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(54) **SELF-STANDING CONTAINER**

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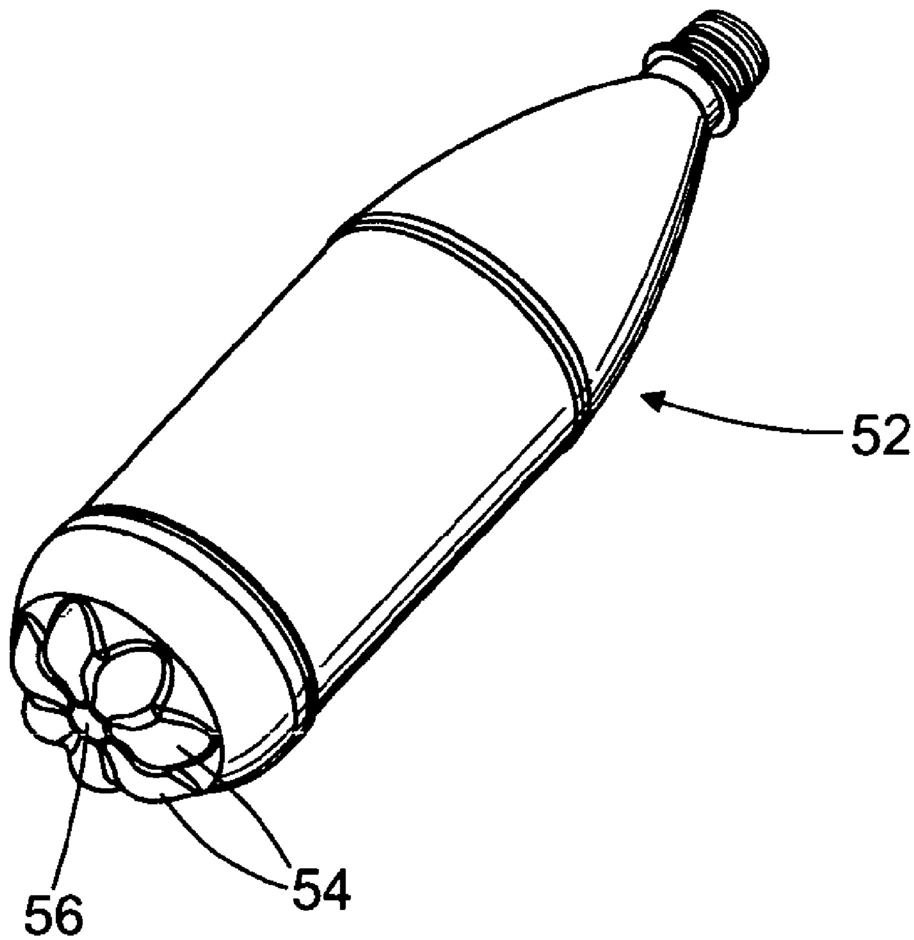
(57) **ABSTRACT**

A petaloid base for a self-standing container has an approximately hemispherical underlying base contour and a plurality of ovoid foot formations that interrupt and project from the underlying base contour to define a corresponding plurality of feet. Its shape resists stress cracking, maximises capacity relative to the height of the container and reduces the surface area of the base and hence material usage in comparison with equivalent known designs.



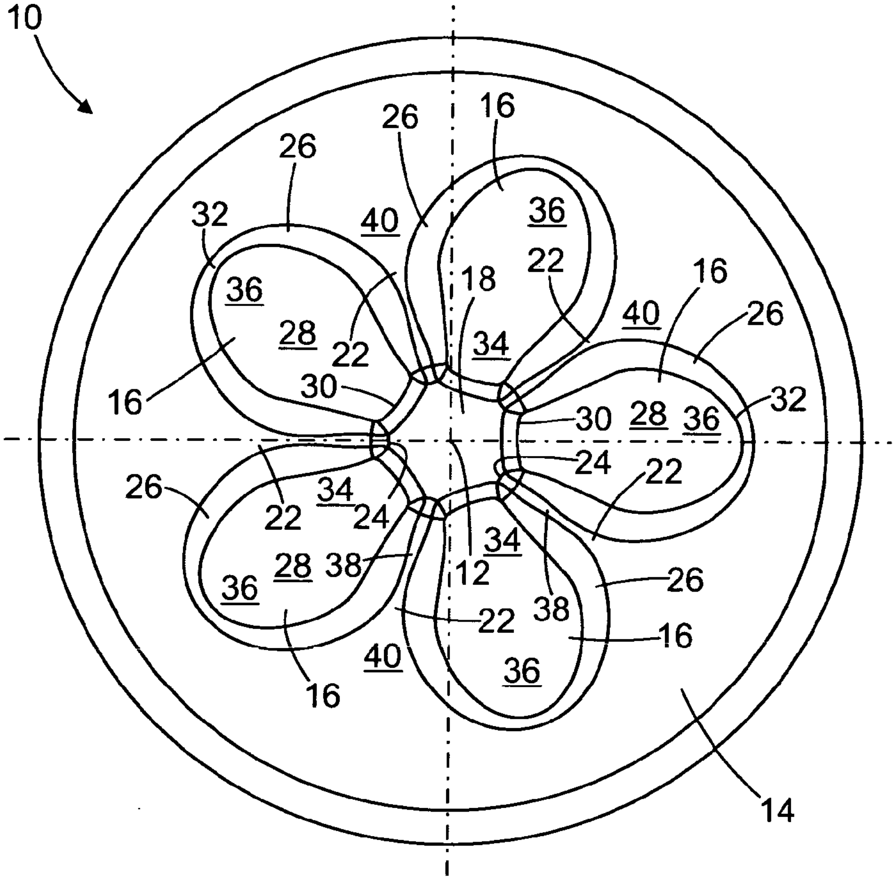

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Fig. 1

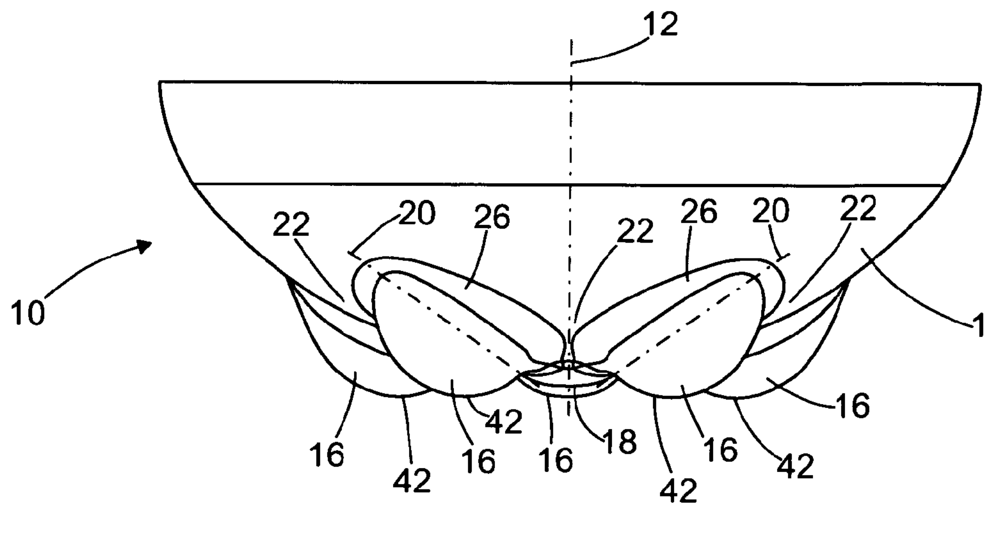
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Fig. 2

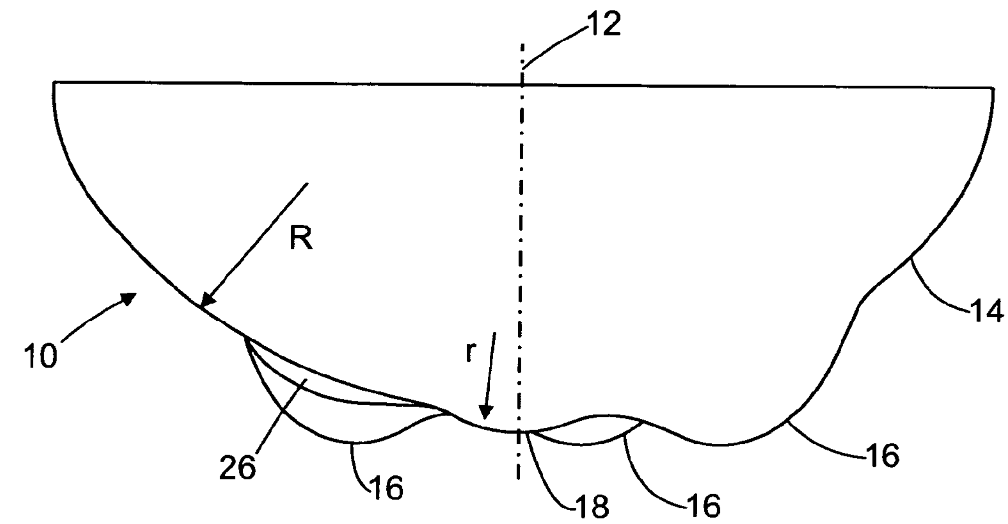


Fig. 3

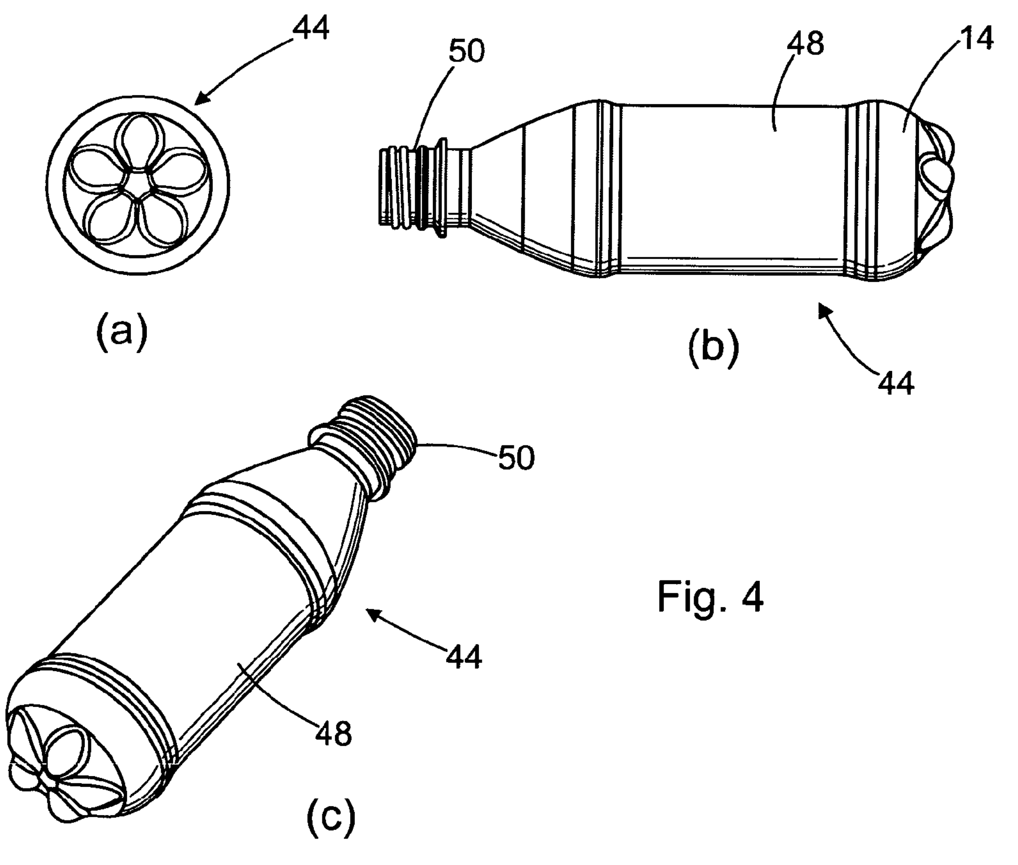


Fig. 4

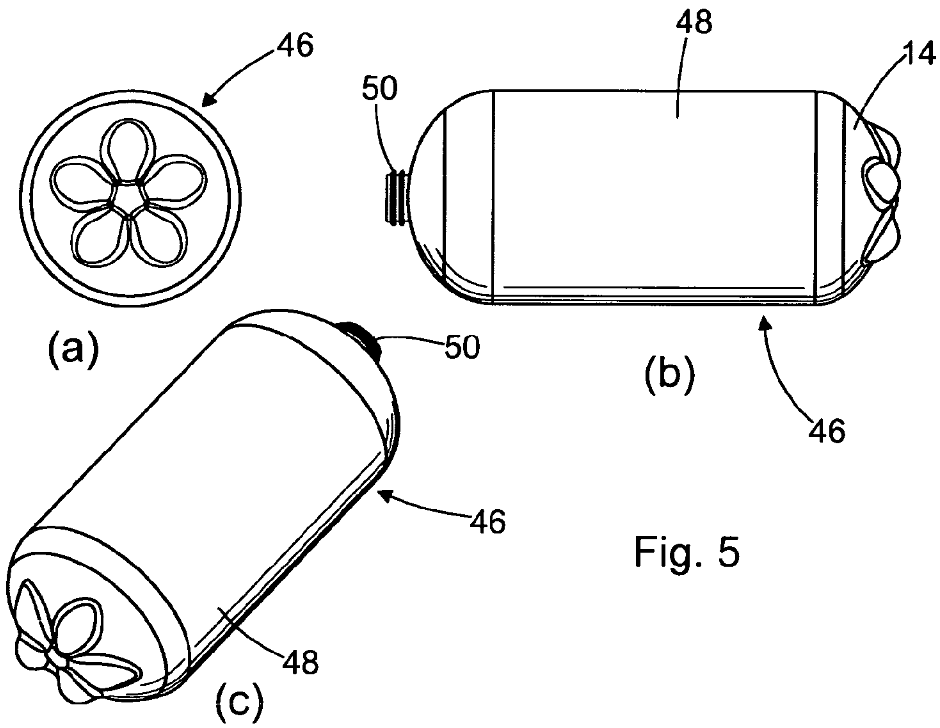


Fig. 5

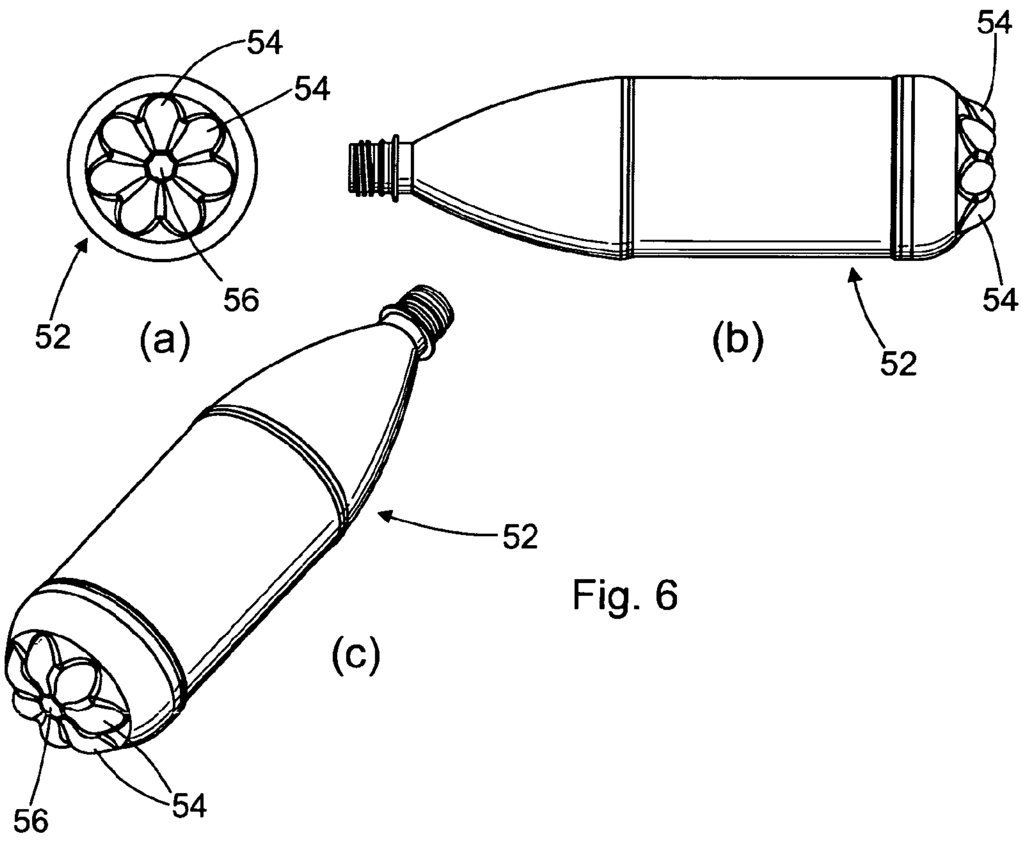


Fig. 6

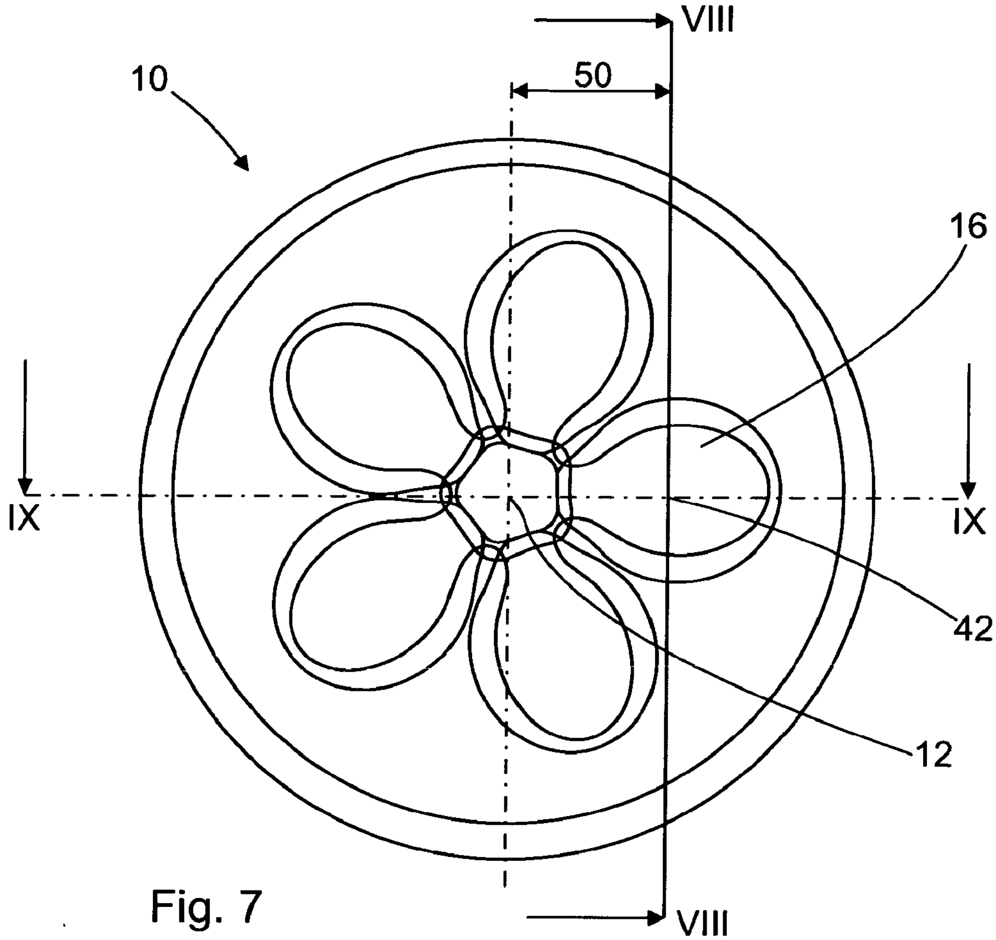


Fig. 7

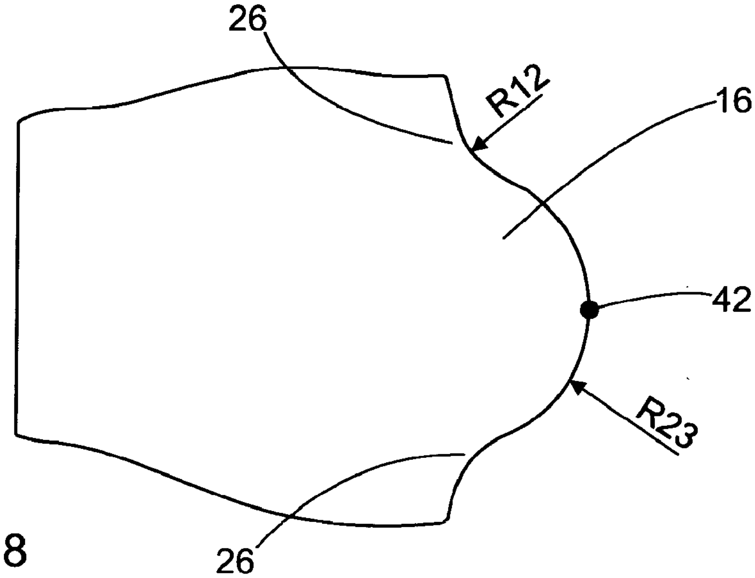
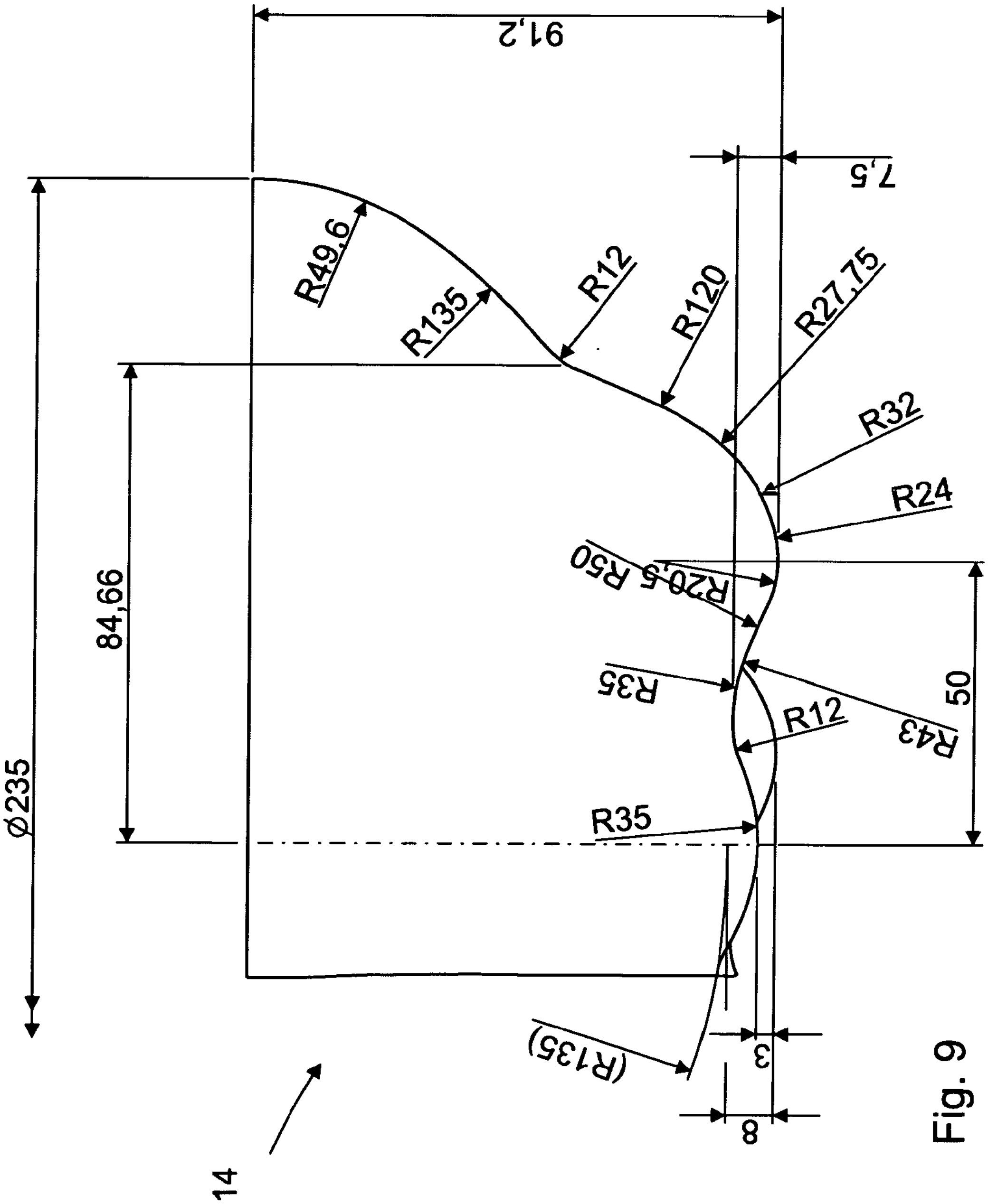


Fig. 8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R135
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Fig. 9

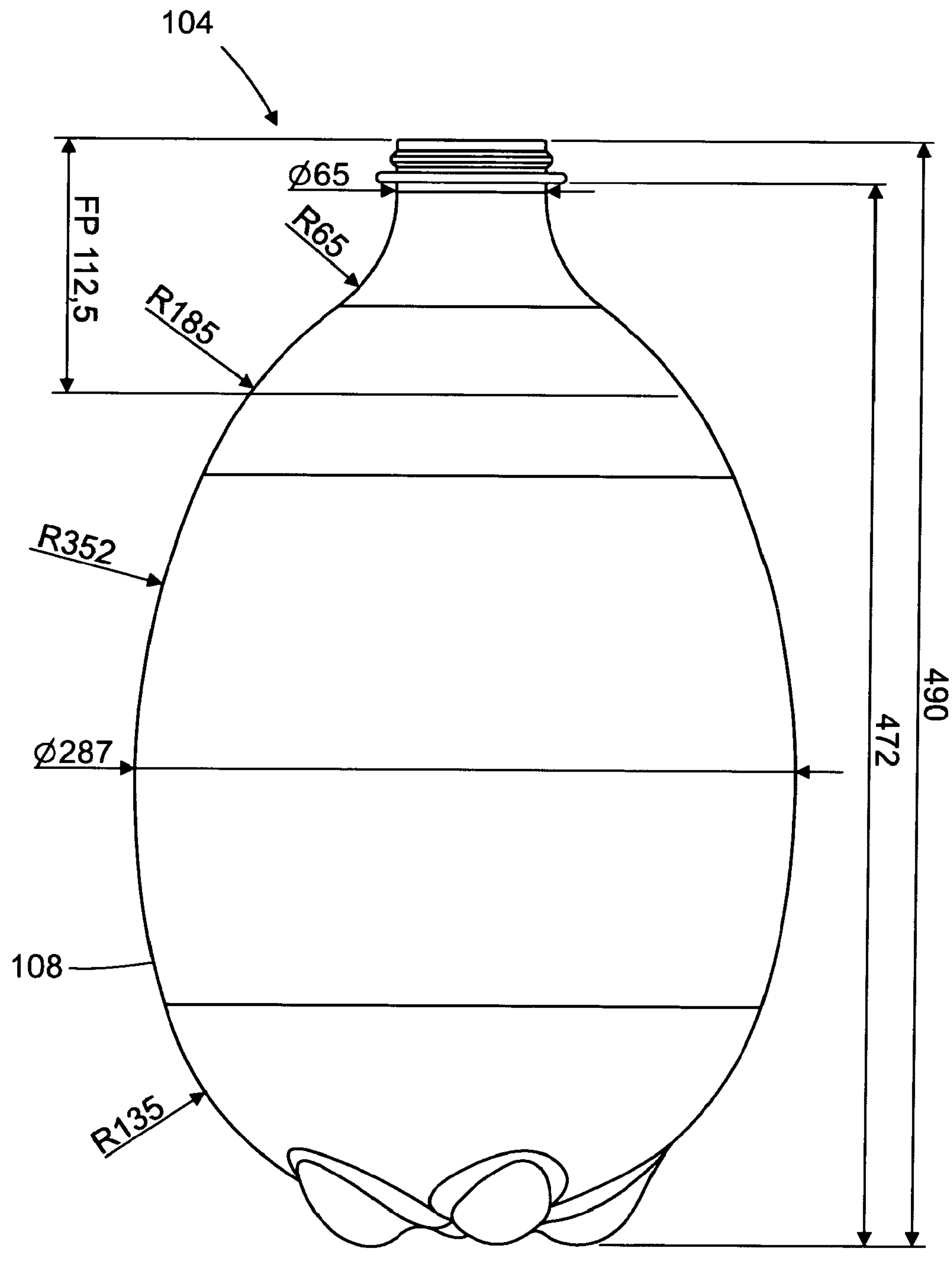

Fig. 10

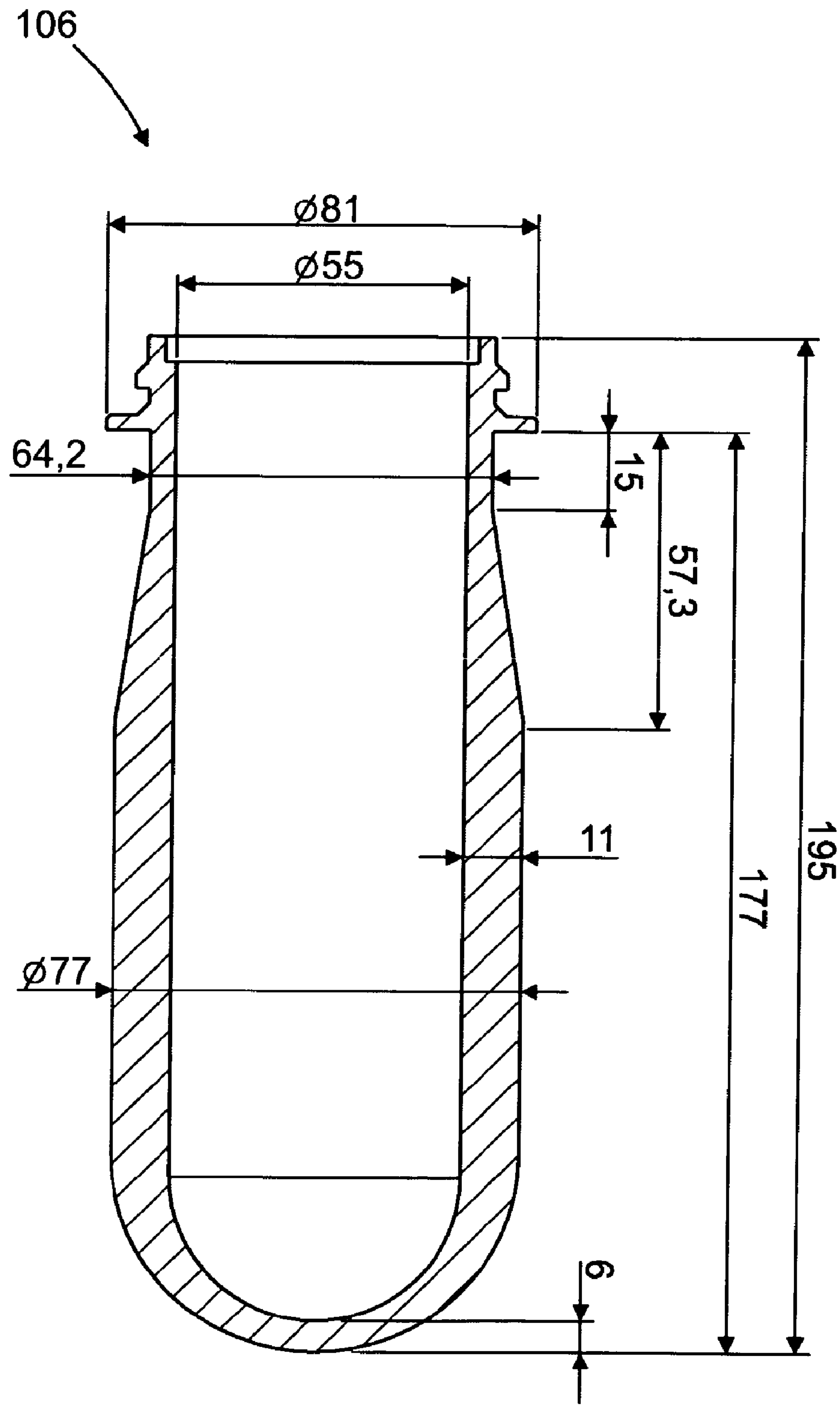

Fig. 11

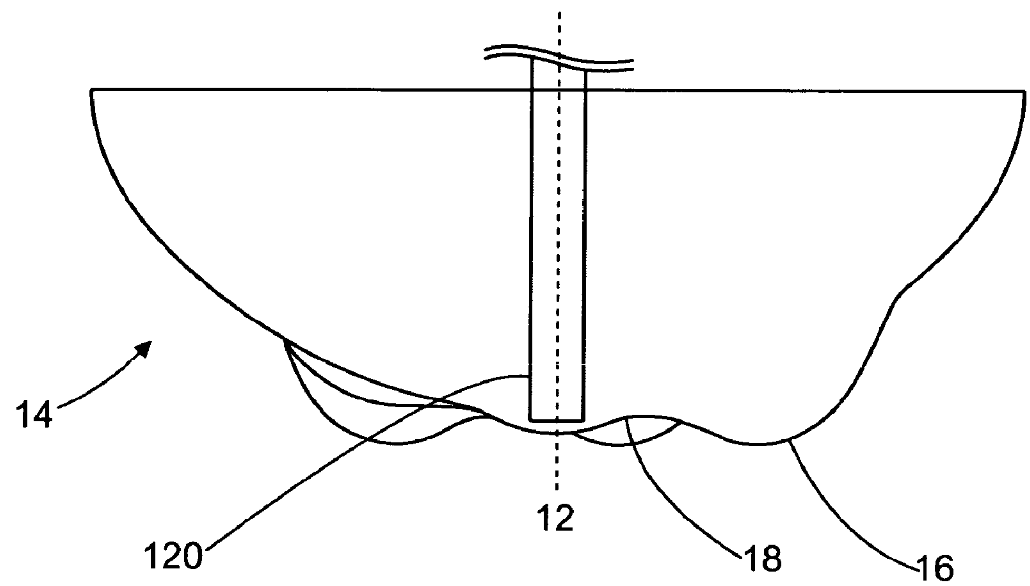

Fig. 12

SELF-STANDING CONTAINER

[0001] This invention relates to self-standing containers, more specifically to a petaloid base for such a container. Such containers may be blow-moulded of plastics material such as polyethylene terephthalate (PET).

[0002] As will be understood in the art, the generic term ‘PET’ includes compositions that predominantly contain polyethylene terephthalate—but may also including other materials. For example, a suitable composition may comprise approximately 95% polyethylene terephthalate and 5% nylon. As is known in the art, these materials may be mixed, or provided in different layers, for example via multilayer injection moulding and overmoulding.

[0003] Blow-moulded PET containers have long been used as bottles for beverages. More recently, they have been proposed for use as kegs for transporting, storing and dispensing beverages such as beer. An example of such a keg is disclosed in WO 2007/064277.

[0004] The example of WO 2007/064277 is given for background reference only: the broad concept of this invention is not limited to any particular use, material or method of manufacture of a container. However the invention has particular advantages in the context of thin-walled blow-moulded containers of the type apt to be manufactured from PET. It is in that context that the invention will be described in this specification.

[0005] Early PET containers had a plain hemispherical base and were rendered self-standing by the attachment of a separate base moulding to the base. Whilst a hemispherical base is simple, light and strong in isolation, the addition of a separate base moulding increases material and production costs and may hinder recycling.

[0006] To make a PET container self-standing without recourse to a separate base moulding, it is now well known to provide the container with an integrally-moulded petaloid base. The term ‘petaloid’ refers to a multi-footed base shape whose feet are disposed in an angularly-spaced arrangement around the base, the resulting shape resembling the petals of a flower when viewed from under the container in use. The container usually has a cylindrical side wall of circular horizontal cross-section, in which case the feet typically lie on a contact circle that is concentric with, and whose diameter is smaller than, the circular cross-section of the side wall. The feet act together to provide a stable multi-point support for the container.

[0007] There is continual pressure in the art of containers to reduce material and production costs and to ease recycling. Not only has this led to the adoption of one-piece containers with petaloid bases, but efforts continue to improve the petaloid base so that containers can be produced more economically while still performing reliably during storage, transportation and use. It is particularly desirable to reduce the amount of material necessary to give the container sufficient integrity and stability for commercial use. Even a small saving of material per container has a massive effect on the cost of production when reproduced across potentially tens to thousands of millions of containers per annum.

[0008] The correct trade off between the amount of material used and the integrity of the container is especially important when the container is to be used as a pressurised vessel. For example, the container may be used for storing, transporting and dispensing effervescent beverages such as beer. The beverage itself may be carbonated, or a propellant gas may be injected into the container at super-atmospheric pressure to force the beverage out of the container. Such a container needs to withstand these internal pressures under a range of environmental conditions. As well as withstanding internal pressures, the container needs to survive rough handling during transportation of the container.

[0009] It is against this background that the present invention has been devised. From one aspect, the invention resides in a petaloid base for a self-standing container, the base having a spheroidal underlying base contour and a plurality of spheroidal foot formations that interrupt and project from the underlying base contour to define a corresponding plurality of feet.

[0010] As the feet are spheroidal, it will be understood that their contact with a planar surface on which the base can rest is via a convex surface. Preferably therefore, contact between a given foot and that planar surface is via a point on the curved surface of that foot.

[0011] To maximise the capacity and strength of the container while minimising material usage, the underlying base contour is preferably substantially hemispherical. The contour may, for example, be that of an oblate spheroid whose polar axis coincides with a central axis of the base. For similar reasons, the foot formations are suitably elongate, such as partial ellipsoids or prolate spheroids. In preferred embodiments of the invention, the foot formations are ovoid (partially egg-shaped), in which case the contact points of the feet are most conveniently defined by the widest part of the cross-section of each foot formation being offset inwardly toward an inner end of the foot formation. In other words, the foot formations taper to a greater extent at their radially outer portions than their radially inner portions with respect to the central axis of the base.

[0012] Preferably, the base comprises formations, such as foot formations, whose shapes are substantially rotationally symmetrical about an axis. For example, shapes such as spheroids, ellipsoids and ovoids that define the foot formations are preferably substantially rotationally symmetrical about an axis. Advantageously, if these shapes that form the base are rotationally symmetrical, the material used to form these structures can be minimised. At the same time the internal capacity of the base, as well as its strength can be maximised.

[0013] To define feet with minimal usage of material, the elongate foot formations preferably have respective longitudinal axes, which axes lie in planes extending radially from a central axis of the base. Those axes of the foot formations suitably extend outwardly and upwardly in conical relation from the central axis of the base.

[0014] Each foot formation may have an elliptical, preferably ovate intersection with the underlying base contour. To reduce stress concentration, the intersection is preferably of concave cross section.

[0015] To strengthen the base, the foot formations preferably radiate from a central protrusion. That protrusion may be approximately polygonal, with a number of sides corresponding to the number of foot formations.

[0016] The foot formations are suitably separated by valleys, that may for example radiate from apices of the polygonal protrusion. To minimise material usage, the valleys preferably widen moving outwardly across the base. Each valley may, for example, have an inner and an outer section and the walls of the valley may diverge more sharply in the outer section than in the inner section. However, the walls of the valley may diverge in both the inner and the outer sections of the valley.

[0017] In plan view, each foot formation may have an enlarged central region from which the foot formation tapers inwardly across an inner portion to an inner end. In that case, the inner portions of the foot formations suitably lie in segmented relation around the base. To minimise material usage, it is preferred that in plan view, each foot formation tapers from the enlarged central region outwardly across an outer portion to an outer end of the foot formation.

[0018] The inventive concept extends to a container such as a keg or a bottle having the base of the invention. Preferably, the container is constructed by blow-moulding a preform, ideally made of PET.

[0019] Preferably, where the material used is PET, the container has an average pressure resistance to material usage ratio of greater than 3 MPa/kg. More preferably, the average pressure resistance to material usage ratio is greater than 3.75 MPa/kg. Also, preferably, the container has a capacity to material usage ratio of over 40 litres/kg. More preferably, the container has a capacity to material usage ratio of over 80 litres/kg.

[0020] In order that the invention may be more readily understood, reference will now be made, by way of example, to the accompanying drawings in which:

[0021] FIG. **1** is a plan view from underneath a container having a petaloid base in accordance with the invention;

[0022] FIG. **2** is a side view of the petaloid base of the container shown in FIG. **1**;

[0023] FIG. **3** is a sectional side view through the petaloid base of the container shown in FIG. **1**;

[0024] FIGS. **4**(*a*), **4**(*b*) and **4**(*c*) are, respectively, an underneath plan view, a side view and a perspective view of a container having a base as shown in FIGS. **1** to **3**, embodied in this example as a bottle of 0.33 litre capacity;

[0025] FIGS. **5**(*a*), **5**(*b*) and **5**(*c*) are, respectively, an underneath plan view, a side view and a perspective view of another container having a base as shown in FIGS. **1** to **3**, embodied in this example as a keg of 20 litres capacity;

[0026] FIGS. **6**(*a*), **6**(*b*) and **6**(*c*) are, respectively, an underneath plan view, a side view and a perspective view of another container having a base in accordance with the invention, embodied in this example as a bottle of 1.5 litres capacity, the base of this example being a variant having seven feet;

[0027] FIG. **7** is the underneath plan view of the container as shown in FIG. **1** marked in this instance with section lines referred to in FIGS. **8** and **9**;

[0028] FIG. **8** is an enlarged partial sectional side view through the petaloid base of the container of FIG. **7**, taken along section line VIII-VIII;

[0029] FIG. **9** is an enlarged partial sectional side view through the petaloid base of the container of FIG. **7**, taken along section line IX-IX;

[0030] FIG. **10** is a side view of a container having a five-footed petaloid base as shown in FIGS. **1** to **3**, embodied in this example as a keg having a non-cylindrical side wall, and of 18-litre capacity;

[0031] FIG. **11** is a side view of a plastics preform for blow moulding into the 18-litre capacity keg as shown in FIG. **10**; and

[0032] FIG. **12** is an enlarged sectional side view of the container base as shown in FIG. **3**, together with a beverage dispensing tube within the container.

[0033] Referring firstly to FIGS. **1** and **2** of the drawings, a container **10** in this example of the invention comprises a hollow body of blow-moulded PET. The body of the container **10** is of circular horizontal section, the radius of that circle extending orthogonally from a central longitudinal axis **12** that extends centrally through the closed base **14** of the container **10**. Above the base **14**, but not shown in FIGS. **1** and **2**, is a substantially cylindrical side wall surmounted by a neck portion. The side wall is integral with and terminates at its lower end in the base **14**; in turn, the side wall is integral with and terminates at its upper end in the neck portion at the top of the container **10**.

[0034] The fundamental or underlying shape of the base **14** is a slightly flattened hemisphere, that hemisphere being rotationally symmetrical about the central longitudinal axis **12** of the container **10**. More generally, the underlying shape of the base **14** is an oblate spheroid, being a rotationally symmetric ellipsoid having a diameter on its polar axis (coinciding with the central longitudinal axis **12**) that is shorter than the diameter of the equatorial circle whose plane bisects it. This approximately hemispherical shape maximises resistance to internal pressure, reduces stress concentrations to resist cracking, and also maximises internal volume while minimising material usage.

[0035] In accordance with the invention, the base **14** further includes integrally-moulded blister-like feet disposed in a petaloid arrangement around the base, the feet being defined in this example by five hollow ovoid foot formations **16** that radiate equiangularly from a relatively shallow generally pentagonal convex protrusion **18** on the central longitudinal axis **12**. More generally, the foot formations **16** are elongate ellipsoids in the form of prolate spheroids, a prolate spheroid being a spheroid whose diameter along its polar axis is greater than its equatorial diameter.

[0036] The polar axes **20** of the spheroidal foot formations **16** extend outwardly and upwardly in equi-angularly spaced radially-disposed planes from the central longitudinal axis **12** of the container **10**. Thus, the polar axes **20** of the foot formations **16** (see FIG. **2**) lie on a virtual frusto-conical surface surrounding the central longitudinal axis **12**.

[0037] Circumferentially adjacent pairs of foot formations **16** are separated by valleys **22** that radiate equi-angularly from the apices **24** of the pentagonal central protrusion **18**. The valley floors follow the spheroidal shape of the base **14** and open at their outer ends to an outer portion of the base **14** that lies radially outwardly beyond the foot formations **16**. Furthermore, each foot formation **16** and the central protrusion **18** are joined via a transition portion that curves smoothly without distinct transitions or discontinuities. Thus, as shown in FIG. **3**, a foot formation **16**, the smoothly curving transition portion and the central protrusion **18** together define a sinuous cross section.

[0038] Also as shown in FIG. **3**, the convex central protrusion **18** has a radius of curvature r that is smaller than the general radius of curvature R of the spheroidal base **14**: thus R>r. Moreover, the convex central protrusion **18** extends to a level beyond—and thus, in use, below—the lowermost apex of the underlying base contour. Also, the convex central protrusion **18** extends to a level within—and thus, in use, above—the extent of the foot formations **16**.

[0039] The foot formations **16** bulge outwardly from the underlying spheroidal contour of the base **14** by virtue of an ovoid convex wall. The convex wall of each foot formation **16** is surrounded by a concave transition zone **26** in the shape of an ovate ring. The transition zone **26** extends smoothly into the spheroidal wall of the base with a large radius of curvature to reduce stress concentration and hence to minimise stress cracking. The transition zones **26** of circumferentially adjacent foot formations **16** partially define the valley **22** between those foot formations **16**.

[0040] Each foot formation **16** is generally elliptical (in this example, ovate) in underneath plan view, reaching a maximum width in an enlarged central region **28** between its inner end **30** and its outer end **32**. Thus, each foot formation **16** tapers in opposite directions from the widest part of the central region **28**: along an inner portion **34** moving inwardly toward the central longitudinal axis **12** to the inner end **30**; and along an outer portion **36** moving outwardly away from the central longitudinal axis **12** to the outer end **32**.

[0041] In underneath plan view, the inwardly-tapering inner portions **34** of the foot formations **16** fit closely between their neighbours around the circular base **14** like segments of an orange. These inner portions **34** of the foot formations **16** alternate with, and are separated by, narrow inner sections **38** of the valleys **22**, which may be approximately parallel but, in this example, widen slightly as they extend outwardly from the pentagonal central protrusion **18**. However where they extend outwardly into their outer sections **40** beyond the widest part of the foot formations **16**, the valleys **22** widen near-exponentially between the tapering outer portions **36** of the foot formations **16** until they reach a maximum width between the outer ends **32** of adjacent foot formations **16**.

[0042] Thus, moving along the valleys **22** from the central longitudinal axis **12** toward the outer diameter of the base **14**, the gap between the foot formations **16** increases. In contrast, in a previously-known petaloid base such as that disclosed in EP 0671331, this gap decreases.

[0043] Viewed now from the side, the foot formations **16** extend to a level beyond—and thus, in use, below—the lowermost apex of the base **14** defined by the central pentagonal protrusion **18**. The foot formations **16** all extend to the same level. Thus, at that level, each foot formation **16** defines a contact point **42** that will lie stably upon a flat support surface (not shown) orthogonal to the central longitudinal axis **12** of the container **10**.

[0044] FIG. **3** shows that the foot formations are somewhat egg-shaped with the widest part of their cross-sections offset slightly inwardly and downwardly toward their inner ends **30**.

[0045] The contact points **42** of the foot formations **16** are equi-spaced on and around a contact circle centred on the central longitudinal axis **12** of the container **10**. The diameter (x) of the contact circle relates to the side wall diameter (Dy) of the container **10** in a ratio as follows:

$$\frac{Dy}{0.5x} = k$$

[0046] In accordance with the invention, k is preferably between 3.6 and 5.5, more preferably between 4.0 and 5.3, still more preferably between 4.2 and 5.0 and typically 4.7. This may be contrasted with typical PET bottles on the market whose corresponding ratio k is typically 2.5 to 3.5. The relatively large value for k in the invention stems from a relatively small value for x. This is advantageous because a small contact circle creates a small—and hence inherently stiff—diaphragm between the contact points **42**.

[0047] The result is a central area within the contact circle between the contact points **42** of the foot formations **16** that is quite rigid and hence resistant to movement during internal pressure, up to burst pressure. The rigidity of the area within the contact circle is enhanced by the undulating wall section defined by the inner portions **34** of the foot formations **16**, the valleys **22** between them, and the central protrusion **18**.

[0048] Stiffness within the contact circle is important not just for a high burst pressure but also for stability. This is because the lowest point on the central longitudinal axis (the lowermost apex of the base **14** defined by the central pentagonal protrusion **18**) will tend to be pushed down under internal pressure. If that lowest point moves so far as to contact a supporting surface in use, the container cannot rest stably on the contact points **42** of the foot formations **16**. The stiffness of the base shape of the invention means that compared to previously known designs, the distance from the central apex of the base to a supporting surface is relatively small, to the benefit of stability and capacity relative to the height of the container.

[0049] Viewing any one foot formation **16** end-on (i.e. from the side of the container **10** looking inwardly towards the central longitudinal axis **12**), the contour of that foot formation **16** describes a substantially constant convex radius between the concave radii of the transition zones **26** to each side. A conventional petaloid base typically has flatter surfaces defining a V-shaped valley between the feet, to the detriment of material usage and stress concentration. Stress concentrations create areas of a container that are particularly vulnerable to rupture under high internal pressure.

[0050] The arrangement of the base **14** of the present invention is particularly suited to containers for dispensing liquids under pressure. In particular, the increased value for k makes the base stiffer and hence better suited for retaining stability whilst the container is subject to high internal pressure. Furthermore, by increasing the value of k, it is possible to have the convex central protrusion **18** positioned axially lower than would otherwise be possible for a container that is subject to high internal pressure. This can maximise the quantity of beverage that can be practically dispensed from the container **10**. This advantage is discussed with reference to FIG. **12** in which is shown the same sectional side view of the container base **14** of FIG. **3**, together with a beverage dispensing tube **120**.

[0051] In this context, the container is used as a beer keg **10** that is provided with a closure assembly that is sealed on to the tubular neck of the keg **10** in a push-fit arrangement. The tube **120** is coupled to the closure assembly (not shown) and extends from it along the central longitudinal axis **12** into the base of the keg **10**. The axially lower end of the tube **120** extends into the central protrusion **18**. The end of the tube **120** sits within the central protrusion **18** and hangs just inside the apex of the central protrusion **18**, thereby providing an annular gap through which a beverage can pass from the keg **10** into the tube **120** or visa-versa. The shape of the central protrusion **18** also enables the axially lower end of the tube **120** to be correctly located and retained within the central protrusion during fitting and use.

[0052] In use, when dispensing a beverage, the keg **10** is maintained in an upright position. The closure assembly allows a pressurised gas to be introduced into the headspace of the keg **10** to force the beverage out through the tube **120**. As the axially lowermost end of the tube **120** is located within the central protrusion **18**, and the central protrusion **18** is disposed at a relatively low axial position within the keg **10**, this ensures that almost all of the beverage within the keg **10** can be extracted from it.

[0053] It may be possible to further increase the amount of beverage that can be practically extracted from the keg **10** by extending the tube **120** into one of the foot formations **16**. In such an arrangement, the tube **120** would need to bend away from the central longitudinal axis **12** at its lower end. Although this may marginally increase the amount of beverage that can be dispensed from the keg **10**, this can complicate process of fitting the closure assembly and tube **120** to the keg **10**. In particular, inserting a bent tube **120** into the keg **10** can require a complicated automated fitting process. Furthermore, the bending of the tube **120** away from the central longitudinal axis **12** can subject the closure assembly to which the tube **120** is attached at its axially upper end to uneven forces. This can reduce the reliability of the closure assembly, which is of particular concern when the keg **10** is subject to high internal pressure.

[0054] The petaloid base of the invention may be applied to a wide range of containers such as bottles and kegs. FIGS. **4**(*a*), **4**(*b*) and **4**(*c*) and FIGS. **5**(*a*), **5**(*b*) and **5**(*c*) show a five-footed base of the invention applied, respectively, to a bottle **44** of 0.33 litre capacity, which may typically be used for carbonated soft drinks, and a keg **46** of 20 litres capacity, which may typically be used for beer. These drawings show features omitted from FIGS. **1** and **2**, namely a substantially cylindrical side wall **48** surmounted by a neck portion **50**. The side wall **48** is integral with and terminates at its lower end in the base **14**; in turn, the side wall **48** is integral with and terminates at its upper end in the neck portion **50** at the top of the container.

[0055] FIG. **10** shows a further five-footed base of the invention applied to a keg **104** of 18-litre capacity with a non-cylindrical side wall **108**. In this example, the side wall **108** is convex, rotationally symmetrical about the central longitudinal axis of the keg **104** and so generally follows the shape of an ovoid. At its axially lower end portion, the side wall curves smoothly into the spheroidal underlying contour of the base of the present invention. At its axially upper end portion, which tapers to a greater extent than the axially lower end portion, the side wall curves smoothly into the concave neck of the keg **104**. The convex side wall **108** is shaped in this way to maximise internal pressure resistance, maximise the internal capacity of the keg **104** and minimise material usage. FIG. **11** is an enlarged side view of a plastics preform for blow moulding into the container as shown in FIG. **10**.

[0056] Other variations of the invention are possible without departing from the inventive concept. For example, a variant of the base of the invention shown in FIGS. **6**(*a*), **6**(*b*) and **6**(*c*) is applied to a bottle **52** of 1.5 litres capacity. This variant has seven foot formations **54** instead of five, with a generally heptagonal central protrusion **56** between them. Like the five-footed base variant, seven-footed base variants can be applied to any size of container, such as bottles of 0.33 litres, 0.5 litres, 1 litre, 1.5 litres or larger, and kegs of 20 litres or other capacities.

[0057] An odd number of feet is preferred for optimum stability, there being at least three feet (in which case the central protrusion is generally triangular) but preferably not more than seven feet; five or seven feet are considered optimal.

[0058] To put the invention into context but without limiting its broadest scope as defined in the claims, various dimensional characteristics will now be given by way of example.

[0059] Firstly, the table below sets out a volume comparison between a conventional base and a base in accordance with the invention, assuming in this instance that the base defines five feet. Volumes in the table are expressed in millilitres (ml). The volume refers to the internal volume of the base, defined as the portion of the container below the cylindrical side wall of the container. It will be noted that the base of the invention has a volume approximately five times greater than the volume of a conventional petaloid container base, to the benefit of compactness and material usage for a given container capacity.

Container with five feet	Conventional base	Base of the invention
20 litre keg, dia 235 mm	128 (20%)	634
0.33 litre bottle, dia 60 mm	2.7 (18%)	15
0.5 litre bottle, dia 65 mm	3.5 (18%)	19
1.0 litre bottle, dia 80 mm	6.5 (18%)	36
1.5 litre bottle, dia 95 mm	11 (20%)	55

[0060] Secondly, the following dimensions help to define the base shape for each of the above capacities of container:

Container with five feet	Radius of underlying base contour	Radius of transition from underlying base contour to side wall
20 litre keg, dia 235 mm	135.0 mm	49.6 mm
0.33 litre bottle, dia 60 mm	34.5 mm	19.1 mm
0.5 litre bottle, dia 65 mm	37.4 mm	20.7 mm
1.0 litre bottle, dia 80 mm	46.0 mm	25.4 mm
1.5 litre bottle, dia 95 mm	54.6 mm	30.2 mm

Container with five feet	Radial projection of foot formations beyond radius of underlying base contour	Diameter of contact circle
20 litre keg, dia 235 mm	18.1 mm	99.9 mm
0.33 litre bottle, dia 60 mm	5.3 mm	28.6 mm
0.5 litre bottle, dia 65 mm	5.5 mm	31.0 mm
1.0 litre bottle, dia 80 mm	7.1 mm	38.1 mm
1.5 litre bottle, dia 95 mm	8.4 mm	45.3 mm

Container with five feet	Length of foot formations along polar axis*	Width of foot formations across polar axis*
20 litre keg, dia 235 mm	80.2 mm	59.5 mm
0.33 litre bottle, dia 60 mm	22.9 mm	15.6 mm
0.5 litre bottle, dia 65 mm	24.8 mm	16.9 mm
1.0 litre bottle, dia 80 mm	30.6 mm	20.8 mm
1.5 litre bottle, dia 95 mm	36.3 mm	24.7 mm

*Including transition zone

Container with seven feet	Radius of underlying base contour	Radius of transition from underlying base contour to side wall
20 litre keg, dia 235 mm	135.0 mm	49.6 mm
0.33 litre bottle, dia 60 mm	34.2 mm	18.9 mm

-continued

Container with seven feet	Radius of underlying base contour	Radius of transition from underlying base contour to side wall
0.5 litre bottle, dia 65 mm	37.3 mm	20.7 mm
1.0 litre bottle, dia 80 mm	46.2 mm	25.6 mm
1.5 litre bottle, dia 95 mm	54.6 mm	30.2 mm

Container with seven feet	Radial projection of foot formations beyond radius of underlying base contour	Diameter of contact circle
20 litre keg, dia 235 mm	18.1 mm	99.9 mm
0.33 litre bottle, dia 60 mm	5.3 mm	28.5 mm
0.5 litre bottle, dia 65 mm	5.8 mm	31.0 mm
1.0 litre bottle, dia 80 mm	7.2 mm	38.5 mm
1.5 litre bottle, dia 95 mm	8.4 mm	45.4 mm

Container with seven feet	Length of foot formations along polar axis*	Width of foot formations across polar axis*
20 litre keg, dia 235 mm	78.9 mm	54.8 mm
0.33 litre bottle, dia 60 mm	22.4 mm	14.0 mm
0.5 litre bottle, dia 65 mm	24.4 mm	15.3 mm
1.0 litre bottle, dia 80 mm	30.3 mm	19.0 mm
1.5 litre bottle, dia 95 mm	35.7 mm	22.4 mm

*Including transition zone

	Radius of transition zone (five feet)	Radius of transition zone (seven feet)
20 litre keg, dia 235 mm	12.0 mm	8.0 mm
0.33 litre bottle, dia 60 mm	3.15 mm	1.88 mm
0.5 litre bottle, dia 65 mm	3.44 mm	2.05 mm
1.0 litre bottle, dia 80 mm	4.26 mm	2.54 mm
1.5 litre bottle, dia 95 mm	5.0 mm	3.0 mm

[0061] FIGS. **7** to **9** provide additional dimensional information relating to a 20-litre keg having a five-footed base **14**. FIGS. **10** and **11** respectively show dimensional information relating to an 18-litre keg **104** having a five-footed base and its preform **106**.

[0062] FIG. **8** shows a partial sectional side view through the petaloid base of the 20-litre keg of FIG. **7**, taken along section line VIII-VIII. The resulting section plane intersects a foot formation **16** at its contact point **42**, and is parallel to and is radially-spaced at a distance of 50 mm from the central longitudinal axis **12** of the keg **10**. At this section of the foot formation **16**, its contour is a substantially constant convex radius of 23.0 mm between the concave radii of 12.0 mm of the transition zones **26** to each side.

[0063] FIG. **9** is a partial sectional side view through the petaloid base of the 20-litre keg of FIG. **7**, taken along section line IX-IX. The resulting section plane is aligned with the central longitudinal axis **12** of the keg **10**, and intersects the same foot formation **16** as shown in FIG. **8** at its contact point **42**. The view shown in FIG. **9** corresponds to the view shown in FIG. **3**, but provides the following additional dimensional information relating to the 20-litre keg:

RADIUS DATA	
Radius of underlying base contour	135.0 mm
Radius of convex central protrusion	35.0 mm
Radius of concave transition zone between the convex central protrusion and the radially inner end of a foot formation	12.0 mm
Radius of a foot formation at a position on the inner portion adjacent the radially inner end	35.0 mm
Radius of a foot formation at a position on the inner portion between the radially inner end and the central region of the foot formation	43.0 mm
Radius of a foot formation at a position on the central region between the contact circle and the inner portion	50.0 mm
Radius of a foot formation at a position on the central region that is radially inner of and adjacent to the contact circle	20.5 mm
Radius of a foot formation at a position on the central region that is radially outer of and adjacent to the contact circle	24.0 mm
Radius of a foot formation at a position on the central region between the contact circle and the outer portion	32.0 mm
Radius of a foot formation at a position on the outer portion between the radially outer end and the central region of the foot formation	27.75 mm
Radius of a foot formation at a position on the outer portion adjacent the radially outer end of the foot formation	120.0 mm
Radius of concave transition zone between underlying base contour and radially outer end of a foot formation	12.0 mm
Radius of transition from underlying base contour to side wall	49.6 mm

[0064] These radius measurements are also applicable to points on other foot formations **16** of the container **10**. These points typically lie within any one of the planes aligned with both the central longitudinal axis **12** of the container and a polar axis of a given foot formation **16**.

DISTANCE DATA	
Distance along central longitudal axis between convex central protrusion and plane containing the contact circle	3.0 mm
Axial depth of convex central protrusion along central longitudinal axis	4.5 mm
Distance along central longitudinal axis from underlying base contour to plane containing the contact circle	8.0 mm
Distance along axis aligned with central longitudinal axis from transition zone (between central protrusion and a foot formation) to plane containing the contact circle	7.5 mm
Axial depth of the base portion (i.e. axial distance from plane containing the contact circle to axially lower end of cylindrical side wall)	91.2 mm
Radial length from central longitudinal axis to transition between base contour and foot formation	84.66 mm

[0065] In addition to dimensional data, the following data derives from pressure tests indicating the typical burst pressure of the 20-litre keg **10** having a five footed petaloid base **14** according to the present invention. By way of comparison, pressure tests were also carried out on a conventional petaloid base under similar conditions. The values represent the burst pressure in bar.

Test	Conventional Base burst pressure (bar)	Base of the invention burst pressure (bar)
1	9.29	9.55
2	7.68	9.04
3	9.09	8.59
4	8.92	9.57
5	8.8	9.29
6	5.99	7.78
7	5.96	8.69
8	6.25	8.08
9	9.14	9.31
10	8.82	8.33
AVG	7.99	8.82
MAX	9.29	9.57
MIN	5.96	7.78
DIFF	3.33	1.79

[0066] Thus, it can be seen that the average burst pressure of the 20-litre keg having a five-footed base is approximately 8.8 bar=880 kPa. Furthermore, the material usage of the litre keg corresponds to 0.234 kg of PET. Accordingly, ratios directed to the pressure resistance, capacity and material usage can be derived for this 20-litre keg:

[0067] Average pressure resistance to material usage ratio=3.76 MPa/kg

[0068] Capacity to material usage ratio=85 litres/kg

[0069] It will be understood that similar ratios can be extrapolated for containers of different shapes and sizes, but also incorporating the base **14** according to the present invention.

[0070] FIG. **10** provides additional dimensional data corresponding to the 18 litre keg **104**:

Convex radius of underlying base contour	135.0 mm
Diameter of body at widest point	287.0 mm
Convex radius of body contour	352.0 mm
Convex radius of contour between body and neck	185.0 mm
Concave radius of neck contour	65.0 mm
Diameter of neck	65.0 mm
Total axial length	490.0 mm
Axial length from base to neck collar	472.0 mm
Axial length from keg opening, to beverage fill point (FP) mark - denoting an 18 litre fill from a level base	112.5 mm

[0071] FIG. **11** provides additional dimension data corresponding to the preform **106** of the 18 litre keg **104** of FIG. **10**:

Total axial length	195.0 mm
Axial length from base to neck collar	177.0 mm
Axial thickness of base	6.0 mm
Thickness of each cylindrical side wall	11.0 mm
Axial length of cylindrical neck portion below neck collar	15.0 mm
Axial length of neck portion from below neck collar to cylindrical side wall (including cylindrical neck portion and frustoconical neck portion)	57.3 mm
Diameter of cylindrical neck portion	64.2 mm
Diameter of cylindrical side wall	77.0 mm
Internal bore diameter of the preform	55.0 mm
Diameter of the neck collar	81.0 mm

[0072] The approximate burst pressure of this 18-litre keg having a five-footed base is approximately 14 bar=1400 kPa. The material usage of the 18-litre keg corresponds to 0.468 kg of PET. Accordingly, ratios directed to the pressure resistance, capacity and material usage can be derived for this 18-litre keg:

[0073] Average pressure resistance to material usage ratio=~3 MPa/kg.

[0074] Capacity to material usage ratio=41 litres/kg.

[0075] For a base with five feet, the following ratios apply in these examples:

[0076] For 20-litre keg:

[0077] Length of foot formations along polar axis/width of foot formations across polar axis=1.35

[0078] Diameter of contact circle/width of foot formations across polar axis=1.68

[0079] Radius of underlying base contour/diameter of side wall=0.57

[0080] Radius of underlying base contour/radius of transition from underlying base contour to side wall=2.72

[0081] Radial projection of foot formations beyond radius of underlying base contour/radius of underlying base contour=1.13

[0082] For bottles of various capacities:

[0083] Length of foot formations along polar axis/width of foot formations across polar axis=1.47

[0084] Diameter of contact circle/width of foot formations across polar axis=1.83

[0085] Radius of underlying base contour/diameter of side wall=0.58

[0086] Radius of underlying base contour/radius of transition from underlying base contour to side wall=1.81

[0087] Radial projection of foot formations beyond radius of underlying base contour/radius of underlying base contour=1.15

[0088] Similarly, for a base with seven feet, the following ratios apply in these examples:

[0089] For 20-litre keg:

[0090] Length of foot formations along polar axis/width of foot formations across polar axis=1.44

[0091] Diameter of contact circle/width of foot formations across polar axis=1.82

[0092] Radius of underlying base contour/diameter of side wall=0.57

[0093] Radius of underlying base contour/radius of transition from underlying base contour to side wall=2.72

[0094] Radial projection of foot formations beyond radius of underlying base contour/radius of underlying base contour=1.13

[0095] For bottles of various capacities:

[0096] Length of foot formations along polar axis/width of foot formations across polar axis=1.59

[0097] Diameter of contact circle/width of foot formations across polar axis=2.03

[0098] Radius of underlying base contour/diameter of side wall=0.57

[0099] Radius of underlying base contour/radius of transition from underlying base contour to side wall=1.8

[0100] Radial projection of foot formations beyond radius of underlying base contour/radius of underlying base contour=1.15

[0101] It will be apparent from the foregoing description that the improved petaloid base shape of the invention has various additional advantages. Its softly-curving shape with an absence of sharp radii is beneficial to resist stress cracking. Also, importantly, its surface area is less than equivalent known designs. Thus, for a given amount of resin, the invention allows a thicker wall and hence a stronger base. Alternatively it is possible to reduce weight and material usage while maintaining the strength of the base. A strong base is particularly important in applications where the containers are subjected to elevated internal pressure and/or elevated temperature, such as carbonated soft drinks, beer and hot-fill or pasteurised liquids.

1. A petaloid base for a self-standing container, the base having a spheroidal underlying base contour and a plurality of spheroidal foot formations that interrupt and project from the underlying base contour to define a corresponding plurality of feet.

2. The base of claim **1**, wherein the underlying base contour is an oblate spheroid whose polar axis coincides with a central axis of the base.

3. The base of claim **1**, wherein the underlying base contour is substantially hemispherical.

4. The base of claim **1**, wherein the foot formations are elongate ellipsoids.

5. The base of claim **4**, wherein the foot formations are prolate spheroids.

6. The base of claim **4**, wherein the foot formations are ovoid, and wherein the widest part of the cross-section of each foot formation is offset inwardly toward an inner end of the foot formation.

7. (canceled)

8. The base of claim **4**, wherein the foot formations have respective longitudinal axes, which axes lie in planes extending radially from a central axis of the base.

9. The base of claim **8**, wherein the axes of the foot formations extend outwardly in conical relation from the central axis of the base.

10. The base of claim **9**, wherein the axes of the foot formations extend outwardly and upwardly from the central axis of the base, and wherein the axes of the foot formations meet at the central axis of the base at a position axially below the base.

11. (canceled)

12. The base of claim **1**, wherein each foot formation has an elliptical intersection with the underlying base contour, the intersection is ovate and of concave cross section.

13-14. (canceled)

15. The base of claim **1**, wherein the foot formations radiate from a central protrusion.

16. The base of claim **15**, wherein the central protrusion has a radius of curvature that is smaller than the radius of curvature of the underlying base curve, and wherein the central protrusion extends to a level beyond the lowermost apex of the underlying base contour.

17. (canceled)

18. The base of claim **15**, wherein a foot formation and the central protrusion are joined via a smoothly curving transition portion,

wherein the foot formation, the smoothly curving transition portion and the central protrusion together define a sinuous cross section, and wherein the transition portion defines a curve whose curvature is converse to the curvature of at least one of the foot formations and central protrusion.

19-20. (canceled)

21. The base of claim **15**, wherein the central protrusion is substantially convex with respect to the exterior of the container.

22. The base of claim **15**, wherein the central protrusion defines a recess with respect to the interior of the container, the recess being arranged to locate and retain a free end of a fluid delivery tube within the container.

23. The base of claim **15**, wherein the central protrusion is generally polygonal, with a number of sides corresponding to the number of foot formations,

wherein the foot formations are separated by valleys, and the valleys radiate from apices of the polygonal protrusion.

24. The base of claim **1**.

25. The base of claim **15**.

26. The base of claim **1**, wherein the foot formations are separated by valleys, the valleys widen moving outwardly across the base, each valley has an inner and an outer section and the walls of the valley diverge more sharply in the outer section than in the inner section, and the walls of the valley diverge in both the inner and the outer sections of the valley.

27-28. (canceled)

29. The base of claim **1**, wherein in plan view, each foot formation has an enlarged central region that tapers inwardly across an inner portion to an inner end of the foot formation, the inner portions of the foot formations lie in segmented relation around the base, and each foot formation tapers from the enlarged central region outwardly across an outer portion to an outer end of the foot formation.

30-31. (canceled)

32. A self-standing container having a base as defined in claim **1**.

33. The container of claim **32**, wherein the foot formations of the base define respective contact points that together are spaced around a contact circle whose diameter (x) relates to a side wall diameter (Dy) of the container as:

$$\frac{Dy}{0.5x} = k$$

where k is between 3.6 and 5.5.

34. The container of claim **33**, wherein k is between 4.0 and 5.3.

35. The container of claim **34**, wherein k is between 4.2 and 5.0.

36. The container of claim **32**, having an average burst pressure resistance to material usage ratio of greater than 3 MPa/kg.

37. The container of claim **32**, having a capacity to material usage ratio of greater than 40 litres/kg.

38. The container of claim **32**, comprising a fluid delivery tube aligned with a central longitudinal axis of the container, the tube extending between the base of the container and an opening of the container.

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