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(54) IMPROVEMENTS IN CONTAINERS AND MOULDS FOR FORMING THEM

(71) We, THE CONTINENTAL GROUP, INC. formerly known as Continental Can Company, Inc., a Corporation organized and existing under the laws of the State of New York, United States of America, of 633 Third Avenue, New York 17, New York, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to containers, and in particular to plastics bottles of the kind suitable for containing effervescent or carbonated beverages, and to improved moulds for forming the containers.

The bottling of carbonated beverages in plastics bottles presents a number of problems many of which arise in connection with the base of bottom structure of the bottle. Mere duplication in plastics of traditional glass bottom configurations is unsatisfactory because of the tendency of plastics to creep or become distorted under pressure, especially in the presence of the elevated temperatures which may be encountered during shipment and storage. Such distortion may alter the shape and dimensions of traditional bottom configurations to the extent that the level of liquid within the bottle falls below the fill line, thereby threatening customer acceptance or satisfaction, and the bottle may become a so-called rocker; that is, it may become unstable on a horizontal surface, with the probability of similar adverse reaction on the part of the customer.

On the other hand, it is frequently desirable that the inner and outer shapes and dimensions of plastics bottles approximate those of glass bottles of the same capacity so that they may be handled by existing equipment and, in certain instances, assist customer identification of the particular product they contain. In any event, they should be aesthetically attractive.

A plastics bottle, when filled with a carbon-

ated beverage and capped, must be able to withstand the impact of falling from at least a moderate height onto a hard surface, and the precipitous rise in internal pressure which accompanies the impact. While this requirement also affects selection of materials and bottle-forming techniques, it is an extremely important consideration in the contemplation of bottom design.

Finally, the optimum bottom structure is one which not only meets the foregoing criteria but which may be readily formed with an economy of material, without unduly expensive or elaborate equipment, and without intricate or additional manufacturing steps.

British Patent Specification No. 1,406,958 discloses a container in which the outer surface of the bottom structure comprises, briefly, a central concave dome portion, a convex annular rim portion circumscribing the dome portion and merging therewith and with an adjacent cylindrical portion of the side wall of the container, and a radial array of convex foot portions extending axially outwardly of the rim portion. Each of the foot portions merges at its radially inner end with the dome portion, at its radially outer end with the side wall, and at its lateral margins with the rim portion to form a shallow rib portion between adjacent foot portions.

Noting that plastics are weakest in tension, such a construction exposes the dome portion to compressive stresses only, and among other advantages, arrests the tensile and flexural stresses at the base of the dome portion while permitting an economy of material in forming the bottom structure.

In Specification No. 1,406,958, the dome portion is shown to be a segment of a sphere (the sphere being commonly recognized as the optimum pressure-bearing surface), whereby the radial profile of the outer surface of the dome portion comprises a concave arc having its center of curvature on the central axis of the bottle. The radial profile of the outer surface of each foot portion comprises a single convex outer arc tangential to the

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(10) inner arc of the dome portion and to the cylindrical side wall portion. The axially outermost point of the latter arc comprises a support point for the bottle when it is at rest on a horizontal surface in an upright position. As is readily apparent, in order effectively to distribute and dissipate the forces arising from internal pressures and/or impact with a hard surface, curved surfaces are used virtually throughout the bottom structure, and to avoid undue stress concentrations adjacent surface portions are smoothly merged or blended with each other.

It has been found that the stresses arising in such a bottom structure may be reduced by increasing the radius of curvature of the arc of the foot portion. However, as this radius is increased, the support point is moved and the bottle therefore tends to become inwardly toward the central axis of the bottle, less and less stable when supported on a horizontal surface. Upright stability is especially critical in the case of certain types of bottle conveying equipment presently in use.

If, on the other hand, the radius of the arc of the foot portion is made smaller to enhance stability, and the radius of the arc of the dome portion thereby increased, the material of the dome portion must be made thicker to avoid snap buckling; that is, the sudden eversion of the dome portion under pressure. A further problem arises in that the radially outer end of the foot portion becomes an increasingly sharp corner as the radius of the outer arc decreases in length. In blow-moulding it becomes more and more difficult to fill the corresponding corner of the mould. Still further, capacity is reduced and more material is required, or still more material must be used to achieve similar capacity.

According to one aspect of the invention there is provided a container having a side wall and a bottom structure closing the container at an end portion of the side wall, the outer surface of the bottom structure comprising a central concave dome portion, a convex annular rim portion circumscribing the dome portion and merging therewith and with the side wall end portion, and a plurality of radially oriented foot portions extending axially outwardly of the rim portion, each foot portion having lateral margins merging with the rim portion to form a rib portion between each pair of adjacent foot portions, the radial problem of each foot portion comprising a curve tangent to the radial profile of the dome portion and to the profile of the side wall end portion, wherein the foot portion curve comprises a plurality of tangential arcs arranged in series, adjacent arcs in the series of arcs having separate centers of curvature.

Such a construction permits wide latitude in designing the bottom structure to meet the sometimes conflicting requirements discussed

hereinabove while taking advantage of the beneficial properties inherent in the basic dome-and-foot configuration.

The invention also contemplates a matrix or mould for forming the container.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a side elevational view of a container comprising a bottle constructed generally in accordance with the invention;

Figure 2 is a bottom plan view, to an enlarged scale, of the bottle of Figure 1;

Figure 3, is a fragmentary sectional view, to an enlarged scale, of the bottle of Figure 1 taken along the line 3—3 thereof;

Figure 4 is a fragmentary sectional view, to an enlarged scale, of the bottle of Figure 1 taken along the line 4—4 of Figure 2;

Figure 5 is a fragmentary, longitudinal sectional view of a mould constructed generally in accordance with the invention and suitable for use in forming the bottle of Figure 1;

Figure 6 is a diagrammatic representation of two radial profiles, one superimposed on the other, of one embodiment of a bottle bottom structure constructed in accordance with the invention; and

Figure 7 is a diagrammatic illustration similar to Figure 6 but representing another embodiment of a bottle bottom structure constructed in accordance with the invention.

Referring to Figures 1 to 4, a container in the form of a bottle 10 is constructed generally in accordance with the invention and is preferably formed of a thermoplastics material having gas barrier properties to a degree such that the bottle will be suitable for containing an effervescent or carbonated beverage at least throughout expected shelf time; that is to say, the period from bottling to consumption. A number of materials of this kind have been developed; among them, for example, are those identified by the trademarks "Cycpac 910", produced by Borg-Warner Corporation, and "Barex 210", produced by Vistron Corporation. The bottle is blow-moulded from an extruded or injection-moulded preform or parison and has preferably been so worked that the material is biaxially oriented.

The bottle 10 is provided with an upper neck portion 12 having any desired neck finish, such as the threaded finish shown. A side wall 14 of any suitable form extends from the neck portion to a bottom structure, indicated generally at 16, which closes the lower end of the side wall. An end portion 14a of the side wall adjacent to the bottom structure is preferably formed with a cylindrical outer surface, although other forms, generally symmetrical about the longitudinal axis of the bottle, may be substituted.

The outer surface 18 of the bottom structure 16 includes a central concave dome portion 20 of substantially spherical form; that

is, it conforms generally to a segment of a sphere. A convex annular rim portion 22 of surface 18 circumscribes the dome portion, merging at its radially inner margin with the dome portion and at its radially outer margin with side wall portion 14a.

A plurality of radially arrayed and oriented convex foot portions 24 extend axially outwardly of rim portion 22, as best viewed in Figure 3, the radial profile of each foot portion comprising a curve tangent to the radial profile of the dome portion and to the profile of the side wall portion, this curve comprising a plurality of tangential arcs arranged in series, adjacent arcs in the series of arcs having separate centres of curvature. While ten such foot portions are shown (Figure 2), the number may be as low as three (the minimum number which will provide stable support on a planar surface), and the maximum number is limited only by the overall dimensions and wall thickness of the bottom structure, the preferred range being from six to twelve, inclusive.

Each foot portion 24 has a relatively narrow radially inner end 26 merging with the dome portion 20 and a relatively wide radially outer end 28 merging with the side wall portion 14a. Each foot portion also has a pair of lateral margins 30, 32 diverging radially outwardly and merging with the rim portion 22 to define an arched groove 33 (Figure 1) between each pair of adjacent foot portions and to form a shallow reinforcing or stiffening rib portion 34 therebetween. The rib portion at its radially inner end merges with the dome portion 20 and at its radially outer end with the side wall portion 14a.

An axially outermost point 36 (Figures 3 and 4) of each foot portion 24 lies in a plane common to the outermost points of the other foot portions, the plane being normal to the longitudinal axis of bottle 10, whereby the bottle may be supported at points 36 on a horizontal surface in an upright position.

The inner surface 38 of the bottom structure 16 may take any suitable form and may be selected to provide variations in the thickness of the material forming the bottom structure; for example, in the manner disclosed and for the purposes explained in British Patent Specification No. 1,406,958.

Turning now to Figure 5, there is shown a portion of a matrix in the form of a mould 40 constructed in accordance with the invention and suitable for use in blow-moulding the bottle of Figures 1 to 4.

The body 42 of the mould may be made up of two or more separable elements and may take any one of a number of known forms adapted to facilitate the forming process and assist ready removal or ejection of the moulded bottle. Mould inserts may be provided in known manner to achieve special

or unusual side wall configurations and various neck finishes.

An interior surface of mould body 40 defines a female mould cavity 44 and is, obviously, complementary to the outer surface of the bottle to be moulded. The mould cavity 44 is bounded in part by a side wall 46 of the interior surface and by a bottom surface portion 48 contiguous with the side wall at an adjacent end portion 46a thereof.

The bottom surface portion 48 includes a central convex dome portion 50 of substantially spherical form, and a concave annular rim portion 52 merging with the dome portion and with side wall portion 46a.

A plurality of concavities 54, corresponding to the foot portions 24 of bottle 10, extend axially outwardly of rim portion 52 in a radial array. As do foot portions 24 as viewed in Figure 2, each concavity 54 has a relatively narrow radially inner end 56 merging with dome portion 50, a relatively wide radially outer end 58 merging with side wall portion 46a, and a pair of lateral margins 60, 62 diverging radially outwardly and merging with the rim portion 52 to form a rib portion 64 between each pair of concavities 54. Each rib portion so formed merges at its radially inner end with the dome portion 50, and at its radially outer end with the side wall portion 46a.

The axially outermost points 66 of the concavities 54 lie in a common plane normal to the longitudinal axis of the mould cavity 44.

The use of female moulds in the blow-moulding of containers is well known. Briefly, a preform or parison at an appropriate temperature is received or enclosed in the mould cavity and is expanded until its outer surface engages and conforms to the interior surface of the mould. Expansion is effected by creating an imbalance in the respective pressures acting on the inner and outer surfaces of the parison, as by introducing a gas under pressure to the interior of the parison or by drawing a vacuum about its exterior.

The bottom surface portion 48 of the mould may be defined in part by an end surface of a reciprocally movable piston or stem (not shown) which is actuated to enter the mould cavity when the parison is received or enclosed therein, the end surface of the piston engaging the nearest surface of the parison before and/or during expansion. An example of such an arrangement is disclosed in U.S. Patent No. 3,412,186, issued November 19, 1968 to T. Piotrowski. While the piston end surface may, if desired, be machined to conform to the configuration of mould dome portion 50, of which it forms a central element when the piston is fully withdrawn from the mould cavity, its use may result in small and centrally located deviations from the design configuration of the bottle dome portion 20. Such deviations have negligible effect on the

properties of the bottle and are well within the purview of the invention.

For any given bottle material and forming process, determination of a particular bottom configuration in accordance with the invention will be guided by desiderata affecting upright stability, impact strength, resistance to internal pressure, capacity, internal and external dimensions, aesthetic quality, economy of material, and adaptability to the forming process. Various considerations touching upon these characteristics are discussed hereinabove. Figures 6 and 7, together with the ensuing description, illustrate the flexibility which the invention affords the designer in deriving a satisfactory structure from the parameters selected.

It will be readily apparent that the profiles represented in Figures 6 and 7, while described with reference to the outer surface of the bottom structure of a bottle, are applicable to the interior bottom surface portion of the corresponding mould as well. However, the terms "convex" and "concave" will, of course, be reversed in the case of the mould.

Figure 6 represents a specific embodiment of the invention in the form of two radial profiles of the outer surface of the bottom structure taken at separate angular locations. Also shown is a portion of the profile 14b of the outer surface of the adjacent side wall end portion.

More particularly, a second profile ACDE extends radially from the longitudinal axis 10a of the bottle through the axially outermost point D of one of the foot portions to the side wall profile 14b, and is superimposed on a first profile ABF of one of the rib portions, the latter profile also extending radially from the axis to the side wall profile. An interrupted line 10b represents the plane which contains the axially outermost points of the foot portions and therefore intersects axis 10a at right angles therewith.

The central dome portion of the outer surface is spherical, and has radial profiles AB and AC (taken at separate angular locations corresponding to the angular positions of the radial profiles of the rib and foot portions respectively). The radial profiles AB and AC are first and second concave arcs which meet the longitudinal axis 10a at right angles at point A. The central dome portion has its center of curvature G located on the longitudinal axis. When profile ACDE is superimposed on profile ABF as in Figure 6, point B is located on second arc AC whereby the first arc AB is merely a segment of arc AC.

It is to be noted that the term "arc" is used throughout this specification in its special sense as meaning a continuous portion of a circle; this is, a curved line having a constant radius of curvature. The word "curve", on the other hand, is used as a generic term, and a curve may therefore consist of a single arc

or a plurality of arcs arranged in a continuous tangential series and having radii of curvature of various lengths.

The radial profile of the foot portion comprises a second curve CDE tangent to arc AC at point C and to side wall profile 14b at point E. Curve CDE, in turn, is formed by a pair of convex arcs CD and DE tangent to each other at point D and having centers of curvature H and I, respectively.

The radial profile of the rib portion comprises a first curve BF tangent to arc AB at point B and to side wall profile 14b at point F. Curve BF is shown as a single convex arc having a center of curvature J, but may be formed of a plurality of arcs.

Side wall profile 14b is shown as a straight vertical line, indicating that the side wall end portion is cylindrical in this instance.

In arriving at the particular bottom configuration represented in Figure 6, upright stability was first considered. As is obvious, the greater the distance between axis 10a and point D, the greater will be the stability of the container when supported on a horizontal surface. When this distance has been selected, the length of radius R_2 of arc DE is established as the distance between point D and the side wall profile 14b when the latter is extended to the plane 10b, and point I may be fixed in accordance with elementary and self-evident geometric methods. Similar methods will be equally self-evident in the placement of other points and in the construction of the various arcs represented in Figures 6 and 7.

It should be pointed out that while radius R_2 may be quite small in accordance with the invention, if it is made too small, impact resistance in the vicinity of arc DE may be reduced to an unacceptable level.

As has been pointed out in British Patent Specification No. 1,406,958, if the radial profile of the foot portion consists of a single arc, and the radius of the single arc is reduced to enhance stability, the material of the dome portion must be made thicker to preclude eversion under pressure, it becomes difficult to fill the corresponding sharp corner of the mould, capacity is reduced, and a greater amount of material is required. These disadvantages are eliminated in the construction of Figure 6, in spite of the reduced length of radius R_2 , by including arc CD as a second arc in the profile of the foot portion and by fixing the length of its radius R_1 at a value substantially greater than that of radius R_2 . Thus, the two arcs CD and DE respectively provide the advantages of a large radius and a small radius, a condition patently impossible to achieve if the foot portion profile consists of a single arc.

The length of radius R_1 is selected to establish the depth of the rib portion; that is, the average distance between arc BF and

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curve CDE, at a value which will provide a substantial stiffening effect. Also, as the length of radius R_2 is increased, the distance CE is increased, whereby the stiffening effect of the rib portion is applied over a greater area.

The length of radius R_2 is selected to some extent on the value selected for the maximum height H_0 of the dome portion above the plane 10b. As height H_0 decreases, the possibility of eversion is increased; as height H_0 increases, capacity decreases and more material is called for.

When height H_0 and radius R_1 have been determined, the length of radius R_1 of arc AC (and thus of its segment AB) and the location of its center of curvature G are established. Center of curvature H of arc CD is located on a line 10c which is parallel with axis 10a and which also includes point I. With this construction arcs CD and DE are tangent at the axially outermost point D of the foot portion, whereby to effect an economy of material for a given capacity without reduction of impact strength at the outermost point of the foot portion, this frequently being the point of impact.

The location of point F, the point of tangency of arc BF with side wall profile 14b, is based on two considerations: as it is placed higher on the side wall, aesthetic quality is lessened and capacity is reduced; as it is placed lower, the depth of the rib portion is reduced and its stiffening effect is diminished. When the location of point F has been selected, the length of radius R_1 of arc BF and the location of its center of curvature J are established.

It is to be noted that in the construction of Figure 6, the point of tangency C of arc AC with arc CD lies at a greater distance from the axis 10a than the point of tangency B of arc AB with arc BF. This results in a relatively great effective length of the stiffening rib portion.

In Figure 7, which represents an alternative embodiment of the invention, the reference characters 10a, 10b, 10c and H_0 identify elements and quantities similar to those identified by the same reference characters in Figure 6.

Referring to Figure 7, a second profile ABCDE of the outer surface of the bottom structure extends radially from the axis 10a through the axially outermost point D of one of the foot portions to the side wall profile 14b, and is superimposed on a similarly drawn first profile AFG through one of the rib portions. The central dome portion of the outer surface is spherical, as in the embodiment of Figure 6, and has radial profiles AF and AB (taken at separate angular locations corresponding to the angular positions of the radial profiles of the rib and foot portions respectively). The radial profiles AF and AB are

first and second concave arcs which have a common centre of curvature H on the axis 10a. When profile ABCDE is superimposed on profile AFG, point B is located on first arc AF whereby the second arc AB is a segment of arc AF.

The radial profile of the foot portion comprises a second curve BCDE tangent to arc AB at point B and to the side wall profile 14b at point E. Curve BCDE is formed of three arcs in series, namely a concave arc BC and a pair of convex arcs CD and DE. Arcs BC and CD are tangent to each other at point C, and arcs CD and DE at point D. Arcs BC, CD and DE have centers of curvature I, J and K, respectively.

The radial profile of the rib portion comprises a first curve FG tangent to arc AF at point F and to the side wall profile 14b at point G. Curve FG is shown as a single convex arc having a center of curvature L, but may consist of a tangential series of arcs.

The configuration of the bottom structure represented in Figure 7 has been devised to provide relatively great resistance to impact and internal pressure, with an economy of material and at the expense of some degree of upright stability. Accordingly, the distance BE is made relatively large to reduce stresses and to enlarge the area subject to the stiffening effect of the rib portion. Dome height H_0 is reduced to conserve material (or to enlarge capacity) but the radius R_1 of arc AF (and thus of arc AB) is lengthened considerably to provide a rib portion having substantial depth.

In order to achieve relatively large values for both the distance BE and the length of radius R_1 , the length of radius R_1 of arc DE is made as large as is compatible with stability requirements, and the concave arc BC is included in the foot portion profile.

Maximum stresses can be expected to arise in the vicinity of point C; however, as the length of radius R_2 of arc CD is made smaller, the height of point C above plane 10b is reduced, thus increasing the distance between point C and rib portion profile FG and, as a result, enhancing the stiffening effect of the rib portion in the high-stress area. It will be noted that in the construction of Figure 7, radius R_2 is smaller in length than radius R_1 . However, this relationship may be reversed; it may be particularly desirable to do so in the case of thin-walled containers formed of high-strength materials such as the metals mentioned hereinbelow.

The location of point G is selected not only on the basis of aesthetic considerations but is placed low enough on the side wall profile that flow of material to the foot portion is unimpeded during the blow-moulding operation, yet high enough that the depth of the rib portion is substantial.

In the embodiment of Figure 7, the point

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of tangency F of the dome arc AF with the rib portion arc FG lies at a greater radial distance from axis 10a than the point of tangency B of the dome arc AB with the foot portion curve BCDE. With the construction shown, it will be apparent that the embodiment of Figure 7 is useful in connection with a mould which is provided with the movable piston or stem mentioned hereinabove, since the large radius R_1 of arc AB permits the piston end to be virtually planar without substantial departure from the configuration of the dome portion.

The following table provides exemplary data with respect to the bottom structure of a bottle having a capacity of 32 fluid ounces and constructed in accordance with the embodiment of Figure 7. In the system of coordinates employed, the x-axis and y-axis may be considered as coincident with interrupted lines 10b and 10a, respectively, and have a common origin at point O. Radial lengths are stated in inches and coordinates are stated in inches from the origin.

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Coordinates		Radius	Length
Point	x y		
A	0 0.422	R_1	3.382
B	0.375 0.401	R_2	0.549
C	0.772 0.158	R_3	0.352
D	1.066 0	R_4	0.528
E	1.594 0.528	R_5	0.560
F	0.887 0.304		
G	1.594 0.844		
H	0 -2.960		
I	0.336 -0.141		
J	1.066 0.352		
K	1.066 0.528		
L	1.034 0.844		

In some applications it may be desirable that the lengths of radii R_3 and R_4 be equal, whereby the curve CDE would consist of a single arc. In such a case it will be apparent that the radial profile of the foot portion will consist of two arcs, namely a concave arc BC and a convex arc CDE, tangent to each other at a point removed from the axially outermost point of the foot portion.

The embodiments represented in Figures 6 and 7 are but two of many which may be realized in accordance with the invention and which may vary with variable requirements, various materials, and various forming processes and equipment. It will be recognized that design of specific bottom structures in accordance with the teaching of the invention is readily adaptable to well-known computer programming procedures.

Further, although the foregoing description is concerned with plastics containers, it will be apparent that the invention in its broader aspects may be applied with beneficial results to containers formed of other materials, metal cans for example, particularly those which are subject to internal pressures. Similarly, the invention is not limited to moulds for blow-moulding bottles but is applicable as well to other container-forming matrices such as the female dies employed in metal pressworking operations.

Accordingly, while the invention has been particularly described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not by way of limitation.

WHAT WE CLAIM IS:—

1. A container having a side wall and a bottom structure closing the container at an end portion of the side wall, the outer surface of the bottom structure comprising a central concave dome portion, a convex annular rim portion circumscribing the dome portion and merging therewith and with the side wall end portion, and a plurality of radially oriented foot portions extending axially outwardly of the rim portion, each foot portion having lateral margins merging with the rim portion to form a rib portion between each pair of adjacent foot portions, the radial profile of each foot portion comprising a curve tangent to the radial profile of the dome portion and to the profile of the side wall end portion, wherein the foot portion curve comprises a plurality of tangential arcs arranged in series, adjacent arcs in the series of arcs having separate centers of curvature.

2. A container according to Claim 1, wherein the radii of curvature of the said adjacent tangential arcs are unequal.

3. A container according to Claim 2, in which the end portion of the side wall is generally symmetrical about the longitudinal axis of the container, the radial profile of each rib portion comprises a first curve tangent to the profile of the side wall end profile and tangent to a first concave arc which constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the said radial profile of the rib portion, and the radial profile of each foot portion comprises a second curve tangent



of tangency F of the dome arc AF with the rib portion arc FG lies at a greater radial distance from axis 10a than the point of tangency B of the dome arc AB with the foot portion curve BCDE. With the construction shown, it will be apparent that the embodiment of Figure 7 is useful in connection with a mould which is provided with the movable piston or stem mentioned hereinabove, since the large radius R_1 of arc AB permits the piston end to be virtually planar without substantial departure from the configuration of the dome portion.

The following table provides exemplary data with respect to the bottom structure of a bottle having a capacity of 32 fluid ounces and constructed in accordance with the embodiment of Figure 7. In the system of coordinates employed, the x-axis and y-axis may be considered as coincident with interrupted lines 10b and 10a, respectively, and have a common origin at point O. Radial lengths are stated in inches and coordinates are stated in inches from the origin.

Point	Coordinates		Radius	Length
	x	y		
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E	1.594	0.528	R_5	0.560
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G	1.594	0.844		
H	0	-2.960		
I	0.336	-0.141		
J	1.066	0.352		
K	1.066	0.528		
L	1.034	0.844		

In some applications it may be desirable that the lengths of radii R_3 and R_4 be equal, whereby the curve CDE would consist of a single arc. In such a case it will be apparent that the radial profile of the foot portion will consist of two arcs, namely a concave arc BC and a convex arc CDE, tangent to each other at a point removed from the axially outermost point of the foot portion.

The embodiments represented in Figures 6 and 7 are but two of many which may be realized in accordance with the invention and which may vary with variable requirements, various materials, and various forming processes and equipment. It will be recognized that design of specific bottom structures in accordance with the teaching of the invention is readily adaptable to well-known computer programming procedures.

Further, although the foregoing description is concerned with plastics containers, it will be apparent that the invention in its broader aspects may be applied with beneficial results to containers formed of other materials, metal cans for example, particularly those which are subject to internal pressures. Similarly, the invention is not limited to moulds for blow-moulding bottles but is applicable as well to other container-forming matrices such as the female dies employed in metal pressworking operations.

Accordingly, while the invention has been particularly described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not by way of limitation.

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1. A container having a side wall and a bottom structure closing the container at an end portion of the side wall, the outer surface of the bottom structure comprising a central concave dome portion, a convex annular rim portion circumscribing the dome portion and merging therewith and with the side wall end portion, and a plurality of radially oriented foot portions extending axially outwardly of the rim portion, each foot portion having lateral margins merging with the rim portion to form a rib portion between each pair of adjacent foot portions, the radial profile of each foot portion comprising a curve tangent to the radial profile of the dome portion and to the profile of the side wall end portion, wherein the foot portion curve comprises a plurality of tangential arcs arranged in series, adjacent arcs in the series of arcs having separate centers of curvature.

2. A container according to Claim 1, wherein the radii of curvature of the said adjacent tangential arcs are unequal.

3. A container according to Claim 2, in which the end portion of the side wall is generally symmetrical about the longitudinal axis of the container, the radial profile of each rib portion comprises a first curve tangent to the profile of the side wall end profile and tangent to a first concave arc which constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the said radial profile of the rib portion, and the radial profile of each foot portion comprises a second curve tangent



to the profile of the side wall end portion and to the second concave arc of the same radius of curvature as, but of different arc length from, the first concave arc, which second concave arc constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the radial profile of the foot portion.

4. A container according to Claim 3, wherein the radius of curvature of each of the tangential arcs is smaller than the radius of curvature of the first arc.

5. A container according to Claim 1, in which the end portion of the side wall is generally symmetrical about the longitudinal axis of the container, and the central concave dome portion is of substantially spherical form, the radial profile of each rib portion comprising a first curve tangent to the profile of the side wall end portion, and tangent to a first concave arc which constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the said radial profile of the rib portion, and the radial profile of each foot portion comprising a second curve tangent to the profile of the side wall end portion and tangent to a second concave arc of the same radius of curvature as, but of different arc length from, the first concave arc, which second concave arc constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the radial profile of the foot portion, the first and second concave arcs having their common centre of curvature on the longitudinal axis, wherein the second curve comprises a third arc tangent to the second arc, and a fourth concave arc tangent to the third arc and to the profile of the side wall end portion, the radii of curvature of the third and fourth arcs being unequal.

6. A container according to Claim 5, wherein the third arc is convex.

7. A container according to Claim 5 or Claim 6, wherein the radii of curvature of the third and fourth arcs are smaller than the radius of curvature of the first arc.

8. A container according to any one of Claims 5 to 7, wherein the radius of curvature of the third arc is greater than the radius of curvature of the fourth arc.

9. A container according to any one of Claims 5 to 8, wherein the point of tangency of the second arc with the third arc lies at a greater radial distance from the longitudinal axis than the point of tangency of the first arc with the first (or rib portion) curve.

10. A container according to Claim 6, in which the axially outermost point of each of the foot portions lies in a plane common to the axially outermost points of the other foot portions and normal to the longitudinal axis, wherein the centers of curvature of the third and fourth arcs lie on a common line parallel with said axis whereby the axially outermost

point is the point of tangency of the third and fourth arcs.

11. A container according to Claim 1, in which an end portion of the side wall is generally symmetrical about the longitudinal axis of the container and the central dome portion is of substantially spherical form, the radial profile of each rib portion comprising a first curve tangent to the profile of the side wall end portion and tangent to a first concave arc which constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the said radial profile of the rib portion, and the radial profile of each foot portion comprising a second curve tangent to the profile of the side wall end portion and tangent to a second concave arc of the same radius of curvature as, but of different arc length from, the first concave arc, which second concave arc constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the radial profile of the foot portion, the first and second concave arcs having their common center of curvature on the longitudinal axis, wherein the second curve comprises a third concave arc tangent to the second arc, a fourth convex arc tangent to the third arc, and a fifth convex arc tangent to the fourth arc and to the profile of the side wall end portion, the radii of curvature of the fourth and fifth arcs being unequal.

12. A container according to Claim 11, wherein each of the radii of curvature of the third, fourth and fifth arcs is smaller than the radius of curvature of the first arc.

13. A container according to Claim 11 or Claim 12, wherein the radius of curvature of the fifth arc is greater than the radius of curvature of the fourth arc.

14. A container according to any one of Claims 11 to 13, in which the axially outermost point of each of the foot portions lies in a plane common to the axially outermost points of the other foot portions and normal to the longitudinal axis, wherein the centers of curvature of the fourth and fifth arcs lie on a common line parallel with said axis whereby said axially outermost point is the point of tangency of the fourth and fifth arcs.

15. A container according to any one of Claims 11 to 14, wherein the point of tangency of the first arc with the first rib (or portion) curve lies at a greater radial distance from said axis than the point of tangency of the second arc with the third arc.

16. A mould for forming a container according to Claim 1, said mould having an interior surface which defines a cavity and which is complementary to an outer surface of a container to be formed in the mould, the interior surface including a side wall and a bottom surface portion closing the cavity at an end portion of the side wall, the bottom surface portion comprising a central convex

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dome portion, a concave annular rim portion circumscribing the dome portion and merging therewith and with the side wall end portion, and a plurality of radially oriented concavities extending axially outwardly of the rim portion to form the said foot portions of the container, each concavity having lateral margins merging with the rim portion to form a rib portion between each pair of adjacent concavities, the radial profile of each concavity comprising a curve tangent to the radial profile of the dome portion and to the profile of the side wall end portion, wherein the said curve comprises a plurality of tangential arcs arranged in series, adjacent arcs in the series of arcs having separate centers of curvature.

17. A mould according to Claim 16, in which at least an end portion of the side wall is generally symmetrical about the longitudinal axis of the cavity, wherein the radii of curvature of the said adjacent tangential arcs are unequal.

18. A mould for blow-moulding a container according to Claim 1, said mould having an interior surface defining a cavity for receiving a parison, the interior surface being complementary to an outer surface of a container to be blow-moulded from the parison, the interior surface including a side wall, at least an end portion of the side wall being generally symmetrical about the longitudinal axis of the cavity, and a bottom surface portion closing the cavity at the side wall end portion, the bottom surface portion comprising a central convex dome portion, a concave annular rim portion circumscribing the dome portion and merging therewith and with the side wall end portion, and a plurality of radially oriented concavities extending axially outwardly of the rim portion to form the said foot portions of the container, each concavity having lateral margins merging with the rim portion to form a rib portion between each pair of adjacent concavities, the radial profile of each rib portion comprising a first curve tangent to the profile of the side wall end portion and tangent to a first convex arc which constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the said radial profile of the rib portion, and the radial profile of each concavity comprising a second curve tangent to the profile of the side wall end portion and to a second concave arc of the same radius of curvature as, but of different arc length from, the first convex arc, which second convex arc constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the radial profile of the concavity, wherein the second curve comprises a plurality of tangential arcs arranged in series, the radii of curvature of adjacent arcs in the series of tangential arcs being unequal.

19. A mould according to Claim 18, wherein

the radius of curvature of each of the tangential arcs is smaller than the radius of curvature of the first arc.

20. A mould according to Claim 18, wherein the dome portion is of substantially spherical form and the second curve comprises a third arc tangent to the second arc, and a fourth concave arc tangent to the third arc and to the profile of the side wall end portion, the radii of curvature of the third and fourth arcs being unequal.

21. A mould according to Claim 20, wherein the third arc is concave.

22. A mould according to Claim 20 or Claim 21, wherein each of said radii of curvature is smaller than the radius of curvature of the first arc.

23. A mould according to any one of Claims 20 to 22, wherein the radius of curvature of the third arc is greater than the radius of curvature of the fourth arc.

24. A mould according to any one of Claims 20 to 23, wherein the point of tangency of the second arc with the third arc lies at a greater radial distance from the central axis than the point of tangency of the first arc with the first (or rib portion) curve.

25. A mould according to Claim 21, in which the axially outermost point of each of the concavities lies in a plane common to the axially outermost points of the other concavities and normal to the central axis, wherein the centers of curvature of the third and fourth arcs lie on a common line parallel with the axis, whereby said axially outermost point is the point of tangency of the third and fourth arcs.

26. A mould according to Claim 18, wherein the dome portion is of substantially spherical form, the radial profile of each rib portion comprising a first curve tangent to the profile of the side wall portion and tangent to a first convex arc which constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the said radial profile of the rib portion, and the radial profile of each concavity comprising a second curve tangent to the profile of the side wall end portion and tangent to a second convex arc of the same radius of curvature as, but of different arc length from, the first convex arc, which second convex arc constitutes the radial profile of the dome portion taken at a radial cross-section corresponding to that of the radial profile of the concavity, the first and second convex arcs having their common center of curvature on the longitudinal axis, and wherein the second curve comprises a third convex arc tangent to the second arc, a fourth concave arc tangent to the third arc, and a fifth concave arc tangent to the fourth arc and to the profile of the side wall end portion, the radii of curvature of the fourth and fifth arcs being unequal.

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27. A mould according to Claim 26, wherein each of the radii of curvature of the third, fourth, and fifth arcs is smaller than the radius of curvature of the first arc. 20
- 5 28. A mould according to Claim 26 or Claim 27, wherein the radius of curvature of the fifth arc is greater than the radius of curvature of the fourth arc. 25
- 10 29. A mould according to Claim 26, in which the axially outermost point of each of the concavities lies in a plane common to the axially outermost points of the other concavities and normal to the central axis, wherein the centers of curvature of the fourth and fifth arcs lie on a common line parallel with the axis, whereby said axially outermost point is the point of tangency of the fourth and fifth arcs. 30
- 15 30. A mould according to any one of Claims 26 to 29, wherein the point of tangency of the first arc with the rib portion curve lies at a greater radial distance from the axis than the point of tangency of the second arc with the third arc.
31. A container as claimed in Claim 1, substantially as herein described with reference to and as illustrated in the accompanying drawings. 25
32. A mould as claimed in Claim 16, substantially as herein described with reference to and as illustrated in Figure 5 of the accompanying drawings. 30

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