United States Patent [19]

Zundel

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[54] **FULL OPEN END AND METHOD OF MAKING**

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[21] Appl. No.: **325,361**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 195,095, Nov. 3, 1971, Pat. No. 3,712,503.

[52] **U.S. Cl.** ..... **113/121 C**; 113/15 A

[51] **Int. Cl.** **B21d 51/38**

[58] **Field of Search** ..... 113/15 R, 15 A, 121 C; 220/54; 72/347, 348, 349

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Attorney, Agent, or Firm—Dressler, Goldsmith, Clement & Gordon

[57] **ABSTRACT**

The present invention relates to a easy open end of the type that has a tab connection thereto by an integral rivet. The invention resides in an improved method for forming a weakened area or frangible connection between the permanent section of the panel and the removable section. The frangible connection in the panel is formed in such a manner that the removable section is relieved of any compressive forces that may have developed during the formation of the frangible connection. In addition, the removable section of the panel incorporates a further area of reduced cross-section that allows the tab and rivet to be pivoted relative to the removable panel section during initiation of rupture of the frangible connection and provides a vent for the inside of the container prior to the rupture of the frangible connection.

13 Claims, 12 Drawing Figures

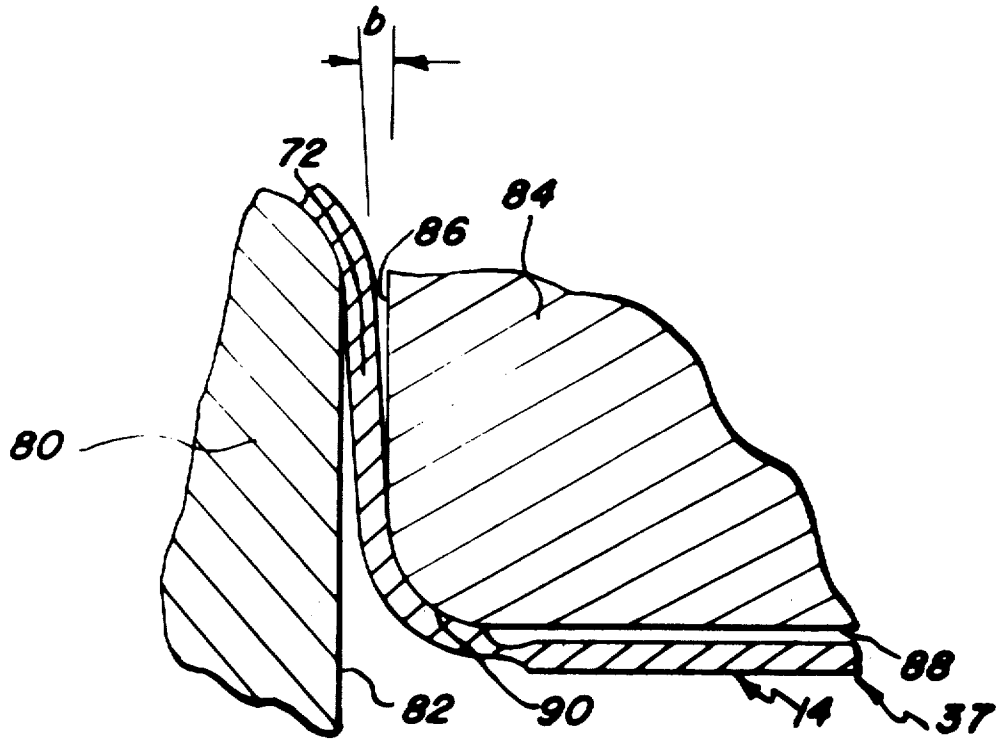


FIG. 1

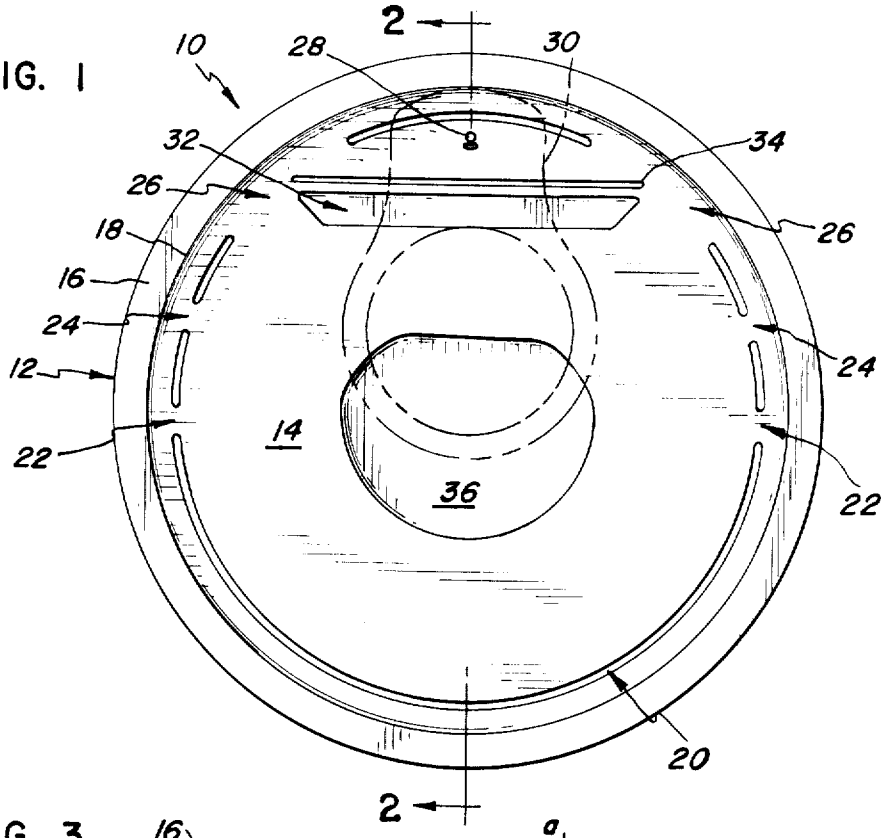


FIG. 3

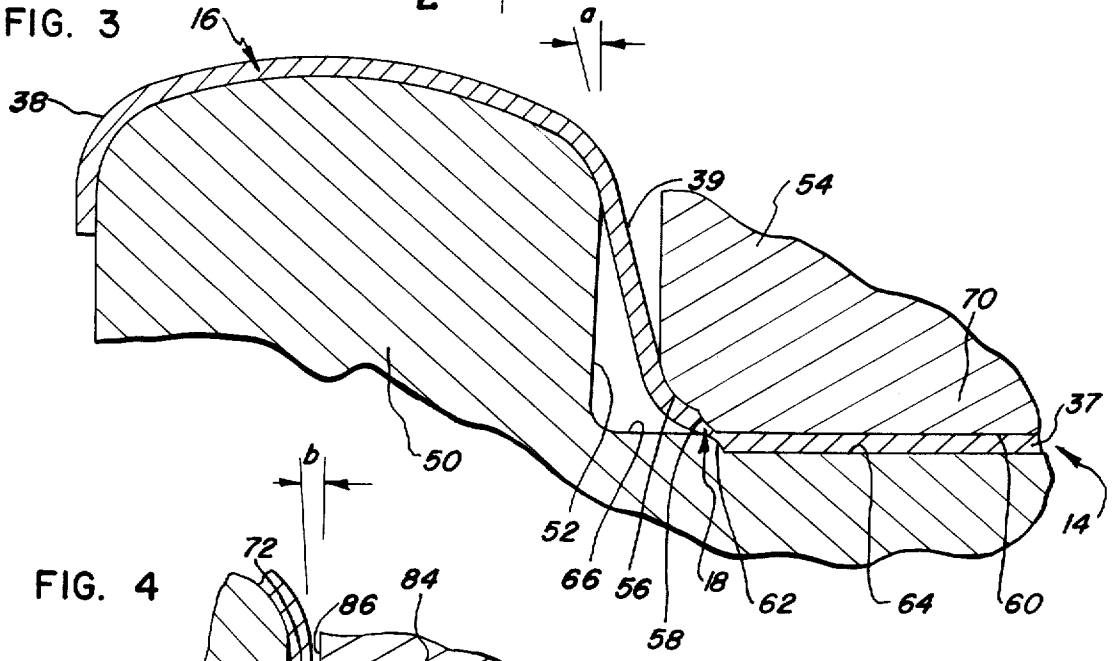


FIG. 4

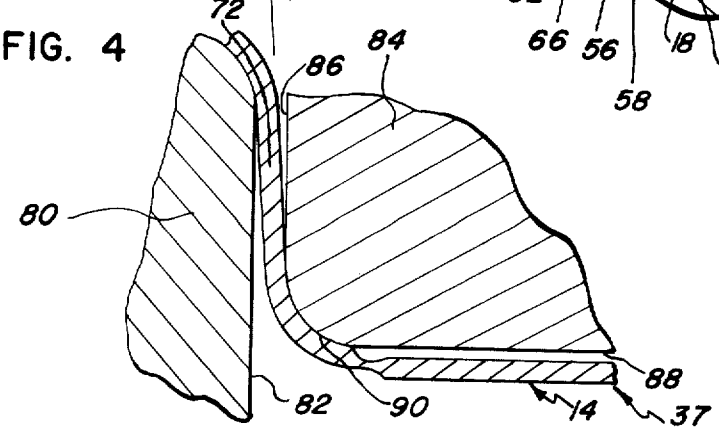


FIG. 2

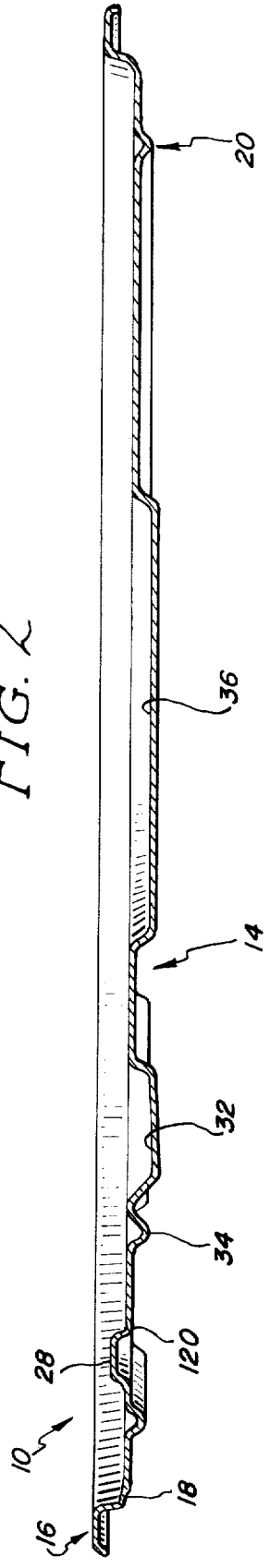


FIG. 9

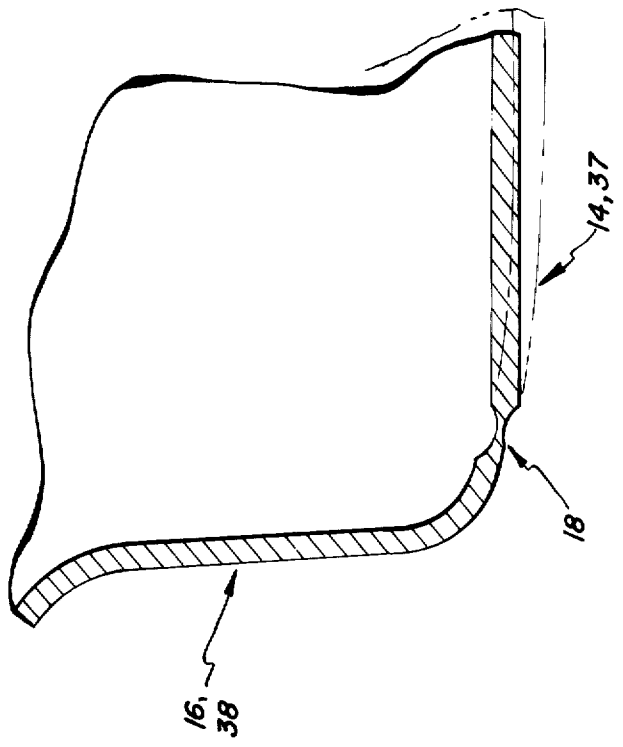
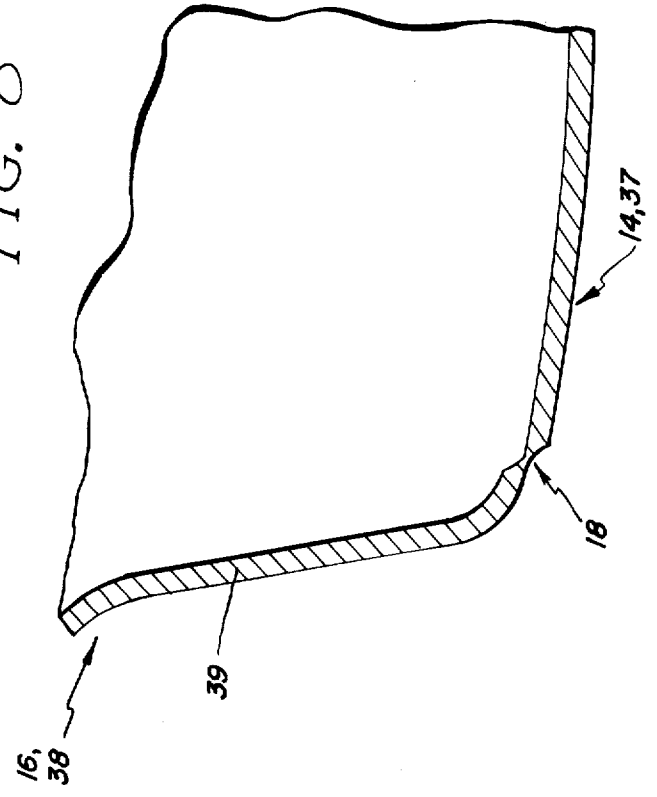


FIG. 8



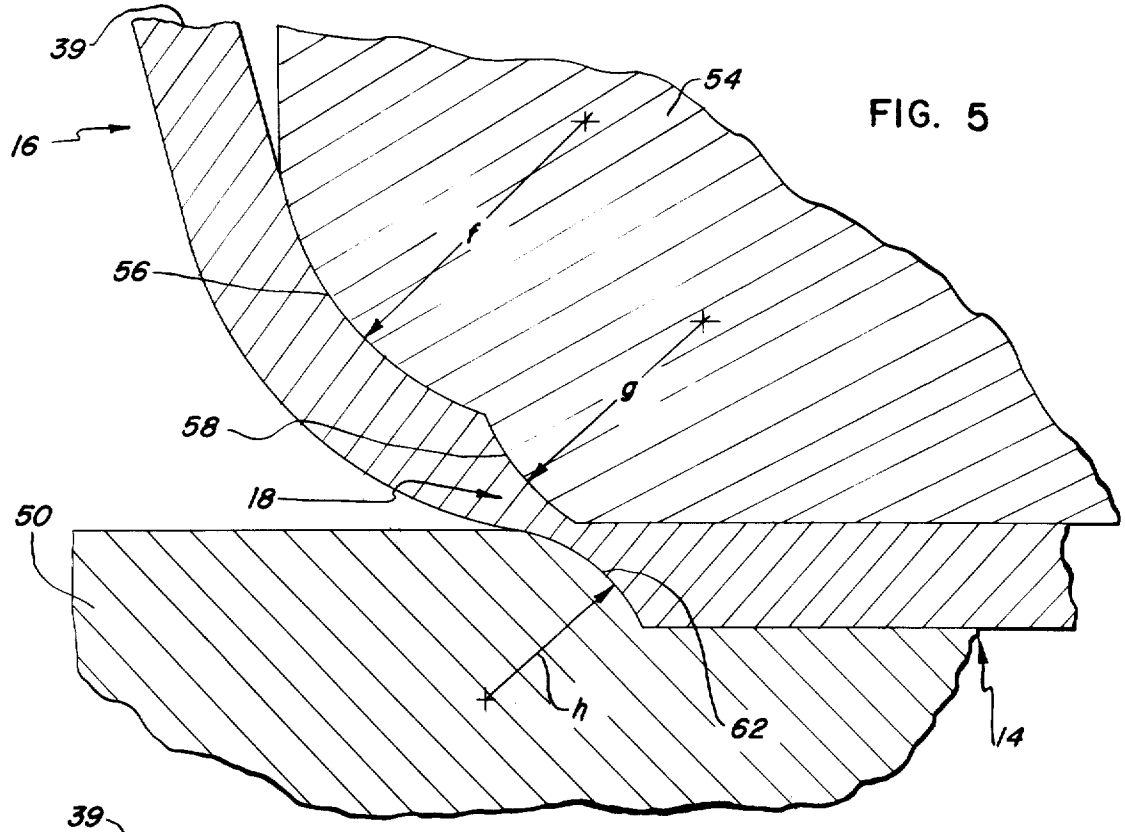


FIG. 5

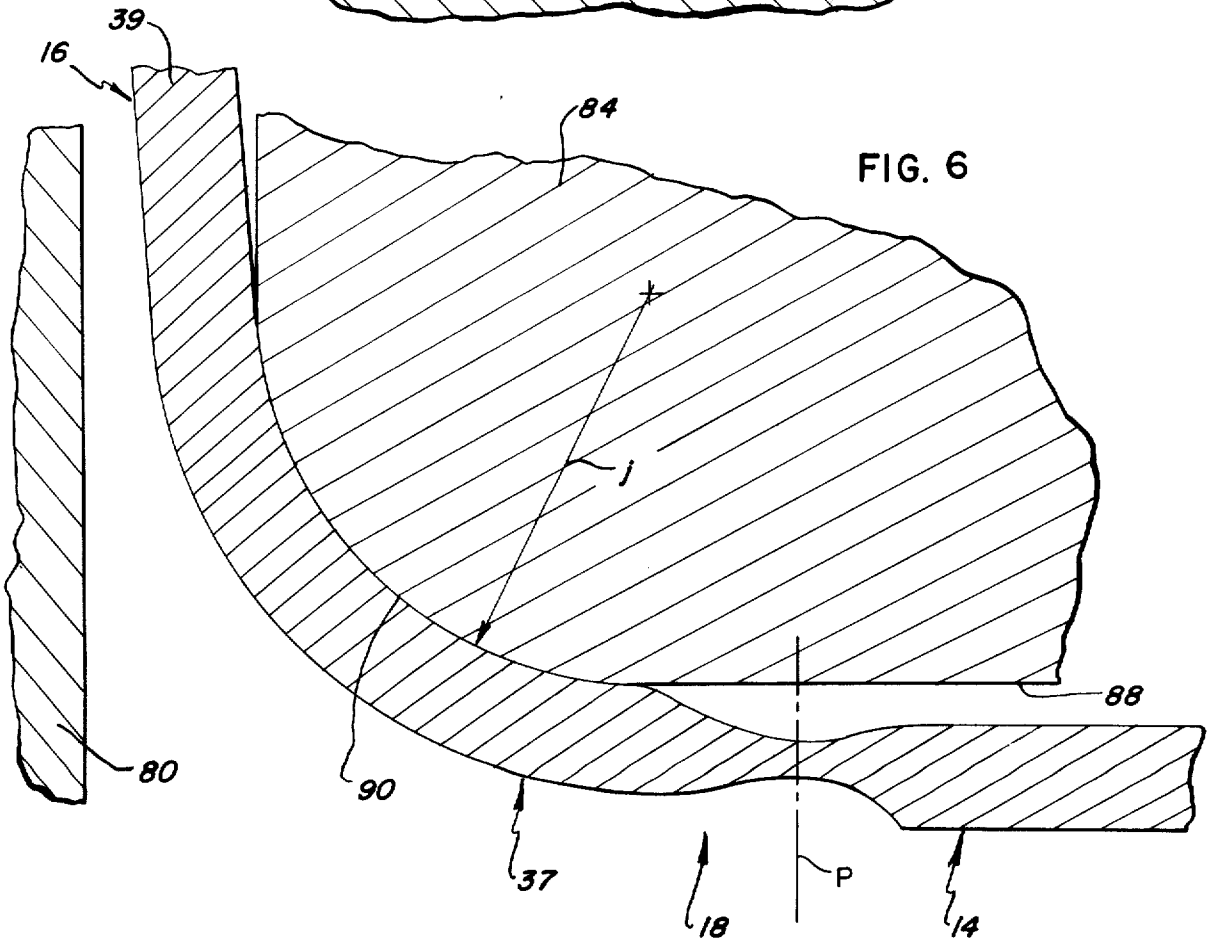


FIG. 6

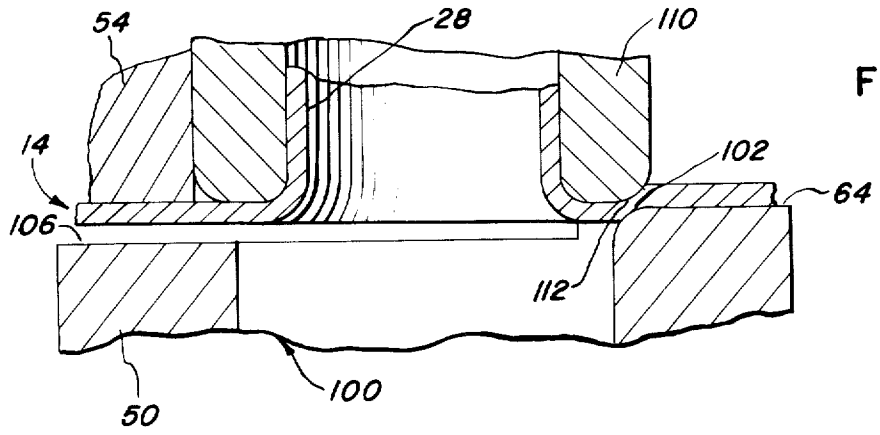


FIG. 10

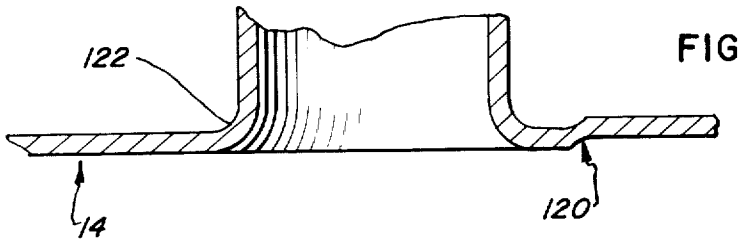


FIG. 11

FIG. 12

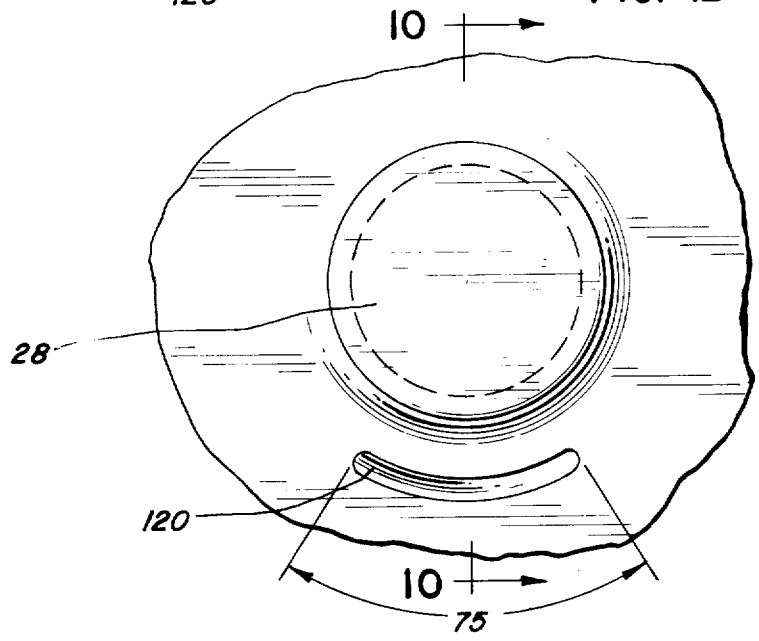
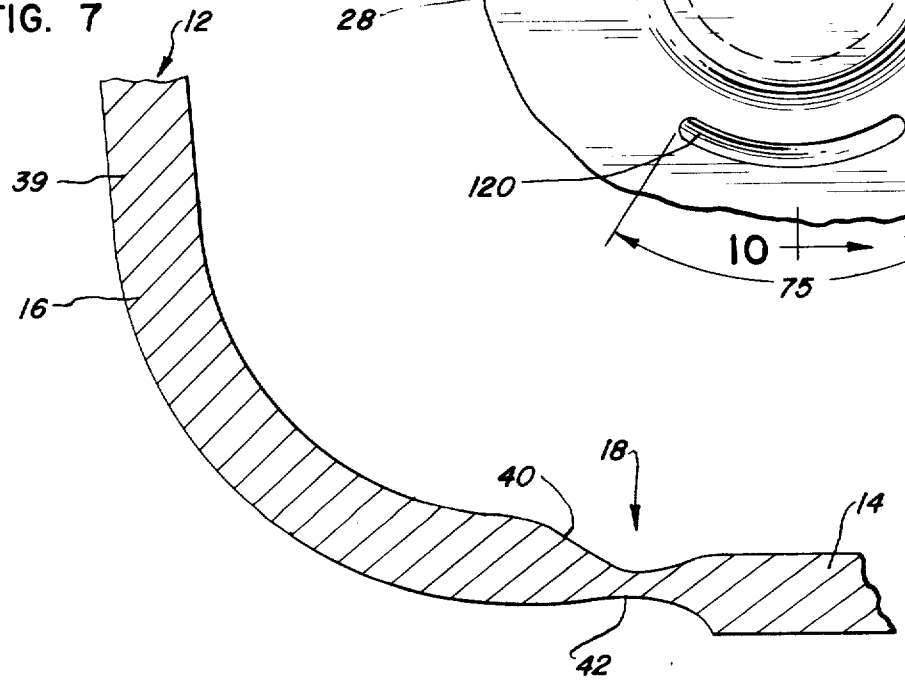


FIG. 7



FULL OPEN END AND METHOD OF MAKING

REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of application Ser. No. 195,095, filed Nov. 3, 1971 now U.S. Pat. No. 3,712,503.

BACKGROUND OF THE INVENTION

The present invention relates generally to container ends and more particularly to an improved fully open end.

Containers having easy open ends have become well-known in recent years and now enjoy a considerable measure of consumer acceptability. One type of easy open end is a full open end closure that normally includes an end panel that is permanently secured to one end of a container body by a permanent seam and has a weakened score line adjacent to permanent connection to define a removable section. An opening tab is secured to a portion of the removable section, normally through an integral rivet forming part of the removable section. Containers having full open ends are used for packaging various types of products, such as coffee, nuts, candy and foods containing liquid.

To separate the removable section from the permanently secured section, the opening tab is moved along a path by initially pivoting the tab towards the permanent seam to cause a downward movement of the portion of the removal section between the rivet and the score line to produce initiate rupture of the score line or weakened area. Subsequently, the tab is pulled in an opposite direction along a path away from the initially ruptured section until the entire score line has been ruptured and the removable section is detached from the permanent section.

As is explained in the above application, one difficulty encountered in full open end closures is that the severed edge of the removable section tends to become located under the adjacent edge of the permanently secured section during initial rupture of a portion of the weakened area of the score line, making it extremely difficult, if not impossible, to remove the entire closure.

In the co-pending application, it is explained that this is believed to be in part caused by loose metal in the removable section resulting from the scoring operation which forms the score line or weakened area that defines the removable portion of the end. This problem has been at least partially solved by providing a trough adjacent the rivet as well as a circumscribing bead located adjacent the weakened area to take up excess metal that is produced in the removable section during the formation of the finished end shown in the above application. As explained therein, the trough and circumferential bead also provides the advantage of preventing crowning between opposite edges of the removable section while it is being separated from the permanent section.

A further problem is that the normal scoring operation results in considerable stress concentration in the metal in the score line or frangible connection and often produces a small crack in the weakened area which thereby may result in fracture of the weakened area before it is desired.

In the normal scoring operation, the score line is produced by supporting one surface of the panel on a flat support and forcing a truncated V-shaped scoring member into the opposite surface of the panel. During the scoring operation, the metal that is located below the flat portion of the truncated V-Shaped scoring member is displaced substantially normal to the panel and results in the large stress concentration in the weakened area of the score line. It has been found that such a scoring operation normally results in at least a small crack adjacent either corner or edge of the reduced cross-section or weakened area which will enhance the possibility of fracture of the weakened area before desired. Stated another way, the portion of the metal directly below the flat surface of the scoring element will act as a slug that initially consists of a section of metal in the panel that has a thickness equal to the thickness of the panel and is reduced in thickness to that of the ultimate thickness of the weakened area.

The problem of producing a small crack or fracture in the weakened area of the removable end is particularly acute when utilizing a metal such as tin plate for the end. Normally, such metals must be surface coated on both surfaces of the panel to prevent the bare metal from being exposed to either the contents of the container or the surrounding atmosphere. When utilizing a scoring operation of the type described above, one or both surface coatings may be cracked or fractured during the scoring operation.

Another problem in the use of full open end closures has come to light when using containers with these types of closures for packaging certain products that are packaged at conditions other than atmospheric pressure. It has been found that when certain products, such as coffee, are packaged in containers of the type discussed above, the initial rupture of the score line will result in an immediate equalization of the pressure between the inside and outside of the container, which many times results in the product being forced from the container through the initially ruptured area of the score line.

SUMMARY OF THE INVENTION

The present invention contemplates the formation of a fully easy open end closure that is capable of being removed smoothly and with a minimum amount of force. The weakened area defining the removable section is produced in a manner to minimize the concentration of stress in the frangible portion of the panel. The end closure is deformed so that there is no excess metal in the removable section which may result in the adjacent edges of the removable section and the permanently secured section from being placed in overlapping relation. Also, the removable section of the end closure has a specifically located area of reduced cross-section or weakened area strategically located to act as a hinge in the panel allowing the tab that is connected thereto to be pivoted sufficiently to initiate rupture of the weakened area. The area of reduced cross-section may also be weakened sufficiently to initially fracture before the main weakened area to produce a vent to equalize the pressure between the inside and outside of the container before the weakened area defining the removable section is ruptured.

According to the broadest aspect of the present invention, the weakened area dividing the panel into a permanent section and a removable section is produced by engaging opposed surfaces of the panel with die elements having arcuate surfaces that allow the metal to flow from the weakened area that is being produced into the remainder of the panel to minimize the

stress concentration in the weakened area or frangible connection of the panel. The panel is then expanded in a direction generally parallel to the plane of the removable section to remove any compressive forces resulting from excess metal that is developed in the removable section of the panel during the formation of the weakened area.

More specifically, the method of the present invention forms a weakened area between a flange portion or rim and a base portion of a cup shaped panel. Initially the flange portion defines an acute angle with respect to a plane extending normal to the base portion of the panel and the step of expanding the panel is performed by engaging the flange portion adjacent the base thereof to reduce the size of the acute angle. This is accomplished by initially supporting the panel on a female die element that has a first opening defining a first diameter and engaging the opposite surface of the panel with a first male die element that has a second diameter less than the first diameter and subsequently, expanding the panel by engaging the other surface of the panel with the second male die element that has a diameter greater than the second diameter and less than the first diameter while supporting the panel on the female die element.

The end panel that is produced by the method described above, consists of an integral removable section that is defined by a weakened area of material formed in the panel which joins the removable section to an adjacent or permanent section of the panel and the weakened area has opposed concave surfaces which produce an area of constantly reducing cross-section from opposite edges towards the center of the weakened area. In addition, the radii of curvature of the opposed concave surfaces are substantially greater than the thickness of the panel and the weakened area has a dimension between the opposite edges that is greater than the thickness of the panel.

According to another aspect of the invention, the removable section of the panel has a substantially continuous circumferential bead in close proximity to the weakened area and the bead has pairs of interrupted portions at opposed locations that define bend lines during the severing of the weakened area to separate the removable section from the adjacent or permanent section. The bead portions or indentations also assist in taking up excess metal that may be developed during the deformation of the panel.

According to a further aspect of the invention, the removable section of the panel is connected to an opening tab or member by an integral circular rivet that is deformed from the main body of the removable section adjacent the weakened area and the removable section has an area of reduced cross-section adjacent the circular rivet on the side opposite the weakened area and in close proximity to the circular connection or rivet. The weakened area of reduced cross-section has opposed arcuate concave surfaces and the linear dimension between opposite ends is substantially equal to the diameter of the circular connection or rivet. The area of reduced cross-section defines a circular arc that has a radius coincident with the center of the rivet.

The reduced area adjacent the rivet will develope sufficient excess metal in the panel to allow the tab to be pivoted relative to the panel and initiate rupture of the frangible connection.

The area of reduced cross-section may be weakened sufficiently to rupture before the frangible connection in the panel and allow the pressure to equalize inside and outside the container before the frangible connection is ruptured. The particular configuration and location of the area of reduced cross-section insures that this area is initially ruptured while still retaining sufficient integrity between the removable panel and the rivet to insure that the tab is not separated from the removable section.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF DRAWINGS

FIG. **1** is a plan view of an easy open end of the type shown in the above mentioned application;

FIG. **2** is an enlarged section as viewed along line **2—2** of FIG. **1**;

FIG. **3** is an enlarged fragmentary sectional view showing the die element and the step of producing the weakened area;

FIG. **4** is a view similar to FIG. **3** showing another step in forming the container end shown in FIG. **1**;

FIG. **5** is an enlarged fragmentary sectional view similar to FIG. **3**;

FIG. **6** is an enlarged fragmentary sectional view similar to FIG. **4**, showing a relationship of the die elements and the panel adjacent the weakened area;

FIG. **7** is an enlarged sectional view of the weakened area and the panel sections on opposite sides of the weakened area;

FIGS. **8** and **9** are views similar to FIGS. **3** and **4** respectively showing the panel in its initially deformed condition and finally deformed condition;

FIG. **10** is an enlarged fragmentary sectional view of the die element and the panel as viewed along line **2—2** of FIG. **1** showing the formation of the rivet and area of the reduced cross-section adjacent the rivet;

FIG. **11** is a view similar to FIG. **10** showing the final configuration of the panel in the area of the rivet; and

FIG. **12** is a fragmentary enlarged plan view of the panel showing the rivet and the adjacent area of reduced cross-section.

DETAILED DESCRIPTION

While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail one embodiment, with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated.

FIGS. **1** and **2** of the drawings generally show the container end **10** that is formed in accordance with the teachings of the present invention. The container end or fully open end **10** is generally shown and described in the above mentioned co-pending application and consists of panel **12** that is divided into a removable section **14** and a permanent or adjacent section **16** interconnected along a weakened area or frangible connection **18**. The permanent section or rim **16** is adapted to be connected to the end of a container body by the usual double seam (not shown).

As explained in the above reference application, the removable section **14** of the easy open end has a substantially continuous bead **20** that circumscribes the entire periphery of the removable section and is located in close proximity a substantially constant dimen-

sion from the weakened area **18**. The bead **20** is interrupted at selected locations **22, 24** and **26** that define opposed pairs of interrupted portions to allow the removable section of the panel to be bent during the removal process.

The removable panel has an integral rivet **28** located adjacent one of the bead portions for connecting a tab thereto shown in phantom in FIG. **1**. The removable section **14** of panel **12** also has a trough **32** located adjacent the rivet **28** and further bead **34** between the trough and the rivet. In addition, the removable section **14** has a downwardly dished portion **36** that is deformed from the planar main body portion of the removable section to provide a small space between the upper surface of the removable section and the lower surface of the opening tab **30**.

As explained in the above mentioned application, the beads **20** and **34** as well as the trough **32** and the dished portion **36** take up excess metal that is developed during the formation of the weakened area **18** in panel **12**. Furthermore, the beads and trough cooperate to act as means for preventing crowning or bulging of the removable section during the opening process and the interruptions **22, 24** and **26** in the substantially continuous bead **20** will accommodate bending of the removable section during the opening process.

As was indicated above, the normal scoring operation to produce a weakened area that defines a frangible connection between the removable section and the permanently attached section of the panel results in an extreme concentration of stresses in the frangible connection between the two sections. To reiterate, the use of either of a sharp cutting tool or a truncated V-shaped cutting tool to produce the weakened area results in the tremendous concentration of stresses in the frangible connection or residual left between the panel sections which invariably results in small cracks developed in the frangible connection that weaken the connection.

According to the present invention, the frangible connection or weakened area between the two sections of the panel is produced in a manner that the material that must be displaced will flow into the main body of the panel without the compression of the material in a direction generally normal to the plane of the panel.

The configuration of the weakened area or frangible connection **18** is shown in enlarged detail in FIG. **7**. As will be seen from an inspection of FIG. **7**, the opposed surfaces of panel **12** are concave in the weakened area and are indicated by the reference numerals **40** and **42**. The concave surfaces **40** and **42** have radii that are located on opposite sides of the panel. While not all points of the respective surfaces are not located at the same point, because of the expansion of the panel, when considering the radii of the surface segments, they may be considered to have a common center.

The radii of curvature of the respective concave surfaces **40** and **42** are greater than the thickness of the panel and the centers of the two concave surfaces **40** and **42** are located so that the width of the weakened area **18** is greater than the thickness of the panel and the center or residual of the weakened area or frangible connection has a thickness substantially less than the thickness of the panel.

Also, it will be noted that the area between the removable panel section **14** and the adjacent section **16** is of constantly reduced cross-section towards the center of the reduced cross-section.

According to another aspect of the invention, the weakened area **18** is produced in such a manner that the removable section is devoid of any excess metal that would result in compressive forces being developed which would cause the severed edge of the removable section to expand under the adjacent severed edge of the permanent section during initial rupture of the weakened area **18**. The arcuate configuration of the opposed surfaces of the weakened area allows the metal to be displaced generally along the plane of the panel while the weakened area is being formed to substantially reduce the stressed concentration in the weakened area at that time. However, because a large amount of metal is displaced into the removable section of the panel, the excess metal develops compressive forces in the removable panel that will tend to cause the panel to expand when the weakened area is ruptured.

The method of the present invention contemplates initially forming a weakened area in the metal panel circumscribing the removable section and thereafter, expanding the panel in a direction generally parallel to the plane of the removable section to remove any excess metal that would develop compressive forces in the removable section. The two steps of deforming a flat panel to the final configuration shown in cross-section in FIG. **7** are generally shown in FIGS. **3** and **4**, while the details of the formation of the weakened area are shown in the enlarged views of FIGS. **5** and **6**. Prior to the formation of the frangible connection, the panel **12** has been deformed to a cup shaped configuration having a base portion **37** and a rim **38** and the base portion has rivet **28** formed therein. The rim **38** has a flange portion **39** that merges with the base portion through an arcuate segment (a portion of which is shown in FIGS. **3** and **5**). Flange portion **39** defines an acute angle (a) with respect to a plane extending normal to base portion **37**.

Referring to FIG. **3**, a cup shaped panel, such as tin plate having protective coatings on opposite surfaces thereof, is initially supported on a female die **50** that has an upwardly directed opening **52** which has an arcuate surface at the upper end thereof. The area of the female die element outside of the opening **52** is configured to conform to the peripheral edge of the rim, as shown in FIG. **3**.

The opposite surface of panel **12** is engaged with a male die element **54** that has an outside diameter which is smaller that the diameter of opening **52** and the lower end of the side wall of the male die element **54** has a first arcuate surface **56** that merges with a second arcuate surface **58** which in turn merges with the flat bottom surface **60** of the male die element.

The female die element also has an arcuate surface **62** that is upwardly spaced from the opening and is generally aligned with arcuate surface **58**. The area of the female die element **50** inside the arcuate surface **62** has a flat bottom wall **64** that is displaced downwardly with respect to the wall portion or ledge **66** between the wall of opening **52** and arcuate surface **62**.

When the die elements are moved towards each other, the cup shaped panel will be deformed in the area the base portion **37** and rim **38** to produce weakened area **18**. During this relative movement, the specific location of the centers of the two surfaces **58** and

62, and the fact that the surfaces engage the panel in the arcuate connections between base portion 37 and flange 39, will allow the metal to flow along the arcuate surfaces 58 and 62 rather than be compressed and produce the undesirable stress concentration in weakened area 18. At the same time the removal section 14 will be displaced downwardly relative to the rim or permanent section of panel 12. In the specific embodiment illustrated, the removable section is displaced by a dimension substantially equal to the thickness of the panel.

During the formation of the weakened area or frangible connection 18, it is desirable to have the rim 38 remain in a static condition. This is accomplished by making the radius of curvature of arcuate surface 56 equal to the radius of curvature of the arcuate connection between flange 39 and base portion 37. This will cause all of the metal that must be displaced from the weakened area to flow into the removable portion 14 of panel 12.

To eliminate the undesirable results of having excess metal in the removable section 14, the portion of the panel outwardly of the flange 39 is supported on a second female die element 80 having an opening 82 that is the same diameter as the opening 52 in the first female die element 50. However, opening 82 has a sufficient depth so that the removable section remains unsupported and the upper end of die element 80 has a configuration similar to die element 50.

The opposite surface of panel 12 is then engaged with male element 84, shown in FIG. 4, that has an outer surface or side wall 86 which has a diameter greater than that of die element 54 but less than the diameter of opening 82. Also, die element 84 has its side wall 86 merging with a flat bottom surface 88 along an arcuate surface 90 that has a radius of curvature greater than that of surface 56.

Moving die element 80 and 84 towards each other while rim or permanent section 16 is supported on die element 80 will cause the male die element 84 to engage the surface of flange portion 39 and expand the panel 12 along a plane extending generally through the body of the panel. During this expansion of panel 12, the size of the acute angle defined between flange portion 39 and a plane extending generally normal to the plane of the removable section 14 will be reduced and the removable section 14 will be displaced upwardly to the position shown in FIG. 4. This expansion will increase the size of the base portion or flat portion 37 of panel 12 and locate frangible connection 18 in the flat portion 37 while the outer edge of rim 39 remains in a static condition.

The advantages of the two step process of forming the weakened area will now be briefly summerized. During the first step, which may be called "cold swedging" all of the metal that is displaced from the weakened area flows into the removable section or base portion 14 of the panel and will result in excessive metal being located in the removable section which developes compressive forces that tend to expand the removable section. Thus, if the panel were to retain this configuration, during initial rupture of the score line, the compressive forces developed in the removable section would tend to expand the panel during the initial rupture of the weakened area or frangible connection and cause the severed edge of the removable section to be displaced under the adjacent severed edge of the permanent section 16. However, by subsequently expanding or sizing the area of the panel outside of the weakened area or frangible connection 18 that is shown in FIG. 6, will result in sufficient expansion of the removable section to remove any compressive forces developed in the removable section and, in fact in most instances, place the removable section in tension. If the removable section is placed in tension, the severing of the weakened area or residual 18 will allow the removable section to assume the non-stressed condition and thereby contract which will result in having the severed edges of the weakened area move away from each other. This arrangement insures that there is no possibility of overlapping the adjacent severed edges that would prevent removal of the panel.

It should be noted that during the expansion of the panel, the removable section is displaced in a general direction normal to the plane of the removable section and in a direction opposite or towards the male die element. Also, since the panel is engaged outside the weakened area or frangible connection, this frangible connection is placed in what may be termed the flat portion of the panel, i.e., inside the radius portion of the rim, as is clearly shown in FIGS. 6 and 7.

While the relative dimensions of the various radii and diameters are critical when considered with respect to each other, the specific dimensions that will now be described are for purposes of illustration only.

For example, deforming a metal panel having a thickness of 0.008 inch, the radius *f* in FIG. 5 would be on the order of 0.025 inch while the radius *g* would be on the order of 0.020 inch and the radius *h* of the female die element would be on the order of 0.014 inch. In addition, the radius *j* would be on the order of 0.032 inch.

With a panel initially deformed to a cup shaped configuration, wherein a flange 39 merges with the flat bottom wall or base portion 14 along a radius *f*, the panel would be deformed to produce the weakened area 18 located within the radius portion between the flange 39 and the base portion 14. At the same time, the base portion or removable section 14 would be displaced in a direction generally normal to the plane of the base portion 14 to the position shown greatly in FIG. 5.

With the die elements as described, the minimum thickness of the weakened area will be about 0.0025 inch.

It has been found that the utilization of the die assemblies, as described above, will allow an accurate control of the displacement of the main section of the panel and produce the thickness of the smallest area of the residual in the weakened area to a point that has heretofore been not possible. For example, the removable section can be displaced to a point where the residual is on the order of 0.001 inch and still have a rigid connection between the removable section and the permanent section. This is believed to be a result of the particular configuration of the die elements which readily allows the metal that is being displaced to flow from the weakened area rather than be compressed and result in the stressed conditions heretofore known.

It should be noted that the final position of the removable section relative to the permanent section, i.e., the offset, will be determined by the diameter of male die element 84 and the radius of curvature of surface 90. It will be appreciated that the removable section will seek its own level since it is free to move.

While the removable section has been shown to be displaced downwardly in the cold swedging operation, in certain instances it may be desired to displace the removable section **14** upwardly during the formation of the frangible connection. By changing the figuration of the respective die elements, the removable section can be displaced upwardly by the same amount as is shown in FIG. **5**, and then the panel could be expanded by engaging the radiused portion of the flange portion of the rim outwardly to expand or stretch the panel and result in the same final configuration of the panel that is shown in FIG. **6**, except that the removable section would be displaced upwardly by the predetermined amount shown in FIG. **6**. This arrangement would have the advantage of completely eliminating any possibility of overlap between the severed edges of the weakened area during the pulling phase of removal of the removable section.

It should be noted that when the end panel **10** is attached to the main body of the container by the double seam process, the panel, more particularly, the base portion thereof, will be further expanded to increase the tension of the metal in the removable section.

In the final configuration, a plane *p* extending through the minimum cross-sectional area or residual of the frangible connection **18** will define an angle of substantially 90° with respect to the plane that extends through the main body of panel portion **14**. This further insures that the severed edge of the residual in the removable section will be able to move above the adjacent severed edge on the permanent section **16** during the rupture of the weakened area.

All of the excess metal in removable section can be removed in the sizing operation to eliminate any compressive forces in removable section **14** by proper selection of angles *a* and *b* in FIGS. **3** and **4**, so that the removable section assumes the position shown in solid line in FIG. **9**. However, in forming end **10**, shown in FIG. **1**, only a portion of the excess metal in removable section is removed during the sizing operation. For example, flange **39** initially defines an angle *a* of approximately 15° and the final angle *b* in FIG. **4** is approximately 4°. This will take up some excess metal in removable section **14** and change the dished configuration of removable section **14** from the position shown in FIG. **8** to the dotted line position of FIG. **9**. The remainder of the excess metal will be removed during the profiling step that will now be described.

After the panel **12** has been reshaped as described above, further die elements are utilized to deform the removable section **14** and produce the portions of beads **20** and **34** as well as a trough **32** and the dished portion **36**.

Beads **20** and trough **32** produce means for preventing crowning of the removable section of the panel between opposite points during the severing of frangible connection or weakened area **18**. The formation of bead **20** and trough **32** as well as bead **34** and dished portion **36** will take up the remainder of the excess metal in the removable section during the deforming of the panel into final configuration shown in FIG. **2**.

According to a further aspect of the present invention, a hinge is formed in the removable section of the panel for allowing the tab connected to the rivet to be pivoted and cause the nose portion of the tab to initiate the rupture of the weakened area between the rivet and the adjacent rim. It has been found that some type of hinge connection adjacent the rivet is necessary to allow the handle or lever to be pivoted during the initial rupture of the weakened area to produce the initial rupture in the frangible connection. It has been found to be advantageous to utilize a cold swedging technique similar to the cold swedging technique in producing the frangible connection **18** in an area adjacent the rivet but on a side opposite that of the weakened area. This will cause the metal to be displaced or flow into the panel adjacent the rivet and the excess metal will allow the lever or pull tab to be pivoted sufficiently during the first phase of removing the removable section and produce the initial rupture of the weakened area. A further advantage of the area of reduced cross-section adjacent the rivet is that reducing the residual left in the area of reduced cross-section will insure that the reduced area is severed during the initial pivotal movement of the lever so that this area acts as a vent to equalize the pressures between the inside of the container and the surrounding atmosphere before the weakened area **18** is initially ruptured. The details of this aspect of the invention are shown in FIGS. **10** to **12**.

Before the cold swedging operation described above in connection with FIG. **5**, the rivet **28** has previously been formed in the removable section of the panel through a multiple stage process that is well-known in the art. In order to produce the area of reduced cross-section or "smile" in a selected area surrounding the rivet **28**, the wall defining an opening **100** in female die element **50** has an arcuate surface **102** that interconnects the wall of opening **100** with the upper surface **64** of die element **50**, while the remainder of the upper surface of the die element has a cutout portion **106** in the area of rivet **28**. The male die element **54** has an annular member **110** that has an inner diameter opening equal to the outer diameter of the rivet **28** with the portion of the annular member **110** that is opposed to arcuate surface **102** also having an arcuate surface **112**.

Thus, during relative movement of die elements **50** and **54**, towards each other, the **102**, **112** in the panel located between the opposed arcuate surfaces **102**,**112** is cold swedged to produce an area of reduced cross-section **120** shown in FIG. **11**. The metal that is displaced to produce the area of reduced cross-section flows into the adjacent portion of the removable section **14** to result in excess metal being located adjacent the reduced area cross-section. This excess metal will allow the rivet having the tab connected thereto to be pivoted with respect to removable section **14**. The excess metal that is developed during the cold swedging operation to produce the area of reduced cross-section **120** will allow sufficient pivotal movement of the tab to produce the initial rupture of the weakened area or frangible connection **18** at a location adjacent the rivet.

If desired, the area of reduced cross-section can perform the additional function of providing a vent that will allow equalization of the pressures on opposite sides of removable section **14** before weaking area **18** is ruptured. This can be accomplished by reducing the residual in the area of reduced cross-section **120** to a point where the reduced area or residual **120** will be ruptured before the weakened area **18** is initially ruptured.

According to another aspect of the invention, the particular dimension of the area of reduced cross-section has been found to be critical. It has been found

that if the area of reduced cross-section, in plan view as viewed in FIG. **12**, is arcuate and defines an arc of less than 90° sufficient metal will be deformed in the area of reduced cross-section into the adjacent portion of the panel to allow the rivet to be pivoted relative to the panel sufficiently to produce the initial fracture of the weakened area and, if the area of reduced cross-section is made thin enough, this area will also rupture during this pivotal movement to provide pivot action.

As most clearly shown in FIG. **12**, the area of reduced cross-section **120** circumscribes an arc of approximately 75° and the arc has its radius coincident with the center of rivet **28**. Stated in another way, the linear dimension between opposite ends of the area of reduced cross-section is substantially equal to the diameter of the rivet **28**.

In the above description, the die elements utilized for the cold swedging step and the sizing step were considered to be two separate sets of die elements. However, it will be appreciated that a single set of die elements having relatively movable parts could readily be used. For example, female die elements **50** and **80** could be one die element in which a portion having arcuate surface **62** could be lowered after the panel is deformed to the configuration of FIG. **5**.

What is claimed is:

1. A method of producing a container end with a removable section comprising the steps of: forming a weakened area in a panel circumscribing the removable section with a substantial portion of the displaced metal flowing into said removable section; and expanding the panel in a direction generally parallel to the plane of the removable section to displace the excess metal developed in the panel during the formation of the weakened area.

2. A method as defined in claim **1**, in which the weakened area is produced by engaging opposed surfaces of the panel with elements having opposed arcuate surfaces.

3. A method as defined in claim **1**, in which said removable section is displaced in a direction generally normal to the plane of the panel during the formation of the weakened area and the removable section is displaced in the opposite direction during the expansion of the panel.

4. A method as defined in claim **1**, in which said panel has a flange portion outside the weakened area and said flange portion defines an acute angle with respect to a plane extending normally to the plane of the removable section and in which the size of the acute angle is reduced during the expansion of the panel.

5. A method of producing a container end with a removable section and a flange portion outside the weakened area comprising the steps of supporting a panel with one surface on a female die element having a first opening with a first diameter, engaging the opposite surface on the panel with a first male die element having a second diameter less than the first diameter to produce a weakened area in the panel circumscribing the removable section with said flange portion defining a small acute angle with respect to a plane extending normal to the plane of the removable section, subsequently engaging the opposite surface of the panel with a second male die element having a diameter greater than the second diameter and less than the first diameter to expand the panel in a direction generally parallel to the plane of the removable section and reduce the size of the acute angle to displace excess metal developed in the panel during formation of the weakened area.

6. A method as defined in claim **5**, in which the weakened area is produced by opposed arcuate surfaces on the female and male die elements to displace metal from the weakened area to the removable section of the panel.

7. A method as defined in claim **5**, in which the first male die has an arcuate surface on the lower end that has a first radius and the second male die has an arcuate surface at the lower end that has a second radius which is larger than the first radius.

8. A method of producing a metal container end having a removable section and a rim surrounding the removable section comprising the steps of deforming a panel that has a base portion and a peripheral flange portion angularly related to the base portion to produce a weakened area adjacent the juncture of the base portion and the flange portion; and expanding the panel to increase the size of the base portion and locate the weakened area of the panel in the base portion.

9. A method as defined in claim **8**, in which the step of expanding the panel is performed by supporting the panel adjacent the upper edge of the flange portion with a die element and the flange portion is engaged with a second die element adjacent the base of the flange portion outside the weakened area to change the angular orientation of the flange portion relative to the base portion.

10. A method as defined in claim **8**, in which said removable section has a hollow connecting member deformed from the panel adjacent the rim and the weakened area is produced between the rim and the connecting member and in which the panel is deformed in the area of the panel adjacent the hollow connecting member and opposite the weakened area to produce an area of reduced cross-section.

11. A method as defined in claim **10**, in which the area of reduced cross-section circumscribes an arc of less than 90° and is concave in cross-section.

12. A metal container end produced by the method of claim **8**.

13. A container end produced by the method of claim **1**.

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