United States Patent [19]

Urmston

[11] **3,929,251**

[45] **Dec. 30, 1975**

[54] **CONTAINER WALL WITH RUPTURABLE WEAKENING LINE**

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[73] Assignee: **Aluminum Company of America,** Pittsburgh, Pa.

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[21] Appl. No.: **357,937**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 281,541, Aug. 17, 1972.

[52] **U.S. Cl.** ..... **220/268;** 113/121 C; 215/253

[51] **Int. Cl.²** **B65D 17/00**

[58] **Field of Search** ..... 220/27, 48, 268, 266, 276; 113/121 C; 215/253

[56] **References Cited**

UNITED STATES PATENTS

2,210,225	8/1940	Walensky	220/266
3,221,924	12/1965	Harvey et al.	220/271
3,227,304	1/1966	Asbury	220/48
3,292,826	12/1966	Abplanalp	270/89 A
3,362,569	1/1968	Geiger	220/27
3,362,570	1/1968	Geiger	220/27
3,638,825	2/1972	Franek et al.	220/27
3,730,381	5/1973	Franek et al.	220/27
3,759,206	9/1973	Dalli et al.	220/27
3,779,417	12/1973	Klein	220/27

FOREIGN PATENTS OR APPLICATIONS

400,823	8/1909	France	220/266
810,309	3/1937	France	220/268
422,052	12/1934	United Kingdom	220/270
1,147,182	4/1969	United Kingdom	220/265
1,964,091	12/1969	Germany	220/266

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Assistant Examiner—Allan N. Shoap
Attorney, Agent, or Firm—David W. Brownlee, Esq.

[57] **ABSTRACT**

An improved method of forming and a construction for a digitally openable container closure. Included therein is a container wall having an inwardly displaceable opening panel defined by a fracturable web which has been formed by selectively displacing metal adjacent a predetermined line substantially perpendicular to the surface of the container wall and by extruding metal between substantially parallel die surfaces which are disposed at an angle to the plane of the container wall. Formed concurrently therewith is an integral inclined deflectable portion projecting outwardly from the container wall adjacent the fracturable web and which deflectable portion is adapted to effect, in response to digitally applied inwardly directed pressure, a relative displacement between the rim of the panel and the lip of the adjacent container wall to selectively strain the web and initiate fracture thereof to permit inward displacement of an opening panel of greater extent than the size of the opening formed in the container wall by the separation of said panel.

24 Claims, 10 Drawing Figures

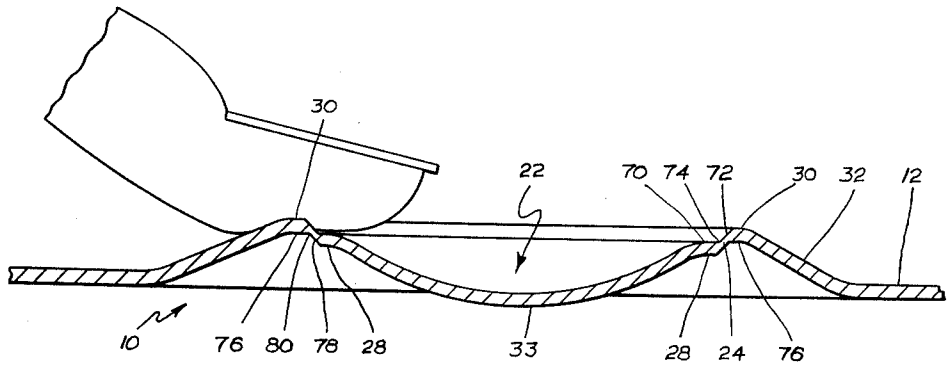

FIG. 1.

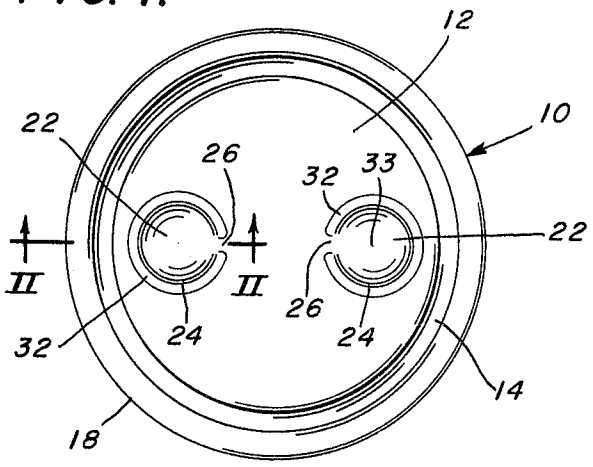

FIG. 2.

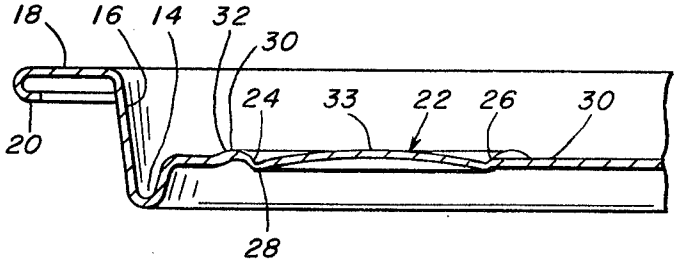

FIG. 3.

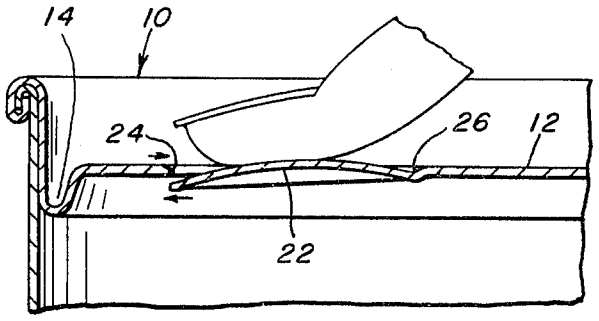

FIG. 4.

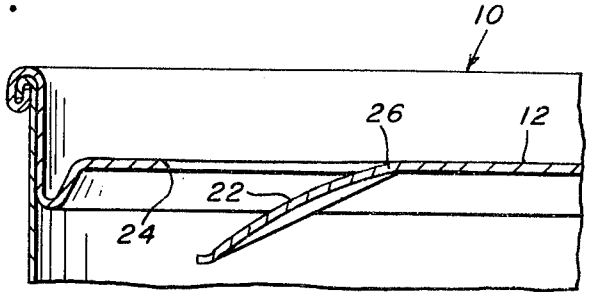

FIG. 5.

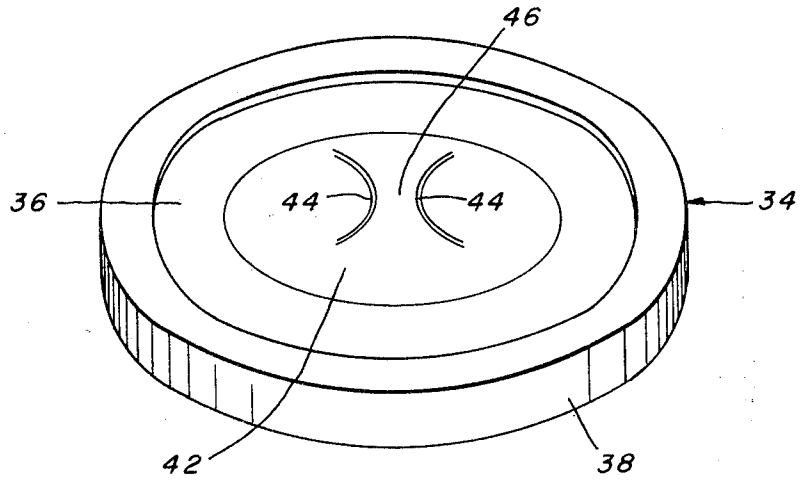

FIG. 6.

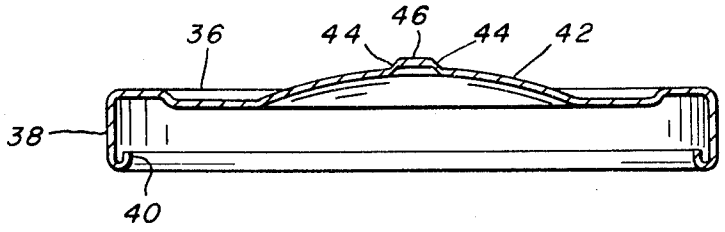

FIG. 7.

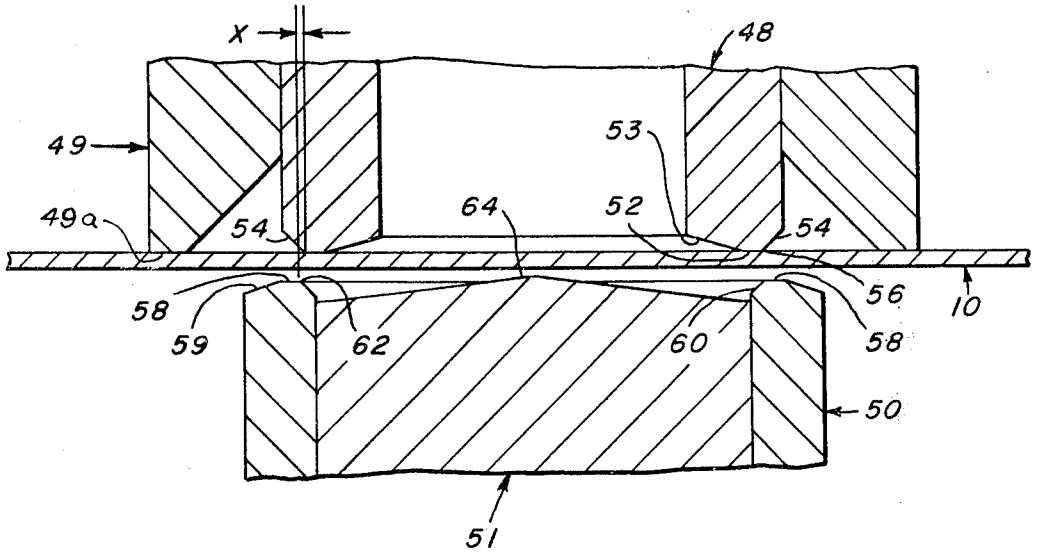

FIG. 8.

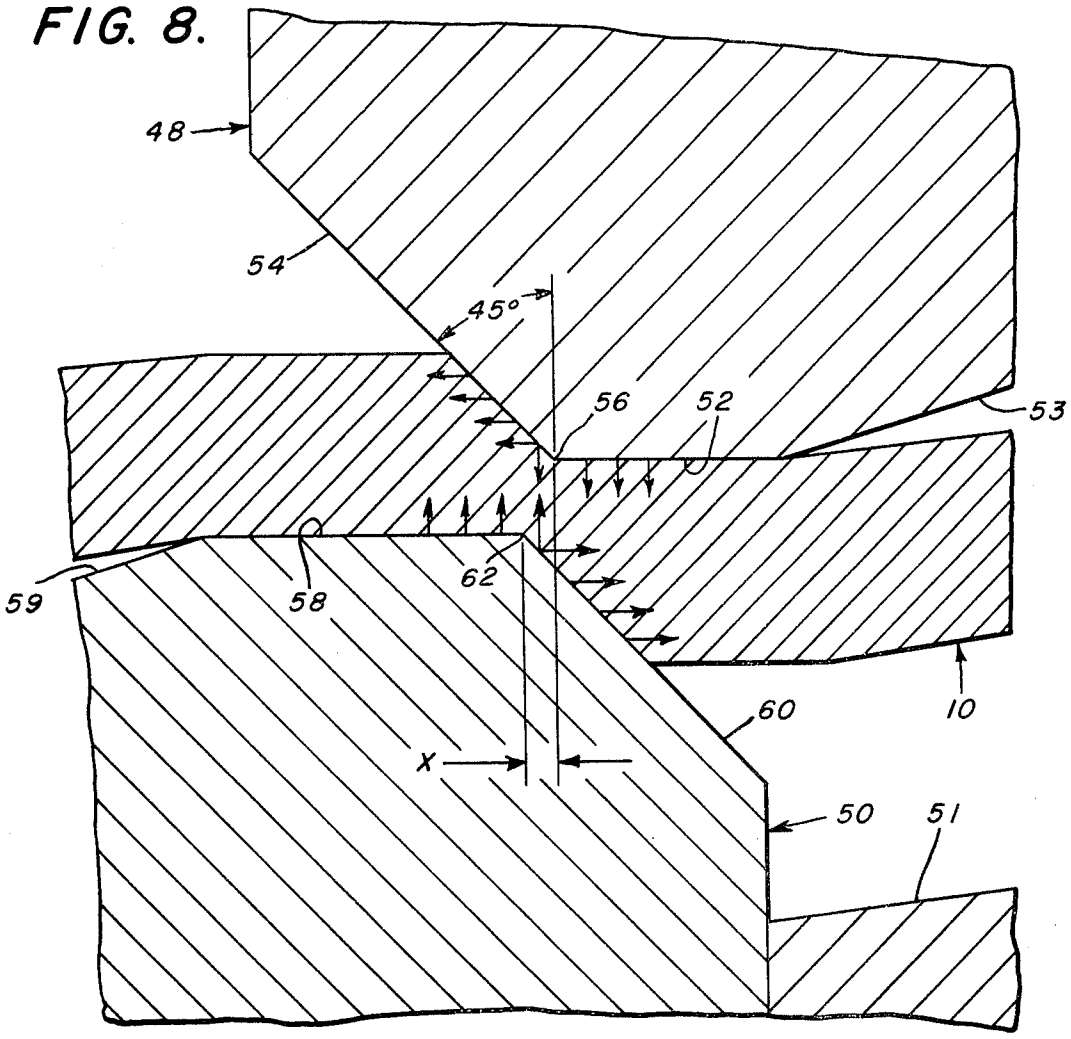
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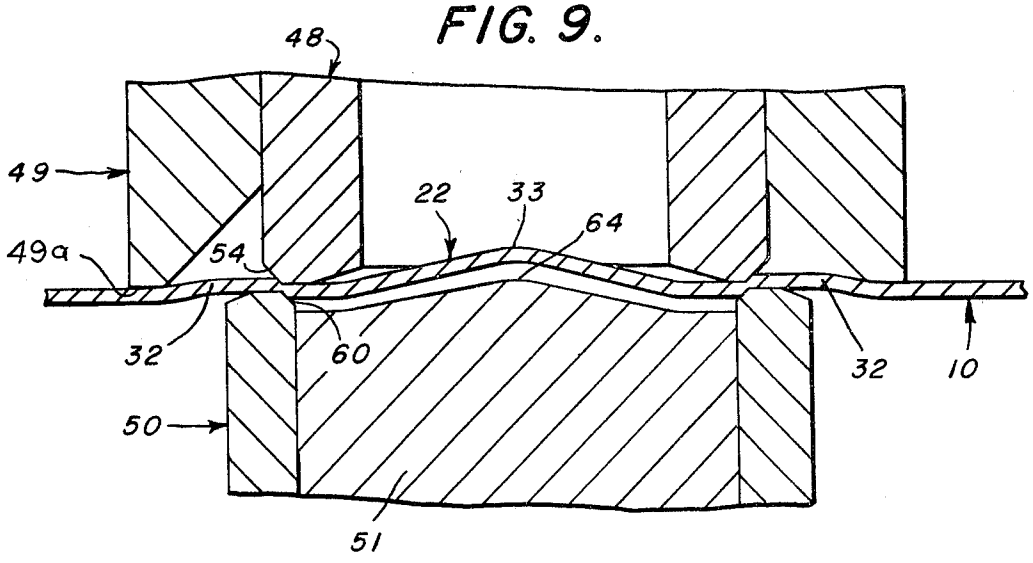
FIG. 9.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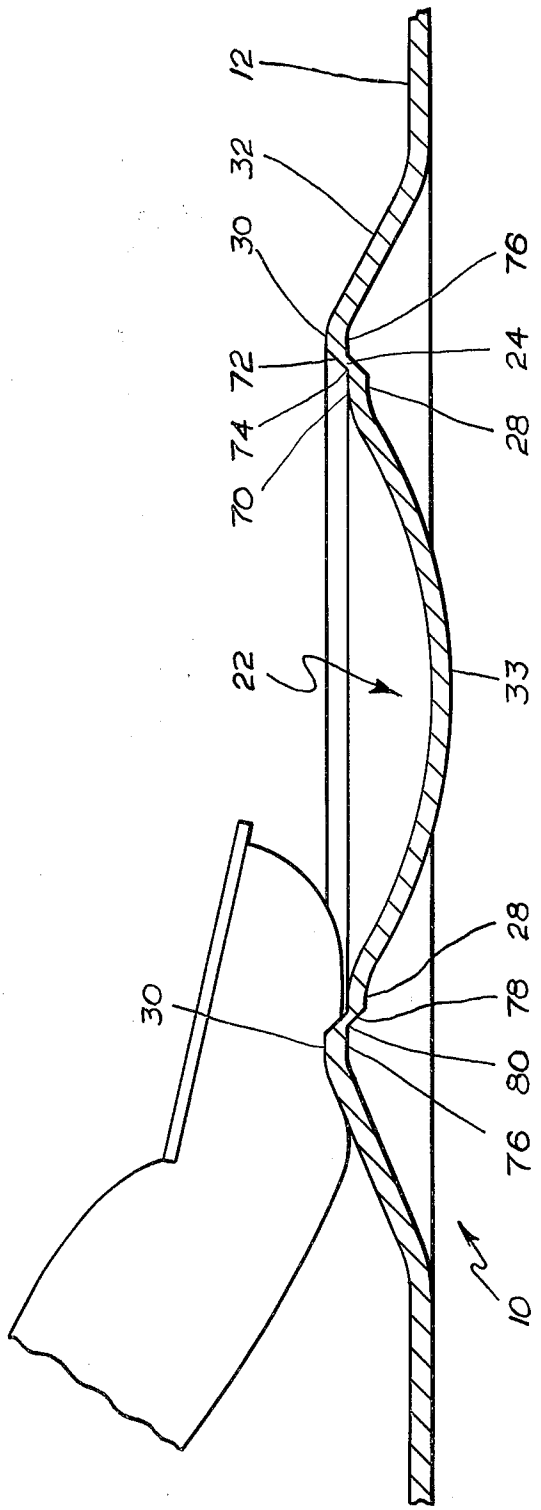

FIG. 10.

CONTAINER WALL WITH RUPTURABLE WEAKENING LINE

This application is a continuation-in-part of my copending application Ser. No. 281,541, filed Aug. 17, 1972.

BACKGROUND OF THE INVENTION

This invention relates to metal container closures and more particularly to an improved method and apparatus for forming and construction for a digitally openable container end closure that not only exceeds the stringent and competitively dictated present day commercial economic and performance criteria but also satisfies all ecology based governmental regulations now extant.

The metal container industry and its ever increasing demands for thin sheet metal has been one of the major motivating factors in both the growth and strength of our domestic economy. At the present day, for example, about 40 billion metal cans are fabricated each year alone to contain, preserve and transport beverages, such as soda and beer. Over the past 75 years or more, the ever increasing demands for product integrity backed up by governmental regulations and juridical pressures have, in an environment of continually increasing cost sensitivity, resulted in the development of commercially and competitively dictated interrelated economic and performance criteria of ever increasing stringency for metal containers. In the more recent years the competitive pressures attendant the fabrication of metal containers has been further complicated by the changing habits of the consumer and a marked increase in the long standing desire for metal containers that could be manually opened at the point of consumption without employment of auxiliary tools or the like. In the beverage field, such demand was recently satisfied, despite the existence of great numbers of suggested expedients therefor in the prior art and attendant unfavorable economic considerations, by the industry-wide fabrication of the Fraze type of pull tab easy open end closure. The widespread utilization of such type of end closures has, apart from the increased costs inherently attendant its fabrication due to increased metal content thereof and required multiple fabricating operations, created a serious ecology problem due to the hazards attendant the relatively sharp-edged removable tab portion thereof and the propensity of consumers to indiscriminately dispose of such tabs immediately following their separation from the container. In part, the problems attendant such indiscriminate tab disposition have resulted in the actual or contemplated banning of such closures in certain jurisdictions with the concommitant creation of problems of major magnitude for the can fabricators.

As noted above, the prior art, and notably the patented art, is replete with hundreds suggested expedients for achieving the long desired objective of simplified can opening, including many suggested expedients for can closures that can be digitally opened, i.e. manually opened without the use of auxiliary tools or the like. Included in such expedients were the use of container walls and end closures which included weakening lines or score lines defining tear strips or panels which could either be depressed into or pried out of a container to form either a vent or a pouring opening therein. Closures of this type are exemplarily disclosed in a number of U.S. Pat. Nos. including Newman

1,805,003, fried 2,176,898, Asbury 3,227,304, Asbury 3,246,791, Asbury 3,355,058, Klein et al 3,334,775, Foss et al 3,410,436, Punte 2,187,433, Punte 2,289,452, Punte 2,312,358, Punte 2,312,359, Fink 2,119,533 and Punte 2,120,186. Such end closures have sometimes required the use of rigid tools, such as a coin or a fork, to rupture the score line around the removable panel in order to form an opening in the end closure. Several of such end closures have included embossments in the removable portion to facilitate opening of the removable portion by pressing or prying against embossments.

It has also been suggested to form a weakening line in the form of a fracturable web in such a container closure by displacing metal along one side of a line at right angles to the initially undisplaced surface of the container wall in such a way that the edge defining the periphery of the removable wall portion underlaps the corresponding edge of the non-removable wall portion and has an abrupt change in cross-sectional wall thickness as is disclosed in Geiger U.S. Pat. No. 3,362,569. That patent discloses that the removable wall portion in such a closure has greater resistance against severance of the fracturable web as would be occasioned by internal pressure than it has against severance due to an opening force applied against the exterior surface of the portion. It has been found, however, that displacing metal at right angles to the surface of the sheet in the manner taught and disclosed in Geiger U.S. Pat. No. 3,362,569 can cause small cracks in, or accidental severance of, the fracturable web that is formed, particularly in hard temper metal. Punte U.S. Pat. No. 2,187,433 suggests another expedient wherein a weakened thinned portion is formed in a container wall by thinning the wall between a rounded corner of a movable die member and a die surface disposed at a 45° angle to the axis of displacement of the movable die member. Other expedients suggested by the art for the formation of particularly shaped weakened areas are embodied in U.S. Pat. Nos. to Barrath 540,625, Fraze 3,291,336, Cookson 3,434,623, Cookson 3,698,590 and Baumeyer et al 3,693,827.

Insofar as I am aware, none of these suggested expedients have apparently been able to satisfy the stringent and complementally interrelated economic and performance criteria necessary for widespread use on beverage and like containers. As evidenced by the span of years covered by the above noted patents, it has long been desired to have a container end closure or container wall with a removable portion in it which can be inwardly displaced from the end closure or wall without need for a separate tool or a pull tab attached to the removable portion. While the Fraze type of pull tab easy open end closure is, as noted above, presently in wide use despite its additional expense, the current ecology induced pressures make it desirable to utilize the concepts of the Geiger patent, but to provide a method of forming a fracturable web that is not subject or vulnerable to small cracks or failure therein and which satisfies the current stringent and complementally interrelated economic and performance criteria necessary for widespread commercial use.

SUMMARY OF THE INVENTION

This invention may be briefly described as including, in its broad aspects, the provision of an improved method and apparatus for forming and construction for a digitally openable container end closure. In such

broad aspect it includes a container wall having a particularly contoured fracturable web defining an inwardly displaceable opening panel having an upper surface on the rim thereof intersecting the inner marginal edge of the lip of an adjacent particularly contoured deflectable portion in a first exposed corner and with the undersurface of said lip disposed in substantial alignment with said upper surface of said panel rim and intersecting the outer marginal edge of said rim in a second corner. The deflectable portion is integral with the container wall and projects outwardly from the plane of the container wall adjacent the fracturable web and is adapted to effect, in response to digitally applied inwardly directed pressure thereon, relative displacement of the lip and rim to strain the web and initiate fracture thereof.

In its narrower aspects the invention includes the formation of a fracturable web by moving metal adjacent a predetermined line substantially perpendicular to the surface of the sheet while squeezing a zone of metal along such line between substantially parallel die surfaces which are disposed at an angle to the plane of the container wall. Such squeezing of the container wall along the zone of metal extrudes metal laterally from such line to produce a bulge forming at least a part of said deflectable portion in the container wall which can be flexed to cause relative movement of the metal on opposite sides of the fracturable web and thereby facilitate initiation of rupture thereof.

Among the advantages of the subject invention are the provisions of a metal container closure construction that exceeds the stringent present day interrelated commercial economic and performance criteria and which also satisfies current ecology based governmental regulations. More specific advantages include the provision of a highly reliable end closure of markedly reduced metal content that can be fabricated with a minimal number of fabricating steps at extremely high production rates with simple tooling. Further advantages include the provision of an end closure that can be opened by application of modest amounts of digitally applied pressure without the use of auxiliary tools and the overcoming of ecology based objection to present day Fraze type severable pull tab closures through inward displacement of a closure panel sized to be larger than the resulting opening in the container wall.

The object of this invention is the provision of an improved method and apparatus for forming and construction for a digitally openable container end closure.

Accordingly, another object of the invention is to provide a tabless container wall which can be opened with the fingers.

Another object of the invention is to provide a method of forming a container wall with a fracturable web in it which can be easily ruptured when force is applied against one surface of the container wall.

Another object of the invention is to provide a method of forming a fracturable web in a container wall by displacing metal at right angles to the plane of the container wall while squeezing a zone of metal to prevent complete severance of the container wall during such displacement of metal.

A further object of the invention is to provide a method of deforming a sheet of metal to provide a selectively contoured fracturable web that can be ruptured without the need for a special cool or a pull tab attached to the severable portion of the sheet.

Another object of the invention is to provide a container wall with a fracturable web in it defining a removable panel and an adjacent flexible or deflectable bulge for displacing portions of the container wall to facilitate initiation of rupture of the web.

Another object of the invention is to provide a container wall with a fracturable web in it defining a removable panel with an edge portion of the removable panel and an adjacent edge portion of the container wall lying in substantially parallel planes, and further including a deflectable bulge in the container wall for selectively displacing portions of the container wall to cause relative movement of the metal on opposite sides of the fracturable web to initiate rupture or fracture of the web.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the invention will be more fully understood and appreciated with reference to the following description and the drawings appended hereto wherein:

FIG. **1** is a plan view of a can end of the invention,

FIG. **2** is an enlarged cross section through the can end of FIG. **1** taken along line II-II,

FIG. **3** is an enlarged cross sectional view of a can end of the invention seamed on a container and illustrating finger pressure applied to an outwardly domed or bulged panel to initiate rupture of the fracturable web in the can end,

FIG. **4** is a section view similar to FIG. **3** and showing the can end after opening,

FIG. **5** is a perspective view of an alternative embodiment of a closure of the invention,

FIG. **6** is a cross section through the closure of FIG. **5**,

FIG. **7** is a cross section illustrating tools for deforming a container wall in accordance with the invention,

FIG. **8** is an enlarged cross sectional view of a portion of the tools from FIG. **7** illustrating an intermediate stage in the forming of a fracturable web in a container wall,

FIG. **9** is a cross sectional view similar to FIG. **7** illustrating further displacement of the die members in the formation of a fracturable web in a container wall, and

FIG. **10** is an enlarged cross sectional view of a portion of a presently preferred embodiment of a container wall constructed in accordance with principles of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. **1** and **2**, a container wall or can end **10** is shown which includes a substantially planar central panel **12**, a peripheral groove **14** around the panel an upstanding wall **16** outwardly of the groove, a flange **18** extending outwardly from the top of the upstanding wall and a curled edge **20** on the outer end of the flange. Such general construction of a peripherally chimed can end is typical of can ends which are adapted to be sealed on container bodies by conventional double seaming operations.

In order to facilitate understanding of the subject invention and in the interest of clarity, the terms "inwardly" and "outwardly" will be herein employed to delineate directions relative to the interior and exterior respectively of a cylindrical container having the end closure of interest mounted on the end thereof.

In accordance with this invention, can end **10** further includes at least one, and preferably two, inwardly displaceable opening panels **22** of equal size defined by weakening lines **24** in the form of fracturable webs in central panel **12.** Panels **22** are designed to be opened by displacing them into a container on which can end **10** is sealed to form a pouring opening and/or a vent in the can end. In the embodiment selected for illustration in FIGS. **1** through **4,** each fracturable web **24** may be C-shaped with a bridge of metal between the ends of the line providing a hinge **26** which prevents complete separation of the opening panel **22** from container end **10.** Hinge **26** between the ends of the fracturable web **24** may be slightly weakened by a shallow score line or the like, but may also be unweakened for some applications. In case of accidental rupture of the web **24** due to excessively high internal pressures in a container, hinge **26** will prevent complete separation of a removable panel **22** from can end **10.** Hinge **26** also normally prevents the panel **22** from dropping into the container after inward displacement thereof.

As illustrated in FIG. **1,** each opening panel **22** is substantially smaller than the can end **10** in which it is provided and constitutes a minor portion, or less than half, of the area of the can end.

It is a feature of a container end constructed in accord with the principles of this invention that at least a marginal edge portion **28** of opening panel **22** adjacent the fracturable web **24** be disposed with respect to an adjacent marginal edge portion **30** of central panel **12** on the other side of the web such that opposite faces of such two marginal edge portions **28** and **30** are disposed in nearly the same plane. In the embodiment selected for illustration in FIGS. **1–4,** such displacement results in the top surface of the edge portion **28** of the opening panel **22** being disposed in nearly the same plane as is the bottom surface of edge portion **30** of the adjacent portion of central panel **12** disposed on the other side of the fracturable web.

It is another feature of this invention that the central panel **12** has a bulge or bulges formed in it adjacent the fracturable web **24** as is best illustrated in FIGS. **2** and **9.** As will be explained, flexing or other digitally induced displacement of such bulge or bulges, which constitute at least part of a deflectable portion of the container wall, facilitates rupture of the web **24** by producing relative movement of metal on opposite sides of the web to strain the residual metal and initiate its failure. In can end **10,** a bulge **32** may be formed adjacent removable panel **22** or a bulge **33** may be formed within the opening panel **22,** as will be described.

Depending on the intended use of a container end e.g. on pressurized or unpressurized cans or on automatically ventable cans; the adjacent portions of metal on opposite sides of the fracturable web **24** and the flexible deflectable portions **32** and **33** may be formed either outwardly or inwardly directed with respect to the initially undisplaced metal in the container wall. In the can end **10** illustrated in FIGS. **1–4,** which is adapted to be sealed on a container for holding relatively high internal pressures, the marginal edge portion **28** of opening panel **22** has preferably been displaced downward with respect to the adjacent portion **30** of central panel **12** on the opposite side of the fracturable web so that the web will have a greater resistance against rupture due to internal pressure in the container than it will have against rupture due to external pressure applied against opening panel **22.** The difference in resistance to rupture of a weakening line depending on the direction of force was previously broadly disclosed in the Punte and Geiger U.S. Pat. Nos. 2,187,433 and 3,362,569, and is believed to result from an overlap of metal on opposite sides of a weakening line.

Deflectable portion **32** is preferably formed outwardly with respect to the initially undisplace surface of can end **10** so that finger pressure applied against opening panel **22** or more desirably against said deflectable portion **32** will cause flexing and selective displacement thereof to facilitate initial fracture of the web **24** as will now be explained. As illustrated in FIG. **3,** depressing the illustrated outwardly domed opening panel **22** causes flexing and displacement of at least portions of central panel **12.** While not fully understood at the present time, it is believed that this flexing of portions of central panel **12** causes relative movement of adjacent portions of metal on opposite sides of the fracturable web **24** to thereby stress and fracture the thin residual of metal constituting such web. Such flexing displacement of portions of container panel **12** is also believed to cause some bending of the thin residual of metal constituting the web to further contribute to the initiation of fracture thereof. As opening panel **22** is further depressed, the web **24** around the panel **22** continues to separate so that the panel may be hinged inwardly into the container as illustrated in FIG. **4.** When both panels **22** have been so opened, one opening can be used for pouring or drinking from the container, and the other opening will vent air into the container.

FIGS. **5** and **6** illustrate another embodiment of a closure incorporating the principles of this invention which is particularly adapted for closing a bottle or other container for food which may be vacuum packed. Closure **34** includes an end wall **36,** a peripheral skirt **38** with a curled edge **40** thereon for engaging under a retaining bead or lugs on a container. In accordance with this invention, closure **34** further includes an upwardly domed deflectable button **42** in end wall **36** and two fracturable webs **44** formed in the button near its top. Fracturable webs **44** may be arcuate in shape and concave toward the periphery of the closure leaving a bridge **46** of unweakened metal between the fracturable webs. In this embodiment of the invention, the metal between the fracturable webs **44** is preferably displaced outwardly with respect to adjacent metal on the opposite sides thereof as illustrated in FIG. **6.**

When it is desired to open a container on which closure **34** is sealed, bridge **46** may be inwardly displaced to cause failure of at least one of webs **44** and thereby release the vacuum in the container. Releasing the vacuum in a container on which closure **34** is sealed will obviously facilitate removal of the closure from the container by freeing the closure to be more easily moved with respect to the container. It is believed that inward displacement of bridge **46** causes relative movement of metal on opposite sides of fracturable webs **44** to stress the thin residual of metal in the web and thereby facilitate initiation of its rupture.

FIGS. **7, 8** and **9** illustrate exemplary tools and a preferred method for forming the particularly contoured fracturable web in accordance with the invention. Such exemplary tools comprise an annular top die **48** and an annular bottom die **50** between which a sheet metal container wall **10** is introduced to have the frac-

turable web formed therein, an auxiliary outer die means **49** and an optionally employable inner doming tool **51** for controlling the direction in which deflectable portion **32** and domed opening panel **22** are formed in the container wall. Top die **48** has a first substantially planar horizontal bottom face or base surface **52**, an inner face **53** inclined upwardly from base surface **52** to permit the formation of an upwardly domed opening panel, and a second and angularly disposed substantially planar metal extruding surface or face **54** which preferably extends outwardly from the first base surface at approximately a 45° angle, although limited angular departure therefrom may apparently be tolerated. The first base surface **52** and second metal extruding surface **54** of die **48** meet at a relatively sharp corner **56** so that a similar sharp corner will be formed in container wall **10**. Preferably the corner **56** between the first and second die surfaces **52** and **54** has a radius of less than 0.001 inch, but may tolerate a radius, as for example as would be occasioned by wear, of up to about 0.005 inch on tools for forming a fracturable web in rigid aluminum alloy container sheet having a thickness in a range of 0.010 inch to 0.015 inch which is typical of sheet used in the production of can ends.

Bottom die **50** has a first substantially planar base surface or top face **58**, a downwardly inclined outer face **59** to permit the formation of a deflectable portion **32** externally adjacent the opening panel **22** and a second and angularly disposed substantially planar metal extruding surface or inner face **60** extending downwardly from the first base surface **58** at approximately a 45° angle. Base surface **58** and metal extruding surface **60** also preferably meet at a relatively sharp corner **62** as do the die faces in top die **48**. Metal extruding surfaces **54** and **60** on top and bottom dies **48** and **50** are preferably substantially parallel, although limited departure therefrom can apparently be tolerated. Inner doming tool **51** may further have an upwardly projecting dome **64** on it to form an outwardly domed opening panel **22** which can be concurrently formed therewith. The auxiliary die means **49** and inner doming tool **51** may be integral parts of tools **48** and **50** respectively, or for ease of fabrication may be separate parts as illustrated, but are preferably moved as unitary assemblies during practice of the invention. Inner doming tool **51** may be omitted from the tools where the presently preferred inwardly domed opening panel **22** is to be formed.

Auxiliary outer die means **49** is disposed on the same side of container wall **10** as is upper die member **48** and has a metal shaping base surface **49***a* facing the same general direction as does first base surface **52** of upper die member **48** and is in laterally spaced relation with the first base surface **58** on the lower die member **50**.

As tools **48, 49, 50** and **51** (when included) are moved against container wall **10** which has been introduced between the dies, metal from the container wall is first drawn or stretched over dome **64** on inner doming tool **51**. As the dies continue to close, the first base surface **52** and the second metal extruding surface **54** of the top die member **48** are lineally displaced toward the second angularly disposed metal extruding surface **60** and first base surface **58** respectively of the second die member **60** and with the corners **56** and **62** being maintained in laterally spaced relation as described above. Following initial engagement of the top die member **48** with interposed metal sheet, metal from container wall **10** begins to be displaced or moved by the base die surfaces **52** and **58** substantially perpendicular, or a right angles, to the initially undisplaced surface of the container wall. When base die surfaces **52** and **58** have closed to within approximately three-fourths to two-thirds of the thickness of container wall **10**, metal begins to be extruded from between the angularly offset metal extruding surfaces **54** and **60** on the dies. Up to that point, the metal in container wall **10** is merely reformed around corners **56** and **62** on the dies.

As dies **48** and **50** continue to close with respect to one another, metal in container wall **10** is squeezed between the metal extruding surfaces **54** and **60** of the dies to cause lateral flow or extrusion of metal away from the fracturable web while metal is also being displaced at substantially right angles to the initially undisplaced surface of the container wall. The described lineal displacement of the top die member **48** toward the lower die member **50** continues until the first base surface **52** thereof is disposed substantially coplanar with the first base surface **58** of lower die member **50**. It is believed that this lateral flow or extrusion of metal away from the fracturable web which is being formed is important in preventing cracks from forming in, and premature severance of the web. In the absence of such extrusion, metal may be sheared or cut by the tools as is done in typical blanking or punching operations in which the metal is separated or sheared along the line of the tools before the dies have completely penetrated the metal. The present invention substantially eliminates the formation of cracks or failures in the fracturable web because metal is extruded laterally away from the web during the right angle displacement of metal to cause lateral flow of metal approximately as fast as the metal is being displaced at right angles so that the metal is not sheared or separated by such right angle displacement. Experience to date indicates that in the practice of this invention, container ends of the type disclosed can be formed at high rates of press operation to produce 300 or more ends per minute per die set up with few or no defective can ends.

Lateral metal flow away from the fracturable web that is being formed also produces an increased surface area of metal in a can end for forming the desired deflectable portion in the metal adjacent the web. As explained above, such deflectable portion **32** is believed to facilitate rupture of the fracturable web. In the tools illustrated in FIGS. **7–9**, the auxiliary die means **49** and the inner doming tool **51** respectively control the direction in which the increased area of metal is formed so that deflectable portion **32** and domed opening panel **22** project outwardly with respect to the original undisplaced surface of the can end. Obviously, for other can ends or closure applications, similar tools could also control the metal working so that the bulges or deflectable portions would be formed downward (i.e., inwardly) on one or both sides of the fracturable web if desired.

After inner doming tool **51** has initiated outward doming of opening panel **22**, lateral extrusion of metal produced by the formation of fracturable web **24** further domes the opening panel so that the metal in the panel is spaced above dome **64** on the doming tool **51** as is illustrated in FIG. **9**. Auxiliary die means **49** controls the formation of the preferred outwardly projecting deflectable portion **32** adjacent the fracturable web **24** by restraining the metal distal the fracturable web so that the metal bows upward over bottom die **50** as is

also illustrated in FIG. **9.** In forming the deflectable portion **32,** the auxiliary die means **49** is lineally displaced to selectively move the base surface **49***a* thereof into predetermined longitudinally offset relations with the first base surface **58** of lower die member **50** in the direction of die displacement.

It is believed that lateral extrusion of metal during formation of the particularly contoured fracturable web **24** in accordance with the principles of this invention results in the formation of complex residual stresses in the web probably having a substantial component thereof in shear which may interact with the stresses produced by inward displacement of the deflectable portions to contribute in initiating rupture of the fracturable web. Such residual stresses apparently act within the fracturable web **24** to make it easier to initiate its rupture.

In the practice of this invention, the amount of lateral spacing "*x*" between the corners **56** and **62** in the horizontal direction may vary depending upon the alloy, temper and thickness of the metal in container wall, the angle of the metal extruding surfaces **54** and **60,** and the residual thickness of metal to be left in the fracturable web among other factors. Such lateral spacing is preferably in the range of **1/4** to **1/6** of the thickness of the container wall in which the fracturable web is formed, but may be from 5 percent to 50 percent of the metal thickness for some applications. In the exemplary practice of the invention, an overlap "*x*" of die surfaces **54** and **60** of approximately 0.0032 inch has been found to work well in forming a fracturable web in a container wall made from a sheet of hard temper aluminum base alloy 0.013 inch thick. In that example, the dies were moved toward one another until base surfaces **52** and **58** were within approximately 0.001 inch of coplanar orientation. This produced a fracturable web with a thin residual of metal approximately 0.004 inch thick with no cracks therein.

FIG. **10** illustrates a presently preferred configuration of a metal end closure incorporating the principles of this invention. There is provided a central panel **12** having a least one circular and relatively rigid opening panel **22** contoured to include an inwardly domed center portion **33** bounded by a rim **28** peripherally terminating in a fracturable web **24.** The web **24** interconnects the rim **28** with a lip **30** of an integral outwardly projecting deflectable portion **32** of generally frustoconical configuration surrounding the opening panel **22** in the adjacent portion of the container wall. Preferably, rim **28** has a substantially planar upper surface **70** which terminally intersects an angularly inclined surface **72** defining the inner marginal edge of lip **30** of deflectable portion **32** in an exposed corner **74.** Lip **30** has a substantially planar undersurface **76** disposed in substantially coplanar relation with the upper surface **70** of rim **28** and which terminally intersects an angularly inclined surface **78** defining the outer marginal edge of the rim **28** of the panel **22** in a second corner **80.** The corners **74** and **80** are disposed in predetermined laterally spaced relation and define therebetween the lateral extent of the fracturable web **24.**

Each opening panel **22** includes means for imparting greater rigidity to the opening panel than that of the deflectable portion. In the preferred embodiment, the domed shape of each opening panel provides the desired increase in rigidity. The size of the opening panel is also believed to be a factor in its rigidity. It will be apparent to those skilled in the art that other means such as greater metal thickness, embossments or the like can be employed to impart the desired increased rigidity to the opening panel.

Deflectable portion **32** in container end **10** is adapted to effect, in response to inwardly directed digitally applied pressure a relative displacement of lip **30** with respect to rim **28** to strain fracturable web **24** and initiate fracture thereof to permit inward displacement of a separated opening panel of greater rim size than the size of the opening which is formed in the end. Such inwardly directed digital pressure is best applied against the end **10** adjacent web **24** and preferably against the raised lip **30** of the deflectable portion **32** as is illustrated in FIG. **10.** Such inward pressure against the deflectable portion **32** appears to move the lip **30** relative to the rim **28** of the relatively rigid opening panel **22** to strain the fracturable web **24** and initiate fracture thereof. As pointed out above, the opening panel **22** is preferably of relatively rigid character to resist bending thereof and thereby insure that the displacement of the deflectable portion **32** will create sufficient relative displacement of the lip **30** thereof with respect to the rim **28** of the opening panel **22** to initiate web fracture. The lateral spacing corners of **74** and **80** are selected to define a web of at least a predetermined minimal extend sufficient to maintain its structural integrity during exposure to variations in the magnitude of the residual stress therein occasioned by normal container handling and usage and less than a predetermined maximum extent that would preclude said displacement induced fracture thereof in response to said digitally applied inwardly directed pressure.

While the mechanics underlying the mode of operation of the subject construction are not well understood at the present ime, it is believed that complex residual stresses are introduced into the particularly contoured fracturable web by the metal displacement effected during the formation thereof. It is further believed that the relative displacement of the deflectable portion induced by the inwardly directed digitally applied pressure introduces a further complex stress pattern of varying character into said web and that localized web fracture is initiated by selectively located and probably localized interactions thereof with the formation-created residual stresses extant therein.

It is therefore seen that a container wall and a method of forming the same are provided which offer improved opening characteristics and improved resistance to the formation of cracks in the fracturable web in the container wall. Metal is moved substantially at right angles to the initially undisplaced surface of the container wall along the fracturable web while metal is extruded laterally away therefrom. The extrusion of metal causes lateral metal flow which is approximately as fast as the right angle displacement of metal during at least the latter part of the forming operation to thereby avoid shearing the metal, and further forms a deflectable portion in the container wall whose digitally induced displacement initiates web fracture.

The invention is particularly well suited for use with container walls made of work hardened aluminum base alloy sheet material in the thickness range of 0.010 inch to 0.015 inch and which is at least quarter hard, and preferably at least three-quarter hard temper or is of extra hard temper alloy which has been partially annealed as a result of heating it to cure a protective coating thereon. Quarter hard aluminum alloy sheet will generally have a yield strength which is at least

one-half the yield strength for the same alloy in a full hard condition, and two or more times the yield strength for the product in a fully annealed or recrystallized condition. It is believed that such work hardened alloy sheet material is particularly well suited to practice of the invention because material of the specified hardness is required to assure conversion of the inwardly directed digitally applied pressures into selectively directed displacement of the lip of the deflectable portion relative to the rim of the relatively rigid opening panel. It is further believed that work hardened aluminum alloy will also result in the presence of greater residual stresses in the metal, both as to those introduced in the initial formation of the fracturable web and those introduced by relative metal displacement as described above.

Experience to date has indicated that opening panels having diameters in the range of about one-eighth inch to three-quarters inch provide adequate pour and venting rates and also result in adequate lateral metal extrusion during forming to produce deflectable portions of desired size and configuration. With respect to such deflectable portions, it is believed that an angle inclination in a range of about **5** to **15** degrees to the general plane of an end closure provides an adequate toggle-like action to effect the necessary displacement of the lip portion relative to the opening panel rim portion to initiate web fracture.

Although a preferred embodiment of a container wall and a preferred method and apparatus for forming the same have been illustrated and described, it will be apparent to those skilled in the art that numerous variations could be made therein without departing from the invention.

What is claimed is:

1. A peripherally chimed sheet metal container component having a wall with

at least one inwardly displaceable opening panel therein non-concentric with the peripheral chime around the container component and constituting a minor portion of the component, said opening panel having an integral rim therearound peripherally terminating in a fracturable web defining a locus of separation of said opening panel from the adjacent portion of said wall,

an integral deflectable portion adjacent said opening panel and projecting outwardly from the general plane of the wall of said container component, said deflectable portion terminating in a lip on the marginal edge thereof toward said web integrally interconnected with the rim of said opening panel and defining therewith said fracturable web,

the rim of said opening panel including an outwardly exposed surface terminally intersecting the outwardly exposed marginal edge of the lip of said deflectable portion in an outwardly exposed corner,

said deflectable portion having a portion of the undersurface thereof terminally meeting the undersurface of the outer marginal edge of said rim in predetermined spaced relation with said exposed corner to define therebetween the extent of said fracturable web,

said opening panel including means for imparting greater rigidity thereto than that of said deflectable portion disposed adjacent thereto to effect an initiation, in response to digitally applied localized inwardly directed pressure against said deflectable portion at a location spaced from the peripheral chime around the container component, of relative displacement of said lip relative to said rim to strain said web and induce fracture thereof to permit inward displacement of a separated opening panel.

2. A sheet metal end closure for a container comprising

a generally planar wall portion peripherally chimed for securement to a container body,

at least one inwardly displaceable relatively rigid opening panel integrally included therein non-concentric with the peripheral chime around the closure and constituting a minor portion of the closure, said opening panel having a center portion and an integral rim therearound peripherally terminating in a fracturable web defining a locus of separation of said opening panel from said wall portion,

an integral deflectable portion adjacent said opening panel and projecting outwardly from the general plane of said wall portion, said deflectable portion terminating in a lip on the marginal edge thereof toward said web integrally interconnected with the rim of said displaceable opening panel and defining therewith said fracturable web,

said rim of said opening panel including an outwardly exposed surface terminally intersecting the outwardly exposed marginal edge of the lip of said deflectable portion in an outwardly exposed corner,

the undersurface of said deflectable portion terminally meeting the undersurface of the outer marginal edge of said rim of said opening panel in predetermined spaced relation with said exposed corner to define therebetween the extent of said fracturable web,

said opening panel including means for imparting greater rigidity thereto than that of said deflectable portion disposed adjacent thereto to effect an initiation, in response to digitally applied localized inwardly directed pressure against said deflectable portion at a location spaced from the peripheral chime around the closure, of relative displacement of the lip thereof relative to the rim of said opening panel to stress said web and initiate fracture thereof to permit inward displacement of a separated opening panel of greater rim size than the size of the opening formed in said wall portion as defined by the inner marginal edge of the lip of said deflectable portion.

3. A closure as set forth in claim **2** wherein said deflectable portion is inclined from the general plane of said wall portion toward said lip at an angle in the range of 5° to 15°.

4. A closure as set forth in claim **2** wherein said opening panel is of generally circular configuration and said deflectable portion is annularly disposed in surrounding relation therewith.

5. A closure as set forth in claim **2** wherein the center portion of said opening panel is domed.

6. A closure as set forth in claim **2** wherein said wall portion includes at least two circular openings panels of equal diameter.

7. A closure as set forth in claim **2** wherein the upper surface of the rim of said opening panel is in substantially coplanar relation with the undersurface of the lip of said deflectable portion.

8. A closure as set forth in claim **2** wherein said wall portion comprises work hardened aluminum alloy

which is at least three-quarter hard.

9. A closure as set forth in claim **2** wherein said opening panel is circular in shape and has a diameter in the range of ⅛ inch to ¾ inch.

10. A closure as set forth in claim **2** wherein said fracturable web interconnects the rim of said opening panel and the lip of said deflectable portion outwardly of the general plane of said wall portion.

11. A sheet metal end closure of work hardened aluminum alloy suitable for a pressurized fluid container comprising

a generally planar wall portion peripherally chimed for securement to a container body,

at least one inwardly displaceable relatively rigid opening panel integrally included therein non-concentric with the peripheral chime around the closure and constituting a minor portion of the closure said opening panel having a domed center portion and a selectively shaped rim therearound peripherally terminating in a particularly contoured, residually stressed fracturable web defining a locus of separation of said opening panel from said wall portion,

an integral inclined deflectable portion adjacent said opening panel and projecting outwardly from the general plane of said wall portion and terminating in a particularly shaped lip on the marginal edge thereof toward said web integrally interconnected with the rim of said displaceable opening panel and defining therewith said fracturable web,

said rim of said opening panel including an upper planar surface terminally intersecting an angularly inclined surface defining the inner marginal edge of the lip of said deflectable portion in a first outwardly exposed corner,

said lip of said deflectable portion including a planar undersurface disposed substantially coplanar with the upper surface of said rim of said opening panel and terminally intersecting an angularly inclined surface defining the outer marginal edge of the rim of said opening panel in a second corner disposed in predetermined laterally spaced relation with said first corner to define, by the overlap therebetween, the lateral extent of said fracturable web,

said opening panel including means for imparting greater rigidity thereto than that of said deflectable portion to effect in response to digitally applied inwardly directed pressure against the deflectable portion at a location spaced from the peripheral chime around the closure, a directional relative displacement of the lip thereof with the rim of said opening panel to initiate fracture of said web to permit inward displacement of a separated opening panel of greater rim size than the size of the opening formed in said wall portion as defined by the terminal edge of the angularly inclined surface of the lip of said deflectable portion,

the lateral spacing of said first and second corners defining a web of at least a predetermined minimal extent sufficient to maintain its structural integrity during exposure to variations in the magnitude of the residual stress therein occasioned by normal container handling and usage and less than a predetermined maximum extent that would preclude said fracture thereof in response to said digitally applied inwardly directed pressure.

12. A sheet metal end closure as set forth in claim **11** wherein said planar wall portion includes two displaceable opening panels of circular configuration, each surrounded by a deflectable portion of annular configuration.

13. A sheet metal end closure as set forth in claim **11** wherein said opening panel is inwardly domed.

14. A sheet metal end closure as set forth in claim **11** wherein said angularly inclined surface of the lip of the deflectable portion is disposed substantially parallel to the angularly inclined surface of the rim of said opening panel.

15. A sheet metal end closure as set forth in claim **14** wherein each of said angularly inclined surfaces is disposed at an angle of about **45°** to the planar surface associated therewith.

16. A sheet metal end closure as set forth in claim **11** wherein said fracturable web is interrupted to form a hinge element of greater thickness than the fracturable web.

17. A sheet metal end closure as set forth in claim **11** wherein the work hardened aluminum alloy forming said planar wall portion has a thickness in the range of 0.010 inch to 0.015 inch.

18. A sheet metal end closure as set forth in claim **11** wherein said wall portion comprises work hardened aluminum alloy which is at least three-quarter hard.

19. A sheet metal end closure as set forth in claim **11** wherein said first and second corners have a permitted difference in elevation no greater than **0.001** inch.

20. A sheet metal end closure as set forth in claim **11** wherein said opening panel is of generally circular configuration and said deflectable portion disposed thereabout is of frusto-conical configuration.

21. A sheet metal end closure as set forth in claim **11** wherein the residual stresses at the locus of separation are of such character and magnitude as to initiate fracture of the web upon localized interaction thereof with stresses induced by digitally applied pressure.

22. A sheet metal end closure as set forth in claim **11** wherein said opening panel is circular in shape and has a diameter in the range of ⅛ inch to ¾ inch.

23. A sheet metal end closure of at least three-quarter hard temper aluminum alloy of a thickness in the range of 0.010 inch to 0.015 inch suitable for a pressurized fluid container comprising

a generally planar wall portion peripherally chimed for securement to a container body,

at least one hinged inwardly displaceable relatively rigid circular opening panel integrally included therein having an inwardly domed center portion and a selectively shaped rim peripherally terminating in a particularly contoured, residually stressed and annularly shaped fracturable web defining a locus of separation of said hinged opening panel from said wall portion,

an integral inclined annularly shaped deflectable portion of frusto-conical configuration surrounding said opening panel and projecting outwardly from the plane of said wall portion and terminating in a particularly shaped lip integrally interconnected with the rim of said displaceable opening panel and defining therewith said fracturable web,

said rim of said opening panel including an upper planar surface terminally intersecting at an angle of about 135° an angularly inclined surface defining the inner marginal edge of the lip of said deflectable portion in a first exposed corner,

said lip of said deflectable portion including a planar undersurface disposed substantially coplanar with

the upper surface of the rim of said opening panel and terminally intersecting at an angle of about 135° an angularly inclined surface defining the outer marginal edge of the rim of said opening panel in a second corner disposed in predetermined laterally spaced relation with said first corner to define, by the overlap therebetween, the lateral extent of said fracturable web, and having a permitted difference in elevation therebetween of no greater than 0.001 inch,

said deflectable portion being adapted to effect, in response to digitally applied inwardly directed pressure, a directional relative displacement of the lip thereof with the rim of said opening panel to interact with the residual stresses extant in said web and initiate fracture thereof to permit inward displacement of a separated opening panel of greater rim size than the size of the opening formed in said wall portion as defined by the terminal edge of the angularly inclined surface of the lip of said deflectable portion,

the lateral spacing of said first and second corners being no more than 0.004 inches and defining a web of at least a predetermined minimal extent sufficient to maintain its structural integrity during exposure to variations in the magnitude of the residual stress therein occasioned by normal container handling and usage and less than a predetermined maximum extent that would preclude said fracture thereof in response to said digitally applied inwardly directed pressure.

24. A sheet metal end closure as set forth in claim **23** wherein said planar wall portion includes two displaceable opening panels of circular configuration, each surrounded by a deflectable portion of annular configuration.

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