(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 048 890 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 81107280.0

(22) Date of filing: 15.09.81

(51) Int. Cl.³: **B 65 D 8/22**

(30) Priority: 26.09.80 US 191225
26.09.80 US 191226

(43) Date of publication of application: 07.04.82
Bulletin 82/14

(84) Designated Contracting States: AT BE CH DE FR IT LI LU NL SE

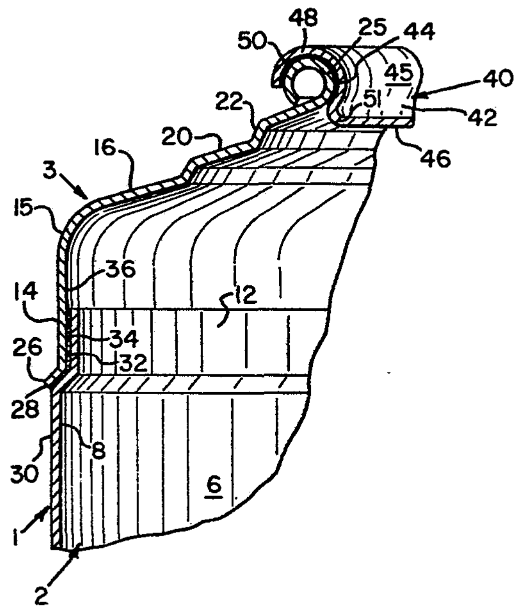
(71) Applicant: THE CONTINENTAL GROUP, INC., 1 Harbor Plaza, Stamford Connecticut 06902 (US)

(72) Inventor: Roth, Donald J., 17 Pleasant Valley Lane, Westport Connecticut 06880 (US)
Inventor: Kubis, Charles S., 313 Chatelaine Court, Willowbrook Illinois 60514 (US)
Inventor: Walter, John, 9815 South Artesian, Evergreen Park Illinois 60642 (US)

(74) Representative: Baillie, Iain Cameron et al, c/o Ladas & Parry Isartorplatz 5, D-8000 München 2 (DE)

(54) Lightweight container.

(57) A novel pressure holding container (1) formed of thin sheet metal of the order of between 10 and 4 mils wherein the container has a bottom portion (2) and a top portion (3), the bottom portion having a body and an integral bottom, and in one embodiment having a necked-in upper end of the body which tigthly fits into a lip portion (14) of the lower end of the top portion and is adhesively bonded thereto and wherein the upper portion (16) of the top portion has a toro-conical shape which under pressure wants to expand it into a spherical shape and thus trhough beam loading on the lip portion imposes compressive stresses theron and holds in compression the adhesive (32) which is interposed between the lip and the annulus of the necked, in portion of the body which is loaded in tension by the internal pressure in the container.



EP 0 048 890 A1

This invention relates to lightweight metal containers such as may be used to contain a beverage.

Containers of the general type under consideration are primarily made of aluminum and have a cylindrical body with an integral bottom. The top is usually closed by a generally flat end member of different alloy than the body which is usually H19-3004. The present commercial aluminum containers including ends weigh approximately 0.018-0.020kg. (.040 - .045 pounds) each. The single service beverage cans of the 1960's included a three-piece steel body, steel bottom and an aluminum top. The most popular can of the 1970's was an all aluminum drawn and wall-ironed can with a double seamed top. The top was of a different alloy than the can body.

Aluminum, because of its light weight and ductility and being able to be easily cast, is finding growing uses, most recently in the automotive industry. Material costs are rapidly escalating and the supply is dwindling. Various structures have been made to shape the bottom of the can to obtain more volume with less strength. Inverted or concave bottoms were provided on the 1970 vintage cans to resist the pressure of the contents, however, this design is wasteful of the material in that a taller than necessary can must be provided necessitating additional material to obtain the desired volume. Furthermore, the flat top end on such cans requires the use of a strong alloy aluminum material having a magnesium content. The compositions of the body and that of the end of each can, being different, complicates recycling of the cans.

Steel cans on the other hand, because of the thickness of the metal used, require high tonnage presses and tools must be more frequently replaced. When thick metal is used, the costs and carrying weights become excessive. In order to obtain an easy opening feature, steel cans invariably use aluminum tops which complicates recycling. The aluminum and the steel must be separated which is a time consuming costly process. The attractiveness of steel for cans is in the lower cost of the metal and its greater availability.

The object of this invention is to provide a metal container which uses less material but retains the strength characteristics of present containers.

Accordingly, the present invention provides a metal container comprising a body, a dome, and a lapped joint including an adhesive layer between said body and said dome, and the relationship between said body and said dome being one wherein when said can is filled with a liquid packaged under pressure said dome in the general area of said lapped joint radially inwardly deforms and said body in the general area of said lapped joint radially outwardly deforms with the combined deformation of said dome and said body compressing said adhesive layer.

Using the present invention, the concave bottoms of the principal current designs .0355 cm - 0.0355 cm (.014 inch) thick are replaced in the can of this invention formed of aluminum by a convex bottom about .0203 cm (.008 inch) thick which results in a container of increased volume using less aluminum. The double seam of the current containers which also consumes aluminum is eliminated by substituting an adhesive telescoped joint. The top or dome of the new container may be about 9 mils thick compared to the double seam flat top of 14 mils thickness of the current containers. The heavy flange thickness of 7 mils of double seamed cans is not required and is reduced to 4 mils. A total package weight of about 1.4 kg. (20 pounds) per one thousand cans is obtained versus 2.67-2.81 kg.(38-40 pounds) per one thousand cans for the present lightest weight aluminum cans.

The two pieces of the new can are assembled at the can plant and later filled through the small drink hole using conventional bottle fillers.

It is postulated that using the present invention, steel cans 2 to 2-1/2 mils in wall thickness are feasible. The elimination of a special alloy for the can ends by making the can of one alloy produces a uni-alloy can, therefore making it more valuable as scrap for recycling.

The improved can remains cleaner, has better pourability and can be reclosed and resealed. The new container provides a top which increases container volume and can be as easily used for 0.07 kg. (16 ounce) cans as well as for 0.052 kg. (12 ounce) cans or even 0.043 kg. (10 ounce) cans merely by lengthening or shortening the can body. A further feature of the new container is that it can be made on present existing equipment without excessive capital investment.

Advantage is taken of the shape of the top and of the thinness of about 0.022 cm. (.009 inch) and short axial length of the top with respect to the body length of the container to which the top is applied by shaping the top in a manner such that on filling the container with pressurized beverage internal pressure forces are exerted on the cone section of the top to cause beamloading of the cone section to exert inward forces on the lip at the base of the cone portion to assist the adhesive by applying compressive forces thereagainst and to the portion of the opposing body portion at the telescoped junction of the body and top. Peeling forces on the adhesive in the bonded telescoped junction as would ordinarily occur under internal pressure loading are thus eliminated. Various configurations of the top portion are shown which obtain specific benefits as hereinafter defined.

In conducting studies with respect to the cans, with particular reference to the adhesive, it has been unexpectedly found that the adhesive, when placed in compression, exhibits a marked increase in shear strength.

In 0.052 kg. (12 ounce) cans, the body has a diameter of 6.60 cm. (2.60 inches) and an axial length of 10.16 cm. (4 inches) whereas in the 0.07 kg. (16 ounce) can the body length or height is 12.06 cm. (4.75 inches)

In order to obtain a beaming action wherein the forces of expansion acting on the conical portion of the top produce compressive forces on the adhesive, the toroidal section, which provides the transition between the sloping conical section and the axial lip section, is arcuate in cross section and has a radius of 0.0158 to 0.0635 cm. (1/16 to 1/4 inch). It has been found that as the material used becomes thinner, the radius must be made larger. If the beaming forces were to be restricted or with a sharp angle at the juncture, the conical portion would buckle and wrinkle adjacent to the lip.

The invention comprehends providing a transition between the cone and the lip such that internal pressure forces tending to expand the conical section as well as the toroidal portion are utilized to produce a compressive force radially inwardly on the adhesive which together with the tensile forces tending to expand the upper end of the body portion ensures parallelism between opposing body and lip portions and thus precludes developing voids such as would produce leaking joints.

Furthermore, the invention comprehends making an adhesively bonded joint as an extremely narrow axial band on the order of 0.0158 to 0.0317 cm.(1/16 to 1/8 inch) which is now feasible because of the compressive loading on the adhesive.

In steel cans to be comparable to the aluminum cans, the wall thickness of both the top and bottom sections of the can would be on the order of 2 to 2-1/2 mils thick or 0.30mm (.0118 inch) thick which in Europe and particularly in the Netherlands is identified as E5,6/5,6 (.50) Flow Brightened Type and Temper DKK (Type D Killed) T52 BA (Temper).

Although the can is in no way restricted to formation from aluminum, as indicated by the possibility of utilizing even thinner gauge steel, for the present it would appear that the best commercial aspects are with respect to a can formed of aluminum, and for that reason there has been established a can deemed most suitable for commercialization and that can, as well as various modifications of the can, have been subjected both to analytical and experimental tests. These tests clearly indicate that a specific relationship of the dome to the body provides for maximum strength with a minimum usage of metal and at the same time assures the formation of a lap bond between the body and the dome which will not be subject to rupture under all expected conditions. Specifically, the applicant has found that metal containers made in accordance with the present invention can sustain at least a 36 kg. (80 pound) axial load and an internal pressure of 7.03 kg. per sq. cm. (100 psi).

The invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of one embodiment of the invention.

Figure 2 is a top plan view thereof.

Figure 3 is a side elevational view thereof shown partly in axial section.

Figure 4 is an enlarged fragmentary sectional view taken substantially on line 4-4 of Figure 3.

Figure 5 is a view similar to Figure 4 showing the container wall portion partly inducted.

Figure 6 illustrates a further embodiment incorporating a modified upper portion of the container.

Figure 7 is a perspective view illustrating a further embodiment of the invention.

Figure 8 is a top plan view thereof.

Figure 9 is a side elevational view thereof partly in axial section.

Figure 10 is an enlarged cross section taken substantially on line 10-10 of Figure 8.

Figures 11-14 illustrate a further embodiment of the invention;

Figure 11 being a perspective view;

Figure 12 being a top plan view;

Figure 13 being a side elevational view partly in vertical section taken substantially on line 13-13 of Figure 12, and

Figure 14 is an enlarged portion of a part of Figure 13.

Figure 15 is an enlarged fragmentary axial sectional view taken through the lap joint area of a preferred embodiment of dome and body relationship.

Figure 16 is a schematic view showing the overall configuration of the dome and upper part of the body of a preferred embodiment.

Figure 17 is a plot comparing the deformation of the dome and body in the lap area under internal pressure with the undeformed can shape.

Figure 18 is an enlarged fragmentary plot of the can of Figures 15 and 16 comparing the deformed shape with the undeformed shape when the can is under a 36 kg. (80 pound) axial fitment load.

Figure 19 is a schematic sectional view of a modified can geometry having a lowered lap joint.

Figure 20 is a plot of the deformed shape of the can of Figure 19 under internal pressure as compared to the undeformed shape.

Figure 21 is a schematic sectional view of another modified can shape wherein the body has a straight wall.

Figure 22 is a schematic sectional view taken through the lap joint and shows the arrangement of adhesive segments utilized in obtaining the analysis data of TABLE II.

Figure 23 is a schematic sectional view through the lap joint showing the use of a six segment adhesive arrangement utilized in obtaining a portion of the analysis data of TABLE III.

Figure 24 is a schematic sectional view through the lap joint showing the use of a nine segment adhesive arrangement utilized in obtaining a portion of the analysis data of TABLE III.

An embodiment of the invention is shown in Figures 1-5 of the drawings as comprising a container, generally designated 1, preferably entirely formed of one alloy of aluminum such as H19-3004.

The container has a lower or bottom portion 2 and a top portion or dome 3. The lower portion 2 comprises a bottom 4 and an integral cylindrical body 6 which at its upper end 8 is necked-in to provide a radially inwardly extending shoulder 10 about 0.0793 to 0.0158 cm. (1/32 to 1/16 inch) wide and about the inner edge of which there is an axially extending annulus or ring 12 of approximately 0.0317 cm. (1/8 inch) in length.

The annulus or ring 12 preferably has a tight or interference fit into the lower end of an annular band or lip 14 of the dome 3 which is of an axial length corresponding to that of the ring 12 while the dome 3 is about 2.12 cm. (.837 inch) in total axial height. The upper edge of the lip 14 merges into the lower edge of a toroidal or arcuate transition section 15 which at its upper edge merges into the lower edge of a conical section 16. The section 15 has a radius of between 0.0158 to 0.0635 cm. (1/16 and 1/4 inch). preferably the thinner the metal, the greater the radius. The conical section 16 shown in Figures 1 and 5 is preferably of a stepped design and comprises a frustoconical annular band 18 which merges at its lower edge with the upper edge of the toroidal section 15 and the upper edge of the band 18 merges with the lower edge of a conical segment 20 which at its upper edge, in turn, merges into the lower edge of a second smaller frustoconical band 22.

The band 22 has its upper edge merging into the lower edge of a second frustoconical segment 24 which, at its upper edge, merges into a curl 25 which is turned outwardly over the second segment 24.

The lower edge of the lip 14 is provided with an outturned downwardly flaring frustoconical or curled flange 26 which has an outer edge substantially coaxial with an external circular surface 30 of the body portion of the container.

A preferably thermoplastic resin or adhesive 32 such as polyvinyl chloride and thermoplastic resin such as polyethylene or polypropylene or alternatively thermosetting epoxy resin, or vinyl plastisol is applied to an outer side 34 of the ring 12 and to an inner surface 36 of the lip prior to assembly of the dome to the lower portion so that after assembly the assembled can may be heated to a temperature melting the plastic adhesive during which time the top and bottom portions of the can may be relatively axially or circumferentially moved to eliminate any pinholes or the like formed in the adhesive and to promote good adhesion of the adhesive to the metal parts. Upon cooling, the adhesive 32 bonds the telescoped parts together.

A metal closure 40 is shown in Figures 1-10 for purposes of illustration, it being understood that plastic closures of various kinds such as shown in Figures 11-13 may also be used. The closure comprises a center plug 42 which fits into the pour opening 44. The plug has an axially extending side wall 45 which at its lower end is connected to a bottom wall 46 and at its upper end has a downwardly open outward curl 48 which overlies the convex upper side 49 of the curl 25 and is drawn tightly against a foam gasket sealing material 50 applied thereto by mechanically crimping and expanding the side wall 45 of the plug to form a shoulder 51 under the curl. The wall 46, side wall 45 and curl 48 are scored at 52, 52 and a ring type opener 55 is formed with the closure or cap and bent downwardly to extend generally parallel with the conical section of the upper portion. The closure is readily opened by lifting the ring 55 thus breaking the scores 52, 52 and thus lifting the closure out of the pour opening.

The side wall of the body portion of the can may be made of aluminum having a substantially uniform thickness on the order of 4 mils. The side wall thickness has been maintained substantially uniform from end to end, there being no necessity for a thick zone about the open end since the double seaming has been eliminated. It is, however, feasible to make the entire side wall of the container, except for the extreme top, of a metal thickness of about 4 mils and the bottom of about 4-8 mils. However, if desired, variable thicknesses may be incorporated in various zones of the side wall.

The telescoping arrangement of the lip of the top and the necked-in band of the bottom portion and the provision of the outturned flange on the lower edge of the lip has been found to provide exceptional resistance to impact breeching of the connection. The flange 26 materially improves the radial strength of the lip portion of the top and the configuration of the lip and toroidal and conical sections develop a compression loading on the connection which together with the radial shoulder and necked-in band of the lower section resist inward displacement and thus do not extend peel stresses to the adhesive.

This feature is illustrated in Figure 5 wherein the body portion is depressed immediately below the necked-in region. The shoulder 10 stops the body from deflecting inwardly and thus prevents peeling of the adhesive. Furthermore, the thin metal top, upon being pressurized, when the can is filled with pressurized beverage, becomes a prehensible member and wants to expand its conical section into a sphere. This, in turn, loads the lip portion 14 in compression which resists the expansion of the necked-in portion 10,12 and holds the adhesive 32 in compression therebetween.

In the embodiment of Figure 6, as well as all others, parts which are identical with the other embodiments are identified by the same reference numerals.

As seen in Figure 6, the top portion of the container is an unstepped conical section. In this embodiment the transition from the toroidal section 15 to the curl is a smooth single conical section 60, a design which is satisfactory depending on the stacking strength required of the container.

In the embodiment of Figures 7-10 the necked-in structure at the upper end of the body section is eliminated and the upper end of the body portion 6 is a continuous cylinder which is slightly precompressed and fitted into the lip 14 of the top portion 3. The adhesive is thus held in compression between the lip 14 and the upper portion of the body 6.

In this embodiment the bottom and top portions of the container are generally of the same diametrical dimension. The bottom portion is precompressed about its upper edge portion 8 prior to insertion into the top lip 14 of the upper portion and then is released compressing the adhesive 32 between the inner surface of the lip and the outer surface of the upper portion 14. The adhesive is preferably a thermoplastic type such that after the container portion of any of the previous or subsequent embodiments are assembled and they are passed through a heating chamber, the adhesive melts and fuses the top and bottom portions into a unitary structure. In this embodiment it will be appreciated that the joint is flexible because of the wall thicknesses being of the order of 4-9 mils, preferably the former for the body portion 6, and the adhesive is flexible. Thus, when the container is struck with a side blow in the body wall adjacent to the joint, the extremely thin section of material, that is the metal and the plastic adhesive, allows the joint to flex inwardly thus attenuating the forces and inhibiting these forces from applying peeling loads on the adhesive and separating the inner portion from the lip.

In the embodiment of Figures 11-14 the structure of the bottom portion 2 is the same as in the embodiment of Figures 1-5.

The top, however, is made to accommodate a different type of closure 100.

In this embodiment the neck 102 at the top of the stepped cone 104 is elongated and has an inturned frustoconical lip 105 which forms a smooth apical annulus 106 against which the bottom side 108 of a radial flange 110 of the plastic closure 100 seats.

The flange 110 is connected to a hollow sleeve 114 which fits into the lip 105 and has external sealing shoulders or rings 115 and 116. Shoulder 115 wedges against the top internal angular surface 117 of the lip 105 and the shoulder 116, which is at the bottom of the sleeve 114, underlaps the lower edge 118 of the lip 105 and tightly engages therewith. At the juncture of the upper end of the sleeve 114 and the flange 110 there is provided an integral tearable thin membrane 122 which is also integral with the outer peripheral edge portion 124 of a depressed closure plug 125 which is integrated with a hinge ring 126 connected by hinge 127 to the flange 110 and at the diametrically opposite side to a pull tab 130 which is angled downwardly toward the cone top portion. Lifting of the tab rips the membrane 122 and opens the container.

It will be noted that in each embodiment described above the bottom 4 of the container is convex and has feet 75. The bottom wall thickness is usually the initial thickness of the blank sheet preparatory to forming of the can, that is 10-6 mils, preferably 8 mils, thick. The body wall 6 is ironed to about 5 mils or less. The top portion 3 is also less than 10 mils thick, preferably 4-9 mils, and the pour opening 44 is less than 30% of the bottom area. The angle of the conical portions is between 10-45 degrees, preferably 22-1/2, in the stepped designs, as well as in the unstepped design of Figure 6. However, to obtain greater axial strength, an angle of 45 degrees would be preferred, but that is dependent upon other desired parameters as will be described in more detail hereinafter. The stepped design greatly improves the axial strength of the top.

Steps have been taken to develop the can for commercialization utilizing aluminum as the metal. Cans such as that generally illustrated in Figures 1-5 have been developed, but with slight modifications in the wall thicknesses, radii, axial dimensions and the like. Reference is made to Figure 15 which illustrates on a larger scale the specifics of the dome and can body in the vicinity of the lap joint between the dome and the can body with respect to what has been considered to be the most efficient construction.

The dome 3 has a wall thickness t1 on the order of 9 mils. The can body 8 has a wall thickness t2 of 4 mils, but increases at its extreme upper end to a wall thickness t3 of 6 mils for a distance generally on the order of 0.0152 cm. (0.06 inch). It is also to be noted that the extreme upper end of the body 8 is provided with a radially inwardly directed curl 29. The ring 12 is radially inwardly offset and has an axial height on the order of 0.0304 cm. (0.12 inch). The lip 14 has a like axial extent and the torroidal section 15 has a preferred radius R1 of 0.0304 cm. (0.12 inch). The extent of the torroidal section 15 is such that the conical section 16 is disposed at an angle to the horizontal on the order of 22-1/2 degrees.

The necking-in of the upper portion of the can body 8 provides a radially inwardly offset on the order of 0.0152 cm. (0.06 inch) with the shoulder 10 being joined to the ring 12 by a radius R2 to the remainder of the body 8 by a radius R3 which is also on the order of 0.0152 cm. (0.06 inch). It is to be noted that the shoulder 10 slopes upwardly and radially inwardly between the body 8 and the ring 12.

Experimental investigations of the can construction of Figure 15 and modifications thereof were made by IIT Research Institute of 10 West 35th Street, Chicago, Illinois 60616, U.S.A.

It was determined in advance that there are four conditions which could place loadings on the can which could be destructive. These are:

1. Internal pressurization loads which may be as high as 7.03 kg. per sq. cm. (100 psi).

2. An axial loading applied to the dome during the application of the closure fitment and which may be as high as 36 kg. (80 pounds).

Reference is made to Figure 16 wherein there is illustrated the geometry of the can which corresponds to Figure 15 and was considered as the basic can construction under consideration. In Figure 17 there is illustrated both the original shape in solid lines and the deformed shape in dash lines of the can in the area of the joint between the body and the dome when the can was subjected to 7.03 kg per sq. cm. (100 psi) internal pressure.

Forces and movements in the body and in the dome were determined with respect to the meridional and circumferential directions. With a permissible yield stress of 3220 kg. (45,800 psi), maximum permissible yield thrust in the body is calculated to be 32.68 kg./cm. (183 lbs/inch and in the dome to be 73.57 kg./cm. (412 lbs/inch), and the maximum permissible yield bending moment in the body to be 0.055 cm.-kg./cm. (0.122 "lb/inch) and in the dome to be 0.28 cm.-kg./cm. (0.618 "lb/inch).

The experiments showed the meridional force at the various points A-H (Figure 17) to be well within the permissible range. The same was generally true of the meridional moments. Also the circumferential forces and moments at the points A-H were within the permissible limit.

The can of Figures 15 and 16 was also theoretically subjected to an axial fitment load of 36 kg.(80 pounds) with the dome and the body deflecting as shown by the dash lines in Figure 18. In this instance the meridional forces and the moments circumferential forces and circumferential moments were negligible.

Having established the can of Figures 15 and 16 as the preferred embodiment and thus as a standard, like internal pressure and axial fitment loading tests were run on other configurations. The modified shape parameters and a comparison of the results are found in TABLE I with the standard being identified by dashes and the modified shape parameters being compared with the standard with numeric identification from 1-4, with the numeral 1 showing the test results of the modified shape parameter being better than the standard; the numeral 2 showing the results to be the same as the standard; the numeral 3 indicating the test results of the modified shape to be worse than those of the standard; and the numeral 4 indicating test results which could possibly be critical including possible rupture or destructive failure of the dome or body.

TABLE I

SHAPE PARAMETERS	FORCE AND MOMENTS 7.03 kg/cm^2 (100 PSI) MERIDIAN	CIRCUM.	AXIAL MERIDIAN	AXIAL CIRCUM.	RADIAL DEFLECTION OF ADHESIVE LAYER 7.03 kg/cm^2 (100 PSI)	AXIAL	NORMAL STRESS IN ADHESIVE 7.03 kg/cm^2 (100 PSI)	AXIAL
Dome Angle								
10°	3	3	3	3	1	3	2	3
Present 22.5	-	-	-	-	-	-	-	-
45	1	1	2	2	3	1	2	2
90	2	2	2	2	3	1	3	1
Dome Torus Radius								
0.152 cm. (.06 inch)	3	3	2	2	1	2	1	3
0.304 cm. (.12 inch) Present	-	-	-	-	-	-	-	-
0.456 cm. (.24 inch)	1	1	2	2	3	1	3	1
Dome Thickness								
0.0101 cm. (.004 inch)	3	3	4	4	1	3	3	4
0.0228 cm. Present (.009 inch)	-	-	-	-	-	-	-	-
Lap Location								
Present - At Tangent	-	-	-	-	-	-	-	-
1.27 cm. (½ inch) Below	2	2	2	2	3	1	3	1
Body Neck In								
Present 0.152 cm. (.060 inch) Offset 0.152 cm. (.060 inch) Radius	-	-	-	-	-	-	-	-
0.152 cm. (.060 inch) Offset 0.076 cm. (.030 inch) Radius	2	3	2	2	1	2	3	1
Not Necked	2	2	2	2	1	2	3	1

TABLE I (Cont'd.)

SHAPE PARAMETERS	FORCE AND MOMENTS 7.03 kg/cm² (100 PSI) MERIDIAN	CIRCUM.	AXIAL MERIDIAN	CIRCUM.	RADIAL DEFLECTION OF ADHESIVE LAYER 7.03 kg/cm² (100 PSI) AXIAL		NORMAL STRESS IN ADHESIVE 8/03 kg/cm² (100 PSI) AXIAL	
0.3048 cm(.12 inch)								
Adhesive Layer	-	-	-	-	-	-	-	-
Full Adhesive Layer	2	2	3	2	2	3	3	1

Figure of Merit - Comparison with the Present Design

1 - Better 3 - Worse

2 - Same 4 - Possibly Critical

It was found that having the lap between the dome and the body located immediately adjacent the toroidal radius 15 of the dome and having the body 8 necked-in produced the most desirable results. However, it was deemed advisable to change the lap location to be 1.27 cm. (1/2 inch) below the dome radius to show the beaming effect of the dome on the lap and to connect the dome to a straight body to show the advantageous effect of the neck-in of the body on the lap.

Accordingly, a can was constructed as shown in Figure 19 wherein the dome 3 included a cylindrical portion 27 having an axial length of 1.27 cm. (0.5 inch). As will be apparent from the deflection tracing, when the can of Figure 19 is subjected to 7.03 kg. per sq.cm. (100 psi) internal pressure, the previously discussed beaming action has a lesser effect on the compression of the adhesive as shown in Figure 20 and will be discussed hereinafter. On the other hand, the force and moments of this modified can construction are generally the same as those of the standard, as indicated in TABLE I. With respect to the absence of a body neck-in, a can as illustrated in Figure 21 was considered. As shown in TABLE I, the force and moments under internal pressurization and axial fitment loading were generally the same as those of the sample of Figures 15 and 16. On the other hand, normal stresses in the adhesive under pressurization were below the standard as will be discussed in detail hereinafter.

It has therefore been concluded that the best possible combination is one wherein the lap is immediately adjancent the dome radius or toroidal curve, and there is a necking-in of the body. Returning now to Figure 17, it will be seen that under internal pressurization the dome conical section 16 is angled upwardly to a greater extent and the radius 15 is deformed and moved radially inwardly so as to urge the upper portion of the lip 14 radially inwardly. At the same time the offset of the necked-in portion of the body tries to straighten out to eliminate the shoulder 10 and the lower portion of the ring 12 moves radially outwardly so as to compress the adhesive. The placing of the adhesive in compression has the obvious beneficial effect of preventing peel. It further has the unexpected advantageous effect that when the adhesive is placed under compression it has greater shear strength.

Having determined that the can configuration of Figures 15 and 16 was the most desirable, tests were made by modifying other shape parameters. For example as indicated in TABLE I, dome angles of 10°, 45° and 90° were analytically tested. As shown in TABLE I, a dome angle of 10° was shown to be less desirable than a dome angle of 22.5° under both internal pressurization and axial fitment loading.

When the dome angle was changed to 45°, the forces and moments remained substantially the same as those of the standard, but under internal pressurization the radial deflection of the adhesive layer worsened as will be specifically indicated hereinafter.

In a like manner, when the dome angle was changed to 90°, which would result in a flat top and therefore not in accordance with the spirit of this invention, the forces and moments were generally the same as those of the standard, but both the radial deflection of the adhesive and the normal stress in the adhesive under internal pressurization worsened. This will be discussed hereinafter.

Analytical experimentation was conducted relative to the dome torus radius, decreasing it in one experiment to 0.152 cm. (0.06 inch) and increasing it to 0.0609 cm. (0.24 inch) in another experiment. As is clearly shown in TABLE I, a reduced dome radius produced undesirable forces and moments when subjected to internal pressurization. The stress in the adhesive was worse under axial loading.

When the dome radius was increased, the forces and moments calculated to be either better or the same as the standard, but under internal pressurization the radial deflection of the adhesive layer and the normal stress in the adhesive layer worsened, as will be discussed hereinafter.

When the thickness of the dome was reduced to 4 mils, the conditions worsened except for the radial deflection of the adhesive layer under internal pressurization. In fact, failure occurred when the dome was analytically subjected to the 36 kg. (80 pound) fitment loading.

The can with a modified radius of the neck-in was analytically tested with a neck-in radius of 0.076 cm. (0.030 inch), and as is clearly shown in TABLE I, the results were not as good as when the radius was 0.152 cm. (0.060 inch).

The above described analytical tests were made by considering the total adhesive layer as being segmented into three, six or nine smaller circumferential rings as shown in Figures 22-24. This segmentation was necessary to implement the computer code and permit a prediction of the compressive forces distribution within the adhesive layer.

Under these conditions test results of various body shape parameters relative to compressive forces on the adhesive were obtained as shown in TABLE II, as follows:

TABLE II

ADHESIVE RING SEGMENT RADIAL STRESSES, KG./CM^2 (lb./cm^2)

(- = COMPRESSION, + = TENSION THREE-RING SEGMENT MODEL

Model	Adhesive Segment	Load Case: 7.03 kg/cm^2 (100 psi) Internal Pressure	Load Case: 36 kg. (80 lb.) Axial Fitment Load
Original Configuration -	U = Upper	-12.86 (-183)	1.47 (21)
	M = Middle	-12.51 (-178)	1.61 (23)
	L = Lower	-38.31 (-545)	6.39 (91)
Lowered Lap Joint	U	- 6.88 (-98)	0.14 (2)
	M	-10.05 (-143)	0.98 (14)
	L	-34.09 (-485)	1.05 (15)
No Body Neck	U	-11.88 (-169)	1.33 (19)
	M	- 6.46 (-92)	-0.14 (-2)
	L	- 4.63 (-66)	-0.56 (-8)
90° Neck-In Body	U	-16.09 (-229)	0.24 (3.5)
	M	- 1.47 (-21)	-1.75 (-25)
	L	-31.98 (-455)	10.75 (153)
Increase Dome	U	- 9.34 (-133)	0.56 (8)
Radius	M	-11.45 (-163)	1.26 (18)
0.30 →0.60 cm.			
(0.12 →0.24 inches)	L	-35.85 (-510)	6.60 (94)
Decreased Dome	U	-19.82 (-282)	2.67 (38)
Radius	M	-10.96 (-156)	2.17 (31)
0.30→ 0.15 cm.			
(0.12→ 0.06 inches)	L	-40.63 (-578)	6.88 (98)
Increase Dome	U	-8.57 (-122)	0.49 (7)
Radius with Less	M	-9.91 (-141)	0.63 (9)
Neck-In	L	-22.35 (-318)	2.74 (39)
Increase Cone Angle	U	-13.21 (-188)	1.12 (16)
(22.5°→ 45°)	M	-11.24 (-160)	1.47 (21)
	L	-36.90 (-525)	6.74 (96)
Decrease Cone Angle	U	-12.51 (-178)	4.78 (68)
(22.5°→ 10°)	M	-13.49 (-192)	3.30 (47)
	L	-40.07 (-570)	7.17 (102)

Comparing the results of TABLE II with the merits of the different shapes of TABLE I, it will be seen that under all conditions the adhesive would be under compression when the can is subjected to 7.03 kg/cm^2 (100 psi) internal pressure.

Other specific tests relative to adhesive loading were made using a six segment adhesive arrangement as shown in Figure 23 when adhesive is applied only to the lap area, and a nine segment adhesive arrangement as shown in Figure 24 when the adhesive is permitted to fill the space between the dome and the body below the lap area.

TABLE III

ADHESIVE RING SEGMENT RADIAL STRESSES

KG./cm^2 (LB/$IN.^2$)

(- = COMPRESSION, + = TENSION)

Model	Adhesive Segment		Load Case: 7.03 kg/cm^2 (100 psi) Internal Pressure	Load Case: 36 kg. (80 lb.) Axial Fitment Load
Simplified Original	U	0.30 cm. (0.120 Inch) Adhesive Length	-16.87 (-240)	1.96 (28)
Geometry	5		- 6.53 (-93)	0.84 (12)
6 Segment Adhesive	4		- 0.63 (-9)	0.42 (6)
Layer	3		- 7.52 (-107)	0.28 (4)
Constant Body Thickness	2		-15.39 (-219)	1.68 (24)
	L		-78.31 (-1114)	15.46 (220)
Simplified Original	U	0.30 CM (0.120 Inch Length)	- 9.06 (-129)	1.19 (17)
Geometry	8		- 6.32 (-90)	0.70 (10)
9 Segment Adhesive	7		- 6.18 (-88)	0.35 (5)
Layer	6		- 6.32 (-90)	0.28 (4)
Constant Body				
Thickness	5		- 4.35 (-62)	-0.42 (-6)
	4		9.98 (142)	-4.00 (-57)
	3		108.61 (1545)	-25.87 (-368)
	2		145.23 (2066)	-34.65 (-493)
	L		103.48 (1472)	-20.17 (-287)

Referring to the foregoing TABLE III, it will be seen that when the adhesive fills the space between the dome and the body below the lap the compressive forces on the adhesive are greatly reduced under internal pressurization of the can and, in fact, in the lower part of the adhesive there are high tensile forces. While this would generally indicate that when the space between the dome and the body is filled with adhesive there is a poor joint, it is understood that even if that added adhesive should fail, the net result will be no less than that with the adhesive only in the lap in that the compressive forces on the remaining adhesive will increase to correspond to the case where there is adhesive only in the lap. On the other hand, the added adhesive will serve to prevent the entrance of foreign matter into the space between the lower edge of the dome and the body and thus does serve a useful purpose. Furthermore, because in the assembly of the dome and the body the adhesive is applied to the body ring 12 and there is an interference fit between the dome and the body, any extra adhesive on the body, and there will always be some, will flow into the lower part of the lap and thus fill the free space between the lower edge of the dome and the adjacent portion of the body.

From the values of adhesive loading in TABLES II and III, and it will be readily apparent that under the compressive loadings of adhesive in accordance with the can configuration of this invention, the adhesive has a much greater shear stress allowance than would normally be expected.

It will become apparent from the foregoing disclosure that novel lightweight pressure holding containers have been developed which adequately contain pressurized beverages, use a minimum amount of metal and strategically employ the metal to obtain a container of improved characteristics which constrain the forces to act in a favorable manner assisting in holding the adhesive bond from being breeched.

CLAIMS

1. A metal container characterized by a body (2), a dome (3), and a lapped joint including an adhesive layer (32) between said body and said dome, and the relationship between said body and said dome being one wherein when said can is filled with a liquid packaged under pressure said dome in the general area of said lapped joint radially inwardly deforms and said body in the general area of said lapped joint radially outwardly deforms with the combined deformation of said dome and said body compressing said adhesive layer.

2. A metal container according to claim 1, characterized in that said adhesive (32) is of the type wherein the shear strength increases with compression of said adhesive.

3. A metal container according to claim 1, characterized in that said adhesive is a flexible adhesive.

4. A metal can according to claim 1, 2 or 3, characterized in that said dome (3) is of a greater wall thickness than said body (2) wherein the resistance of said dome at said lapped joint to radially outwardly directed deformation is greater than that of said body.

5. A metal container according to any of claims 1 to 4, characterized in that said dome (3) has a lower cylindrical lip (14) forming part of said dome, said lip merges at its upper edge into a toroidal curve (15) which merges into a conical inner and upper portion, (16,18,20, 22,24;60) and wherein under internal pressure said conical portion is deformed generally axially upward and said toroidal curve (15) is deformed generally radially inwardly with an associated tilting of said lip (14) and a radially inward deformation of at least an upper portion of said lip and compression of an upper part of said adhesiver layer (32).

6. A metal container according to claim 5, characterized in that said conical portion has at least one annular step (18,22).

7. A metal container according to claim 5 or 6, characterized in that said conical portion (16,18,20,22, 24;60) is disposed at an angle to the horizontal generally ranging from 10 degrees to 45 degrees.

8. A metal container according to any of claims 1 to 7, characterized in that an upper end portion (8) of said body (2) is necked-in to define a radially inwardly offset upper ring (12) connected to an adjacent portion of said body by a radially inwardly and axially upwardly sloping shoulder (10), and internal pressure within said can functioning to straighten out said body in the general area of said shoulder (10) to deform at least a lower portion of said ring (12) radially outwardly to compress at least a lower part of said adhesive layer (32).

9. A metal container according to claim 8, characterized in that the axial extents of said lip (14) and said ring (12) are generally the same, and said lip and said ring are in full overlapping relation.

10. A metal container according to claim 8 or 9, characterized in that said dome (3) terminates in a lowermost radially outturned curl (26) and said curl overlies said shoulder (10) within an axial extension of said body, said curl forming means facilitating telescoping of said lip and said ring.

11. A metal container according to claim 10, characterized in that said adhesive layer (32) extends between said curl (26) and said shoulder (10).

12. A metal container according to claim 8, 9 or 10, characterized in that said body (2) terminates in an uppermost radially inwardly directed curl (29), said curl (29) forming means facilitating telescoping of said lip (14) and said ring (12).

13. A metal container according to any of claims 8 to 12, characterized in that there is an interference fit between said lip (14) and said ring (12) wherein in a non-loaded state of said can said adhesive layer (32) is in a compressed state.

14. A metal container according to any of the preceeding claims, characterized in that said body (2) has a bottom (4) and said dome (3) has a fitment receiving opening (44), said opening (44) having an area less than 30 percent of the area of said bottom (4).

15. A metal container according to any of the preceeding claims, characterized in that said dome (3) has a short axial length as compared to said body (2).

16. A metal container according to any of the preceeding claims, characterized in that said body (2) and said dome (3) are both formed of aluminum, said dome has a wall thickness on the order of 0.0228 cm. (0.009 inch) and said body has a wall thickness on the order of 0.0101 cm. (0.004 inch).

17. A metal container according to any of claims 1 to 15, characterized in that said can is formed of sheet steel.

18. A metal container according to any of claims 1 to 15, characterized in that said body is formed of sheet steel having a thickness no greater than 0.0050 cm.(0.002 inch).

19. A metal container according to any of claims 1 to 15, characterized in that said body is formed of sheet steel having a thickness on the order of 0.0076 cm. (0.003 inch).

20. A metal container according to any of the preceeding claims, characterized in that said body, said dome and said lapped joint all can sustain a 36 kg. (80 pound) axial load in the empty can state and an internal pressure of 7.03 kg. per sq. cm. (100 psi).

FIG. 2

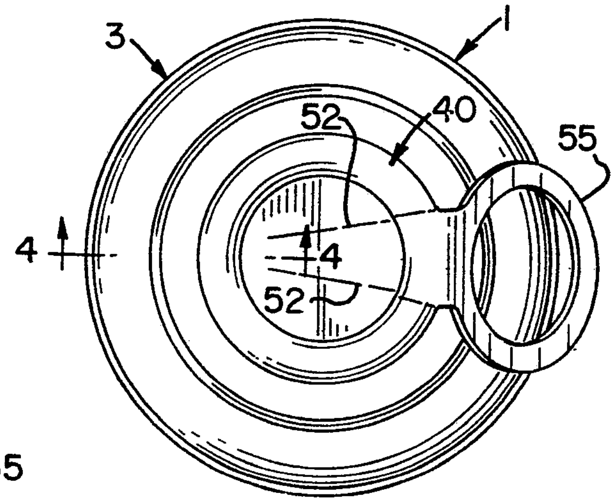


FIG. 1

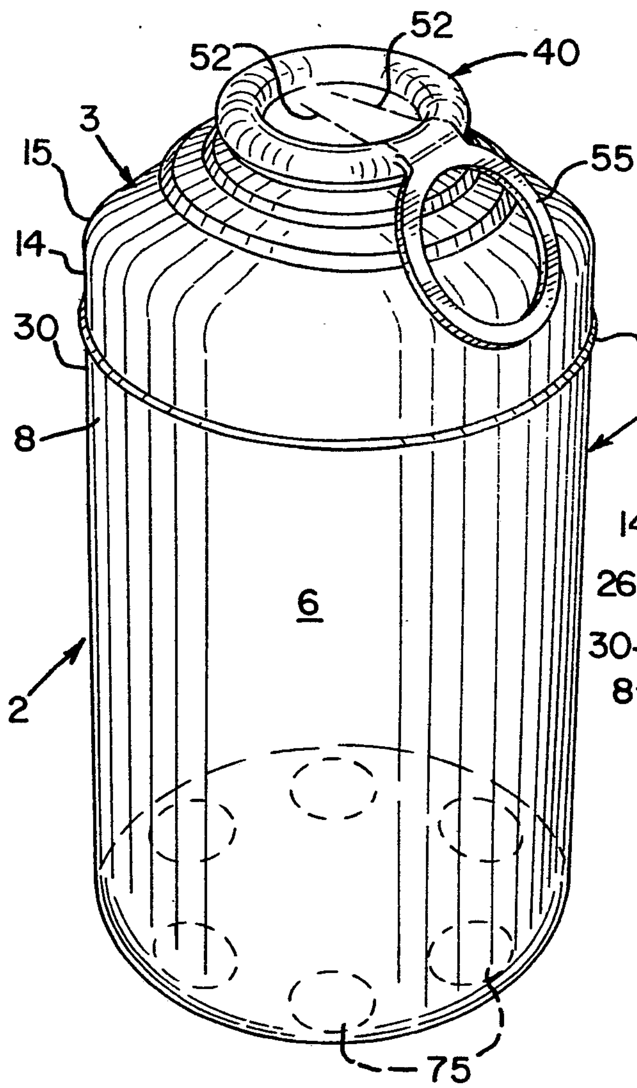


FIG. 3

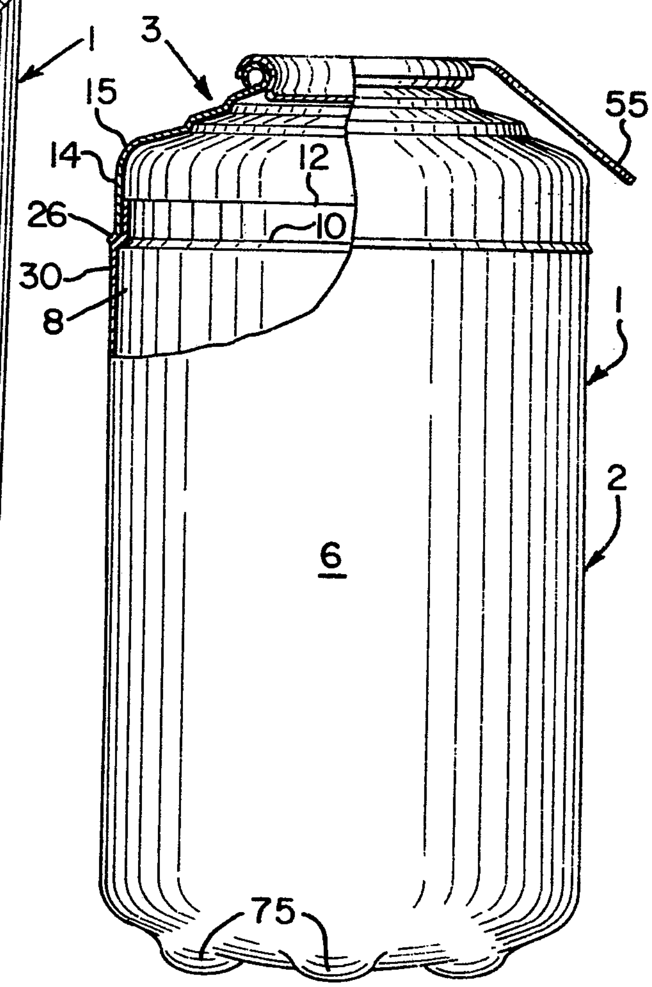


FIG. 4

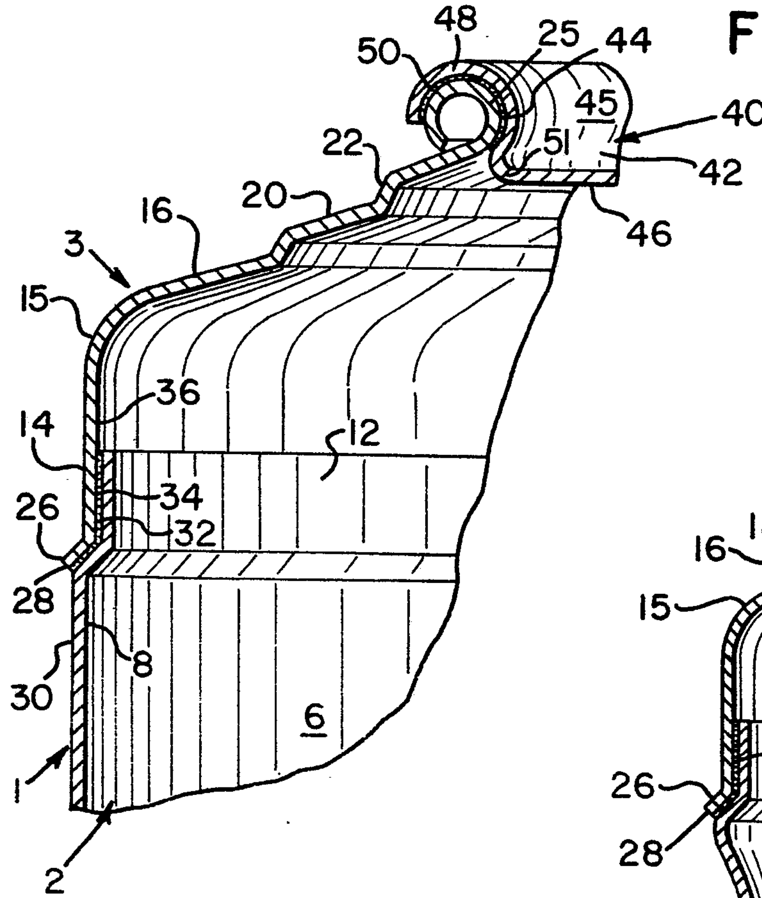


FIG. 5

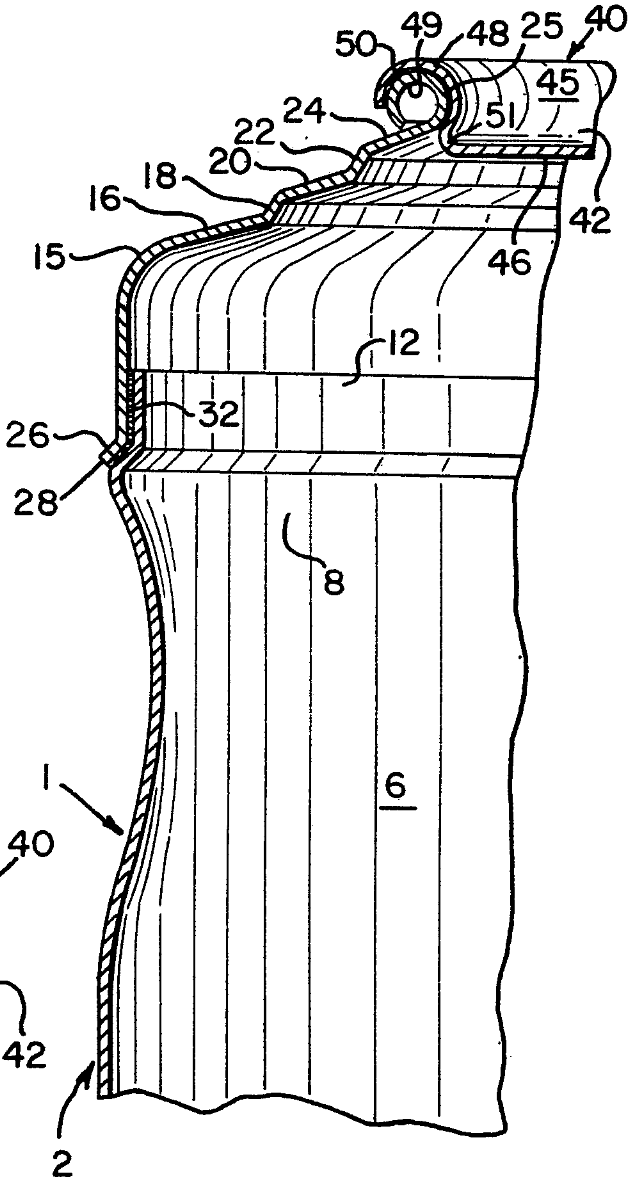
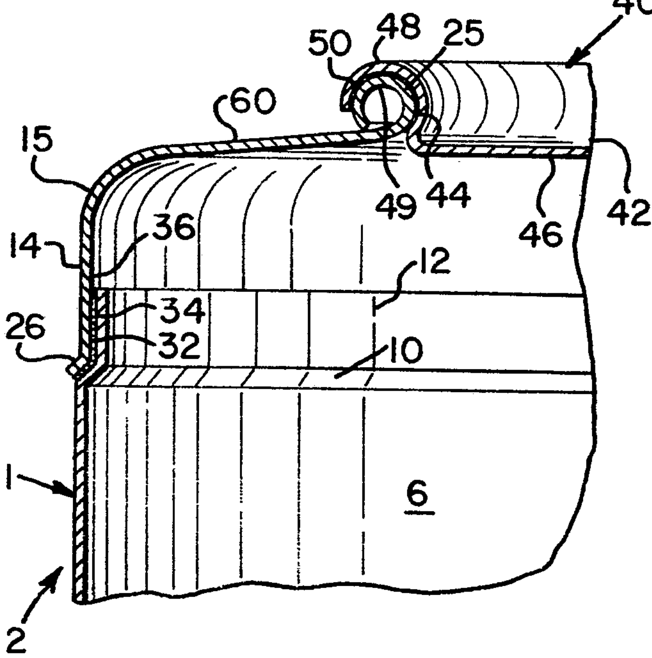


FIG. 6



0048890

FIG. 7

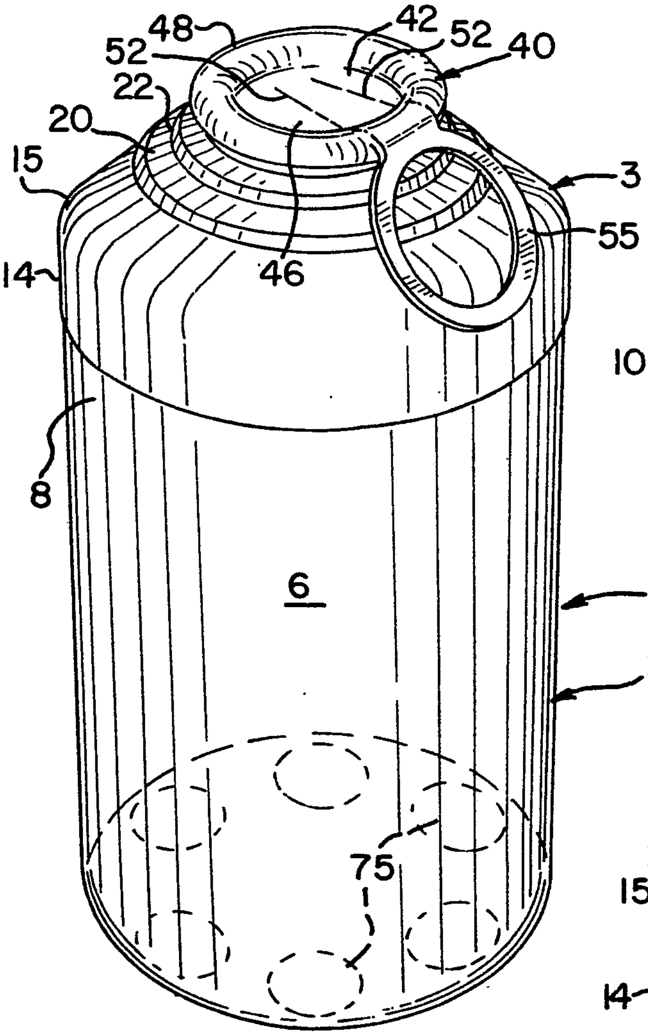


FIG. 8

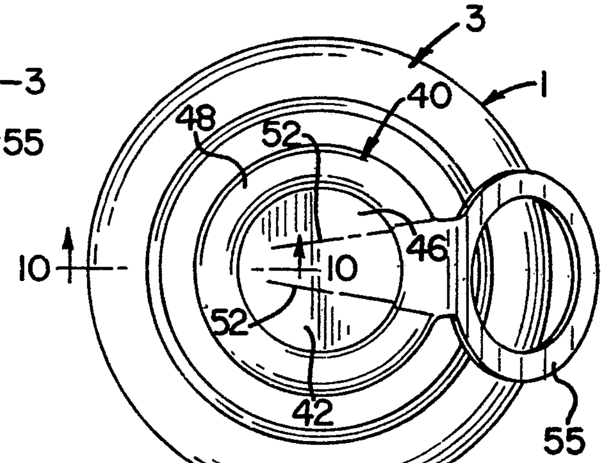


FIG. 9

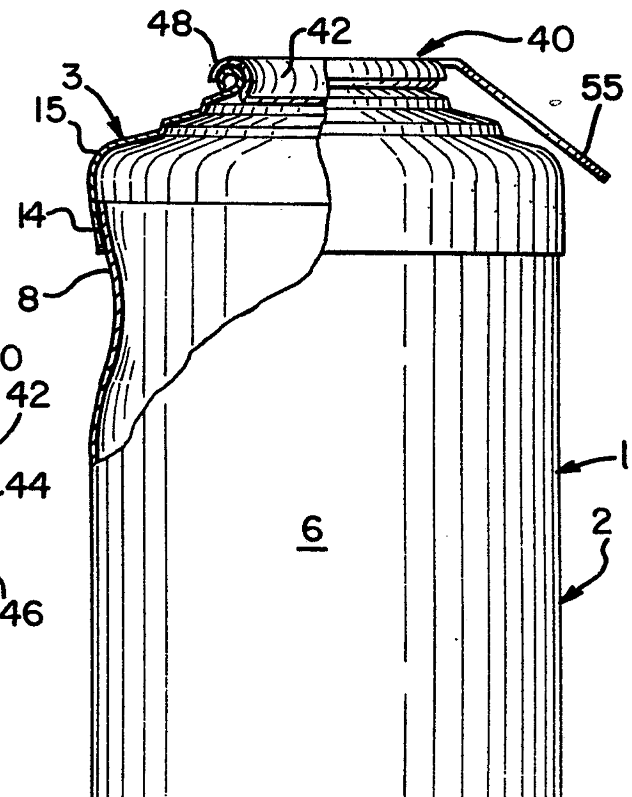


FIG. 10

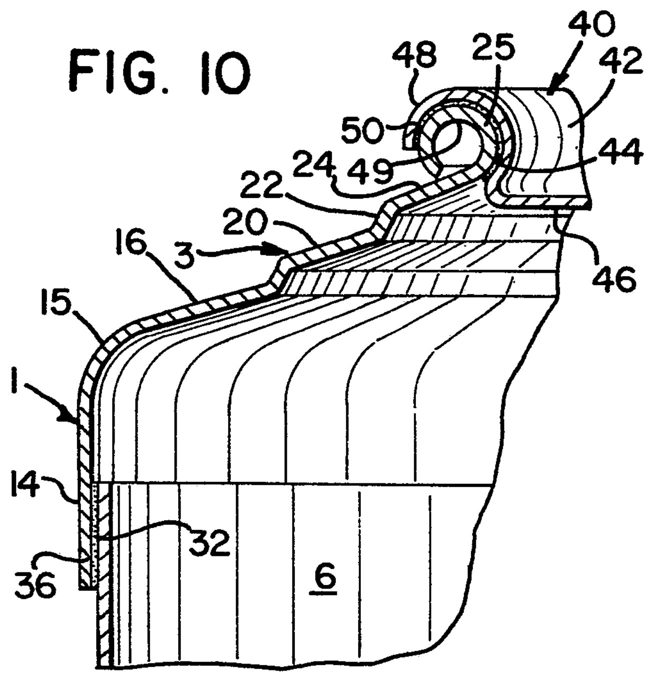


FIG. 11

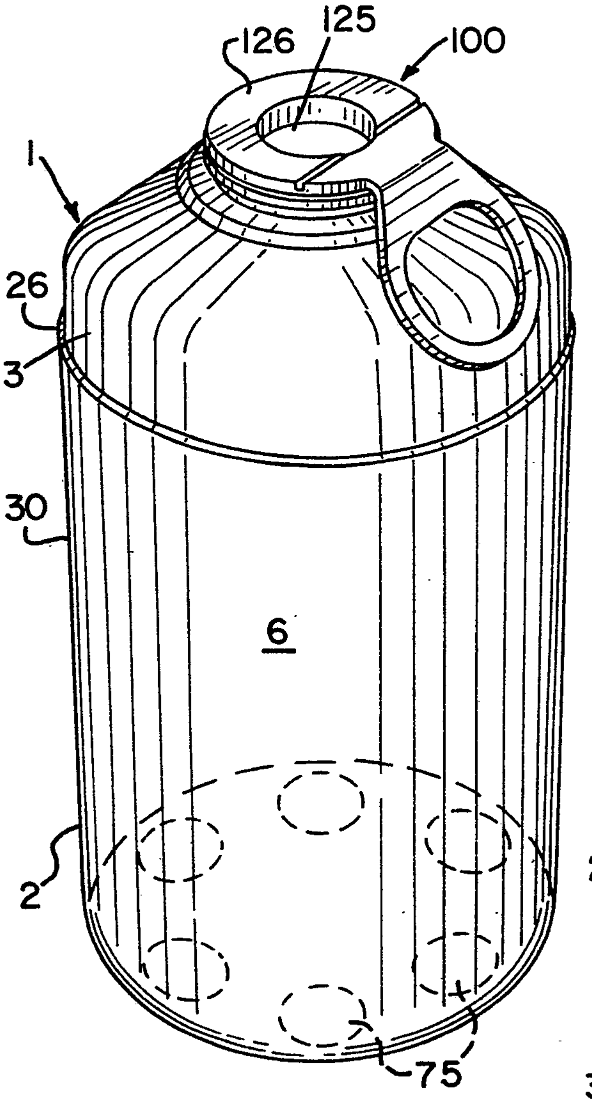


FIG. 12

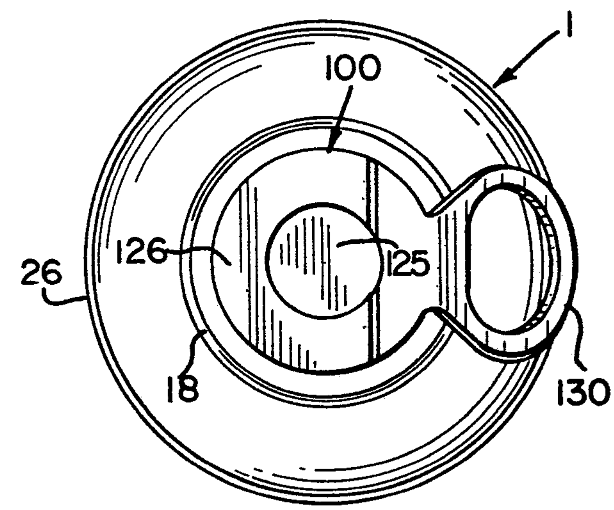


FIG. 13

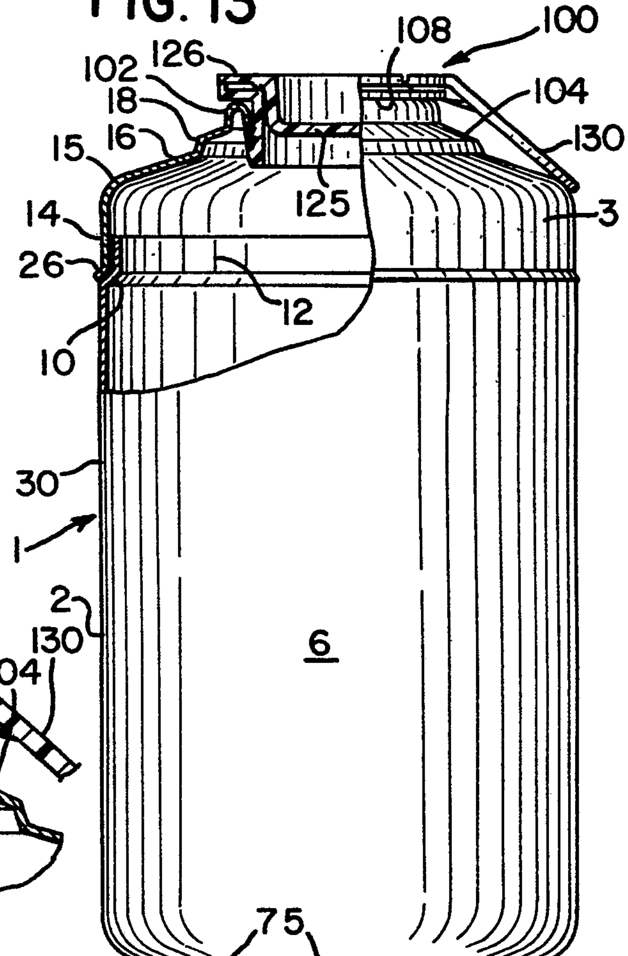


FIG. 14

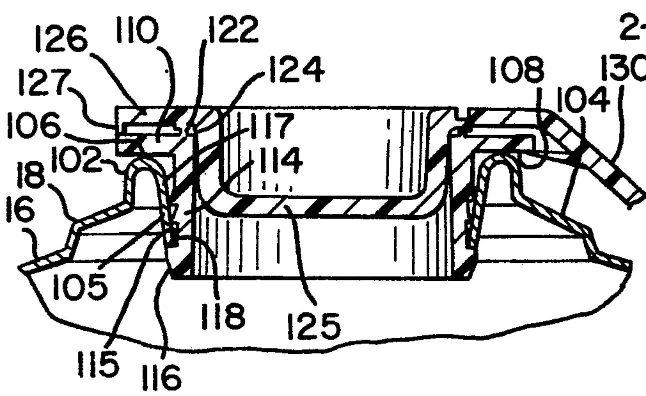
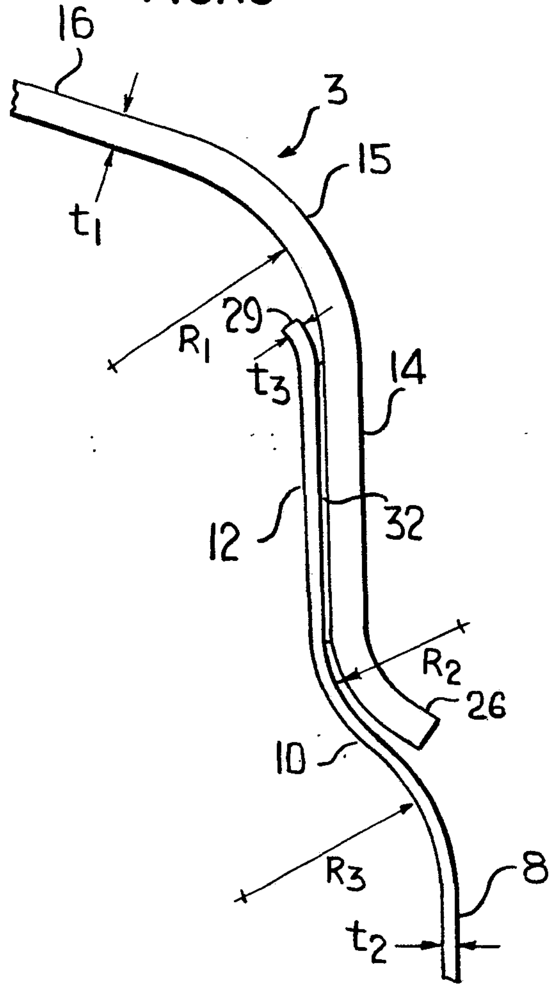


FIG. 15


16
3
15
t_1
R_1
29
t_3
14
12
32
R_2
26
10
R_3
8
t_2

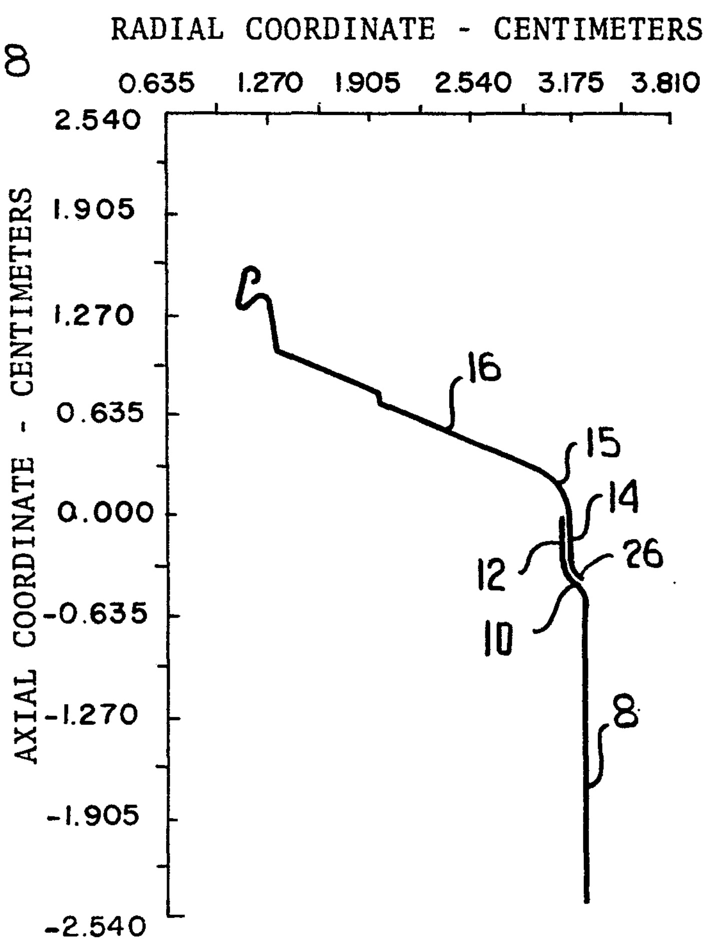

RADIAL COORDINATE - CENTIMETERS
0.635
1.270
1.905
2.540
3.175
3.810
AXIAL COORDINATE - CENTIMETERS
2.540
1.905
1.270
0.635
0.000
-0.635
-1.270
-1.905
-2.540
16
15
14
12
26
10
8

FIG. 16

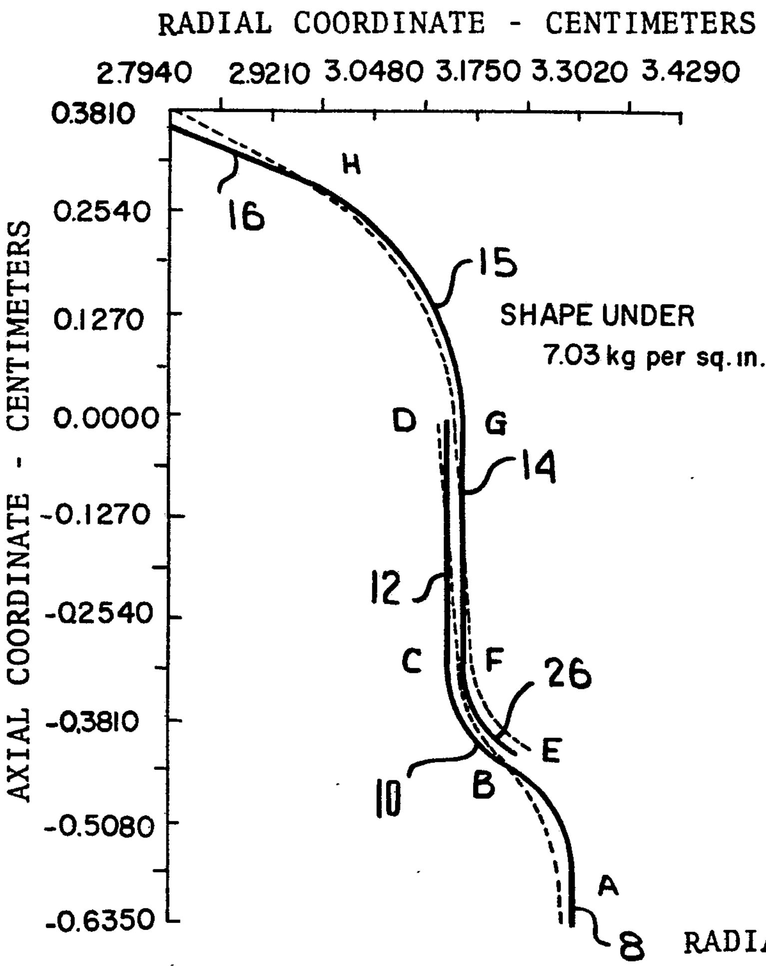

RADIAL COORDINATE - CENTIMETERS
2.7940 2.9210 3.0480 3.1750 3.3020 3.4290
AXIAL COORDINATE - CENTIMETERS
0.3810
0.2540
0.1270
0.0000
-0.1270
-0.2540
-0.3810
-0.5080
-0.6350
SHAPE UNDER
7.03 kg per sq. in.
H
16
15
D
G
14
12
C
F
26
E
10
B
A
8

FIG. 17

FIG. 18

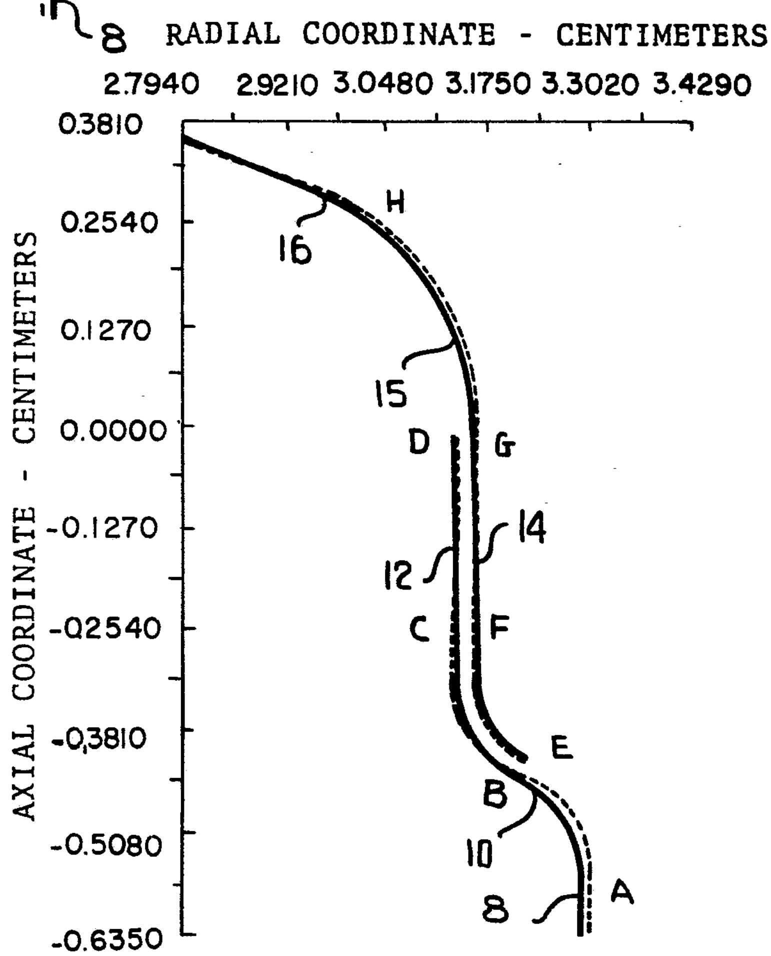

RADIAL COORDINATE - CENTIMETERS
2.7940 2.9210 3.0480 3.1750 3.3020 3.4290
AXIAL COORDINATE - CENTIMETERS
0.3810
0.2540
0.1270
0.0000
-0.1270
-0.2540
-0.3810
-0.5080
-0.6350
H
16
15
D
G
14
12
C
F
E
B
10
8
A

FIG.19

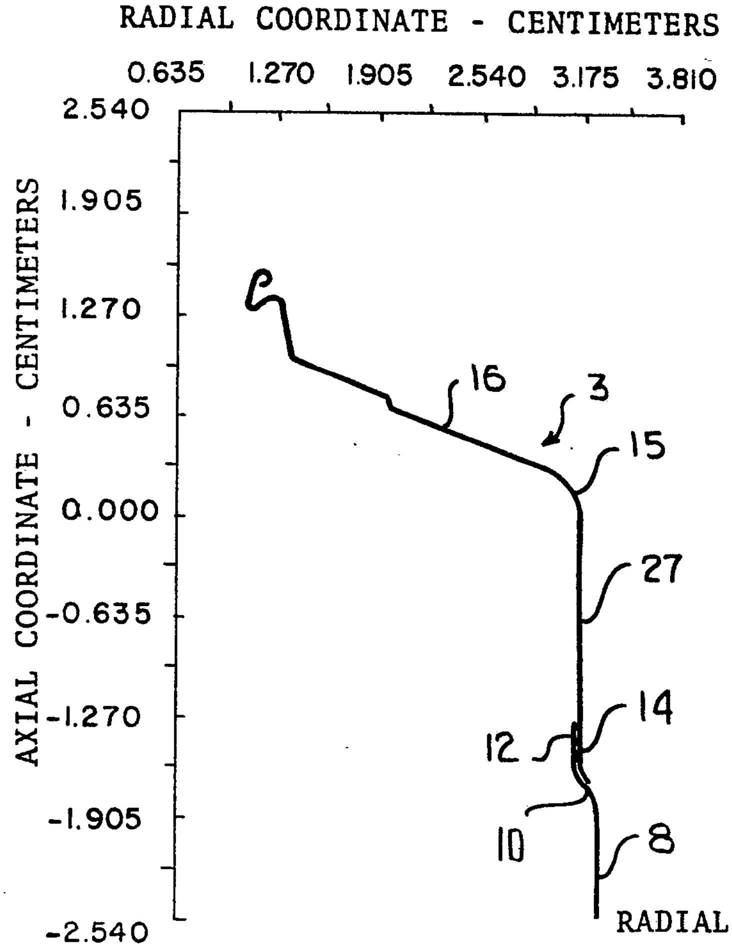

RADIAL COORDINATE - CENTIMETERS
0.635 1.270 1.905 2.540 3.175 3.810
AXIAL COORDINATE - CENTIMETERS
2.540
1.905
1.270
0.635
0.000
-0.635
-1.270
-1.905
-2.540
16
3
15
27
14
12
10
8

FIG. 20

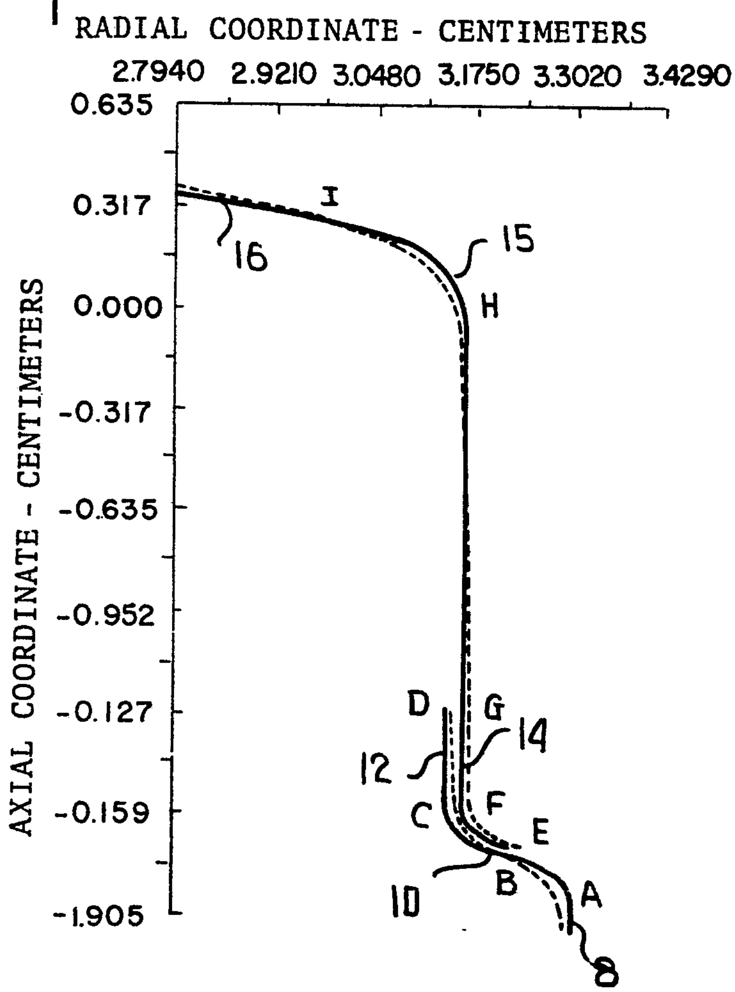

RADIAL COORDINATE - CENTIMETERS
2.7940 2.9210 3.0480 3.1750 3.3020 3.4290
AXIAL COORDINATE - CENTIMETERS
0.635
0.317
0.000
-0.317
-0.635
-0.952
-0.127
-0.159
-1.905
I
16
15
H
D
G
14
12
F
C
E
10
B
A
8

FIG.21

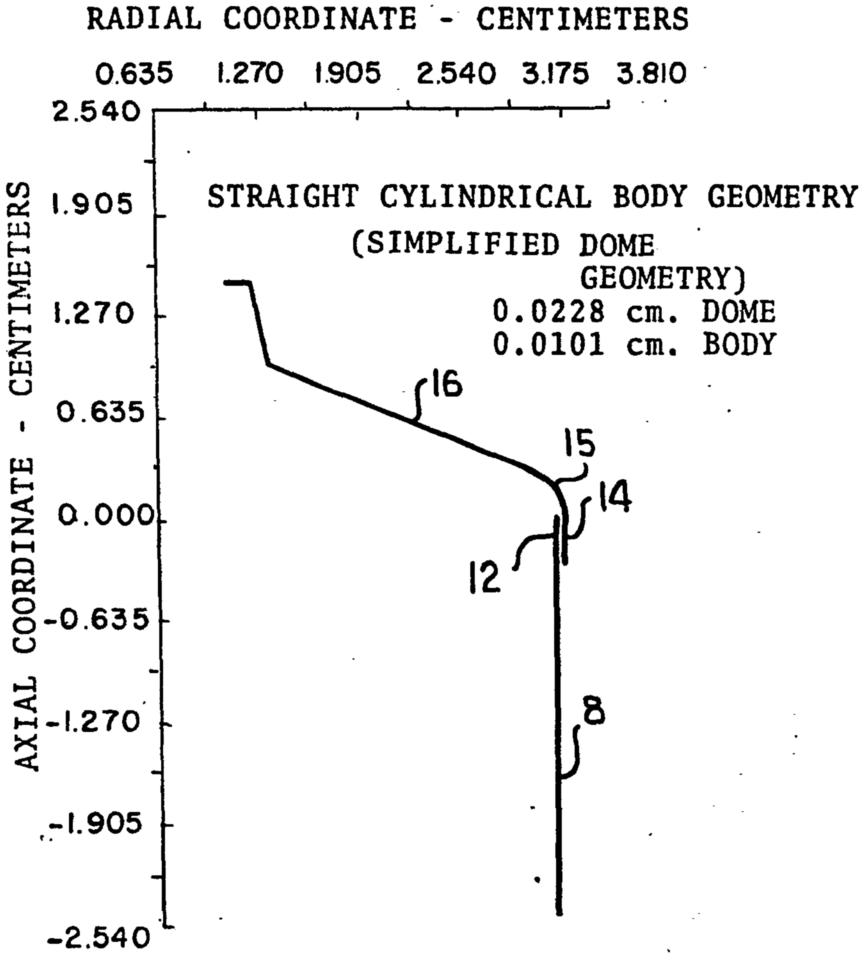
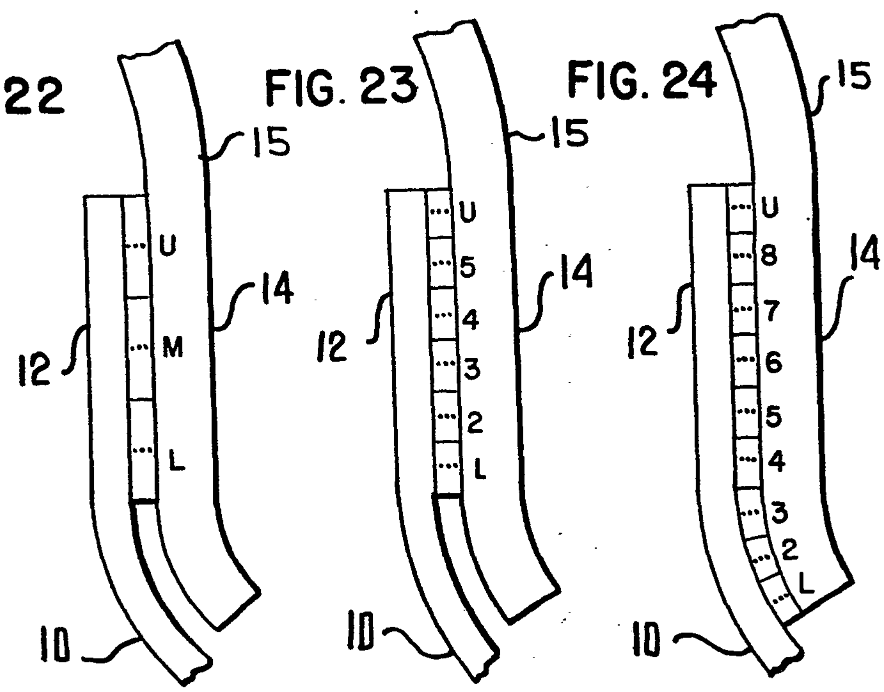


FIG. 22 FIG. 23 FIG. 24



European Patent Office

EUROPEAN SEARCH REPORT

0048890

Application number

EP 81107280.0

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int Cl)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	US - A - 2 384 810 (CALLESON) * Fig. 2,4 * ----	1	B 65 D 8/22
			TECHNICAL FIELDS SEARCHED (Int. Cl.)
			B 65 D 1/00 B 65 D 6/00 B 65 D 8/00
			CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
X	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document

Place of search	Date of completion of the search	Examiner
VIENNA	04-12-1981	JANC

EPO Form 1503.1 06.78