200**, the third groove being closer to the bell **108** than the fourth groove **200**. The first and third grooves **200** can be vertically aligned relative to the central axis **120**, and the second and fourth grooves **200** can be vertically aligned relative to the central axis **120**. In this configuration, each groove **200** is circumferentially offset by being rotated (or horizontally translated) either in a clockwise direction or a counterclockwise direction relative to the adjacent groove **200**. In one or more examples of embodiments, the angular distance defining the circumferential offset can be the same or can be different between adjacent pairs of grooves **200** within the plurality of grooves **200**.

**[0042]** In yet other examples of embodiments, the plurality of grooves **200** can have an alternating circumferentially offset geometry, however every other groove **200** of the plurality of grooves **200** is not vertically aligned relative to the central axis **120**. Stated another way, and as a nonlimiting example, in an embodiment of a bottle **100** having a plurality of grooves **200** that includes at least four grooves **200** vertically spaced along the central axis **120**, a second groove **200** can be circumferentially offset from an adjacent first groove **200**, the first groove being closer to the bell **108** than the second groove **200**. A third groove **200** can be circumferentially offset from the adjacent second groove **200**, the second groove being closer to the bell **108** than the third groove **200**. A fourth groove **200** can be circumferentially offset from the adjacent third groove **200**, the third groove being closer to the bell **108** than the fourth groove **200**. The second groove **200** is circumferentially offset from the first groove **200** by being horizontally translated a first distance (or having a first angular distance) in a first direction relative to the first groove **200**. The third groove **200** is circumferentially offset from the second groove **200** by being horizontally translated a second distance (or having a second angular distance) in a second direction, opposite the first direction, relative to the second groove **200**. The absolute value of the second distance (or the second angular distance) is not the same absolute value as the first distance (or the first angular distance). The fourth groove **200** is circumferentially offset from the third groove **200** by being horizontally translated a third distance (or having a third angular distance) in the first direction relative to the third groove **200**. The absolute value of the third distance (or the third angular distance) is not the same absolute value as the first distance (or the first angular distance) or the second distance (or the second angular distance).

**[0043]** The illustrated embodiment of the bottle **100** discusses the circumferentially offset orientation of adjacent grooves **200***a*, **200***b* of the plurality of grooves. It should be appreciated that the offset between two grooves **200** that are not adjacent can be determined. For example, and with reference to FIG. **8**, the circumferential offset between the first groove **200***a* and a third groove **200***c* that is not adjacent to the first groove **200***a* can be determined by multiplying the angular distance between the first groove **200***a* and the adjacent second groove **200***b* (e.g., the first angle $\theta_1$, the second angle $\theta_2$, etc.) by one plus the total number of grooves between the first and third grooves **200***a*, **200***c*. As a nonlimiting examples, in the illustrated example in FIG. **8**, if the angular distance between the first and second grooves **200***a*, **200***b* is hypothetically 5 degrees, the angular distance between the first and third grooves **200***a*, **200***c* is (5 degrees)×(1+3 grooves between the first and third grooves **200***a*, **200***c*)=(5 degrees)×(4)=20 degrees.

**[0044]** With reference back to FIGS. **3** and **6**, in one or more examples of embodiments, adjacent grooves **200***a*, **200***b* can be shifted approximately 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 91.9, 92, 93, 94, or 95 mm in a horizontal direction. In one or more examples of embodiments, a vertical distance between peaks **204** (e.g., $P_1$ to $P_2$, etc.) of adjacent grooves **200***a*, **200***b* can be approximately 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, or 35 mm. In one or more examples of embodiments, a vertical distance between a valley **208** of the first groove **200***a* and a peak **204** of an adjacent second groove **200***b* can be approximately 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 mm. In one or more examples of embodiments, one or more of the grooves **200** can have an amplitude of approximately 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 mm. In one or more examples of embodiments, one or more of the grooves **200** can have a period of approximately 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, or 45 mm.

**[0045]** One or more aspects of the bottle **100** provides certain advantages. For example, the sidewall **104** includes a plurality of grooves **200**, and more specifically at least two grooves **200***a*, **200***b*. The plurality of grooves **200** are circumferentially offset from each other. The circumferential offset arrangement of the grooves **200** advantageously improve load strengthening by disrupting a downward load path. The load is diverted in a curved, downward direction by the circumferentially offset grooves **200**. More specifically, the load is diverted from a valley **208** of one groove **200** (or **200***a*) towards the closest peak **204** of an adjacent, offset groove **200** (or **200***b*) positioned on the base side of the groove **200** (or **200***a*). The additional strength reduces a risk of buckling (or failure) of the sidewall **104**, while also increasing strength in a hoop (or circumferential) direction. These and other advantages are realized by the disclosure provided herein.

What is claimed is:

**1**. A bottle comprising:

a finish defining a bottle opening;

a bell carrying the finish;

a base;

a central axis extending from the finish to the base;

a sidewall extending between the bell and the base; and

at least two grooves that circumferentially extend around the sidewall and spaced apart relative to the central axis, the grooves being circumferentially offset from one another.

**2**. The bottle of claim **1**, wherein each of the at least two grooves include a plurality of alternating peaks and valleys.

**3**. The bottle of claim **1**, wherein each of the at least two grooves are sinusoidal.

**4**. The bottle of claim **1**, wherein the at least two grooves include a first groove and a second groove.

**5**. The bottle of claim **4**, wherein the first groove includes a plurality of alternating first peaks and first valleys, and the second groove includes a plurality of alternating second peaks and second valleys.

**6**. The bottle of claim **4**, wherein the first groove and the second groove are each sinusoidal in shape.

**7**. The bottle of claim **4**, wherein one of the second peaks of the second groove is circumferentially offset from a closest first peak of the first groove by an angular distance of 5 degrees to 45 degrees.

**8**. The bottle of claim **4**, wherein one of the second valleys of the second groove is circumferentially offset from a closest first valley of the first groove by an angular distance of 5 degrees to 45 degrees.

**9**. The bottle of claim **4**, wherein the first groove is positioned closer to the bell than the second groove, and wherein the first and second grooves are configured, in response to a load applied to the bottle, to direct the load from each of the first valleys of the plurality of first valleys of the first groove towards each of the closest second peaks of the plurality of second peaks of the second groove.

**10**. A bottle comprising:

a finish defining a bottle opening;

a neck coupled to the finish;

a bell coupled to the neck;

a base;

a sidewall extending between the bell and the base;

a central axis extending from the finish to the base;

a first groove extending around the sidewall, the first groove having a wave shape defined by at least one peak and at least one valley; and

a second groove extending around the sidewall, the second groove having a wave shape defined by at least one peak and at least one valley, the second groove being circumferentially offset from the first groove, and spaced from the first groove along the central axis.

**11**. The bottle of claim **10**, wherein the first groove and the second groove are sinusoidal in shape.

**12**. The bottle of claim **10**, wherein the second groove is circumferentially offset from the first groove by an angular distance of 5 degrees to 45 degrees.

**13**. The bottle of claim **10**, wherein the at least one peak of the second groove is circumferentially offset from the at least one peak of the first groove by an angular distance of 5 degrees to 45 degrees.

**14**. The bottle of claim **10**, wherein the at least one valley of the second groove is circumferentially offset from the at least one valley of the first groove by an angular distance of 5 degrees to 45 degrees.

**15**. The bottle of claim **10**, wherein the first groove is positioned closer to the bell than the second groove, and wherein the first and second grooves are configured, in response to a load applied to the bottle, to direct the load from the at least one valley of the first groove towards the closest at least one peak of the second groove.

**16**. A bottle comprising:

a neck defining a bottle opening;

a bell coupled to the neck;

a base;

a sidewall extending between the bell and the base;

a central axis extending from the neck to the base;

a first groove extending around an outer circumference of the sidewall, the first groove having a wave shape defined by alternating first peaks and first valleys; and

a second groove extending around an outer circumference of the sidewall, the second groove having a wave shape defined by alternating second peaks and second valleys, the second groove being circumferentially offset from the first groove such that the alternating second peaks and second valleys of the second groove are positioned out of vertical alignment with the alternating first peaks and first valleys of the first groove.

**17**. The bottle of claim **16**, wherein the first and second grooves are sinusoidal in shape.

**18**. The bottle of claim **16**, wherein one of the second peaks of the second groove is circumferentially offset from a closest first peak of the first groove by an angular distance of 5 degrees to 45 degrees.

**19**. The bottle of claim **16**, wherein one of the second valleys of the second groove is circumferentially offset from a closest first valley of the first groove by an angular distance of 5 degrees to 45 degrees.

**20**. The bottle of claim **16**, further comprising:

a third groove extending around an outer circumference of the sidewall, the third groove having a wave shape defined by alternating third peaks and third valleys, the third groove being circumferentially offset from the second groove such that the alternating third peaks and third valleys of the third groove are positioned out of vertical alignment with the alternating second peaks and second valleys of the second groove, wherein the first groove is positioned closer to the bell than the second groove, and the second groove is positioned closer to the bell than the third groove.

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