United States Patent

[11] **3,602,980**

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[21] Appl. No. **786,084**
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[45] Patented **Sept. 7, 1971**
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Pittsburgh, Pa.

[54] **METHOD FOR FORMING A SHEET METAL JOINT**
3 Claims, 14 Drawing Figs.

[52] **U.S. Cl.** **29/509,** 29/522, 113/121, 220/54
[51] **Int. Cl.** **B21d 39/00,** B23p 11/00
[50] **Field of Search** .... 29/509, 522; 113/121 C; 220/54

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Primary Examiner—Charlie T. Moon
Attorney—David W. Brownlee

ABSTRACT: This disclosure describes a method for forming a sheet metal joint for attachment of a pull tab to a tear strip in a container end closure in which a bubble is first formed in the closure end panel, the bubble is reformed into a hollow rivet having a substantially cylindrical sidewall and an arcuate transverse end wall, and the rivet is staked or upset to compressively fold the transverse end wall thereof to form a head on the rivet which is at least as thick as the transverse end wall of the unstaked rivet.

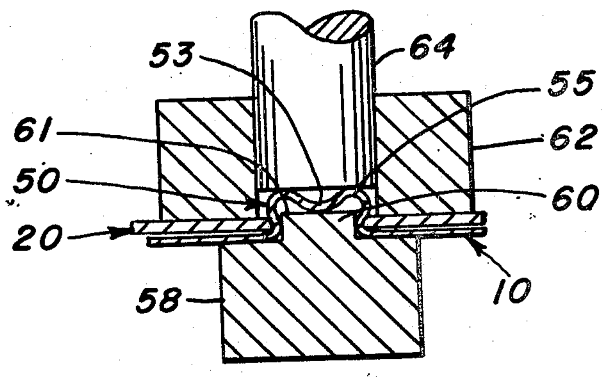

Fig. 1.

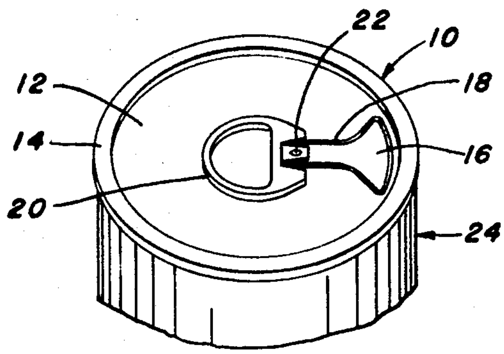

Fig. 2.

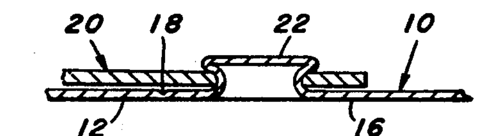

Fig. 3.

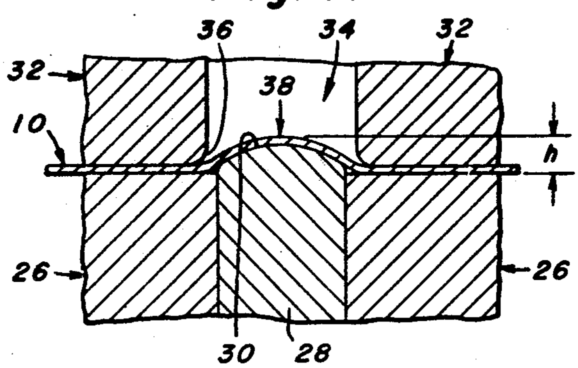

Fig. 4

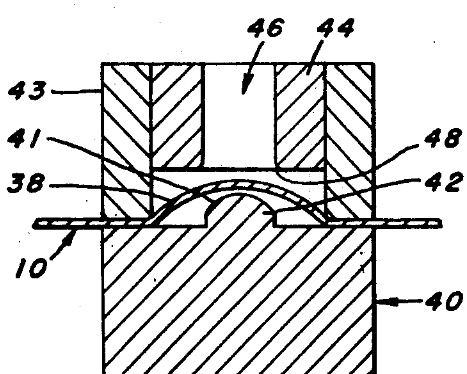

Fig. 5.

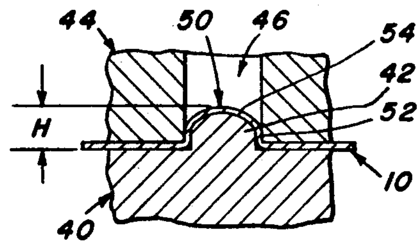

Fig. 6.

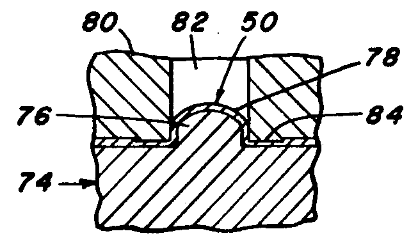

Fig. 7

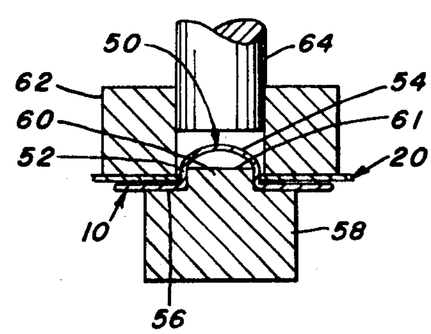

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Fig. 8.

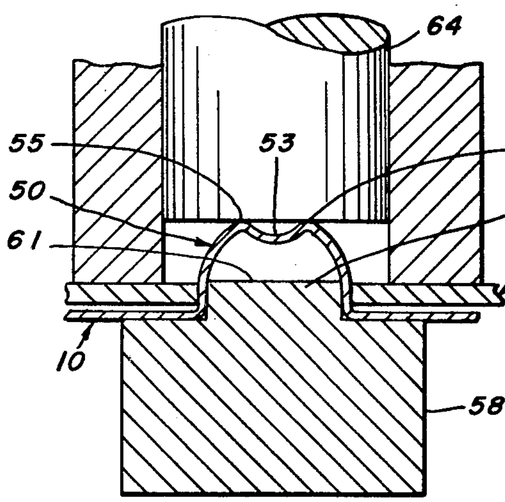

Fig. 11.

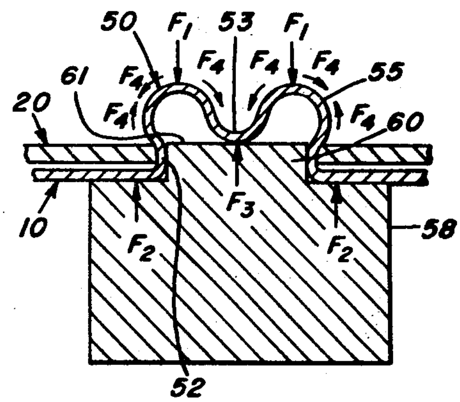

Fig. 9.

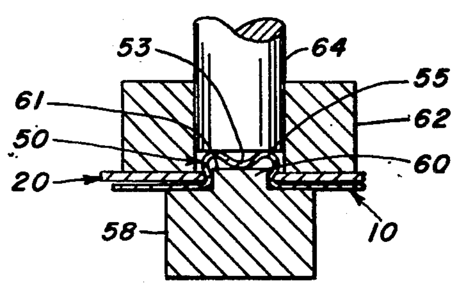

Fig. 12.

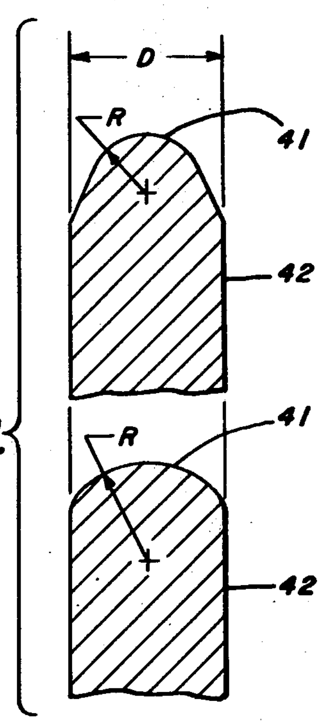

Fig. 10.

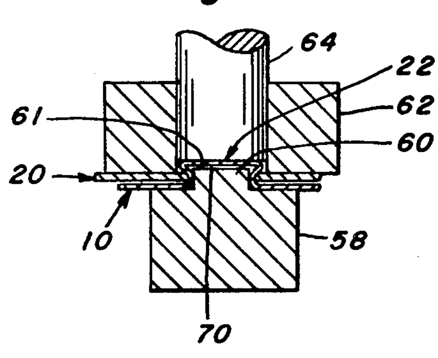

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Fig. 13.

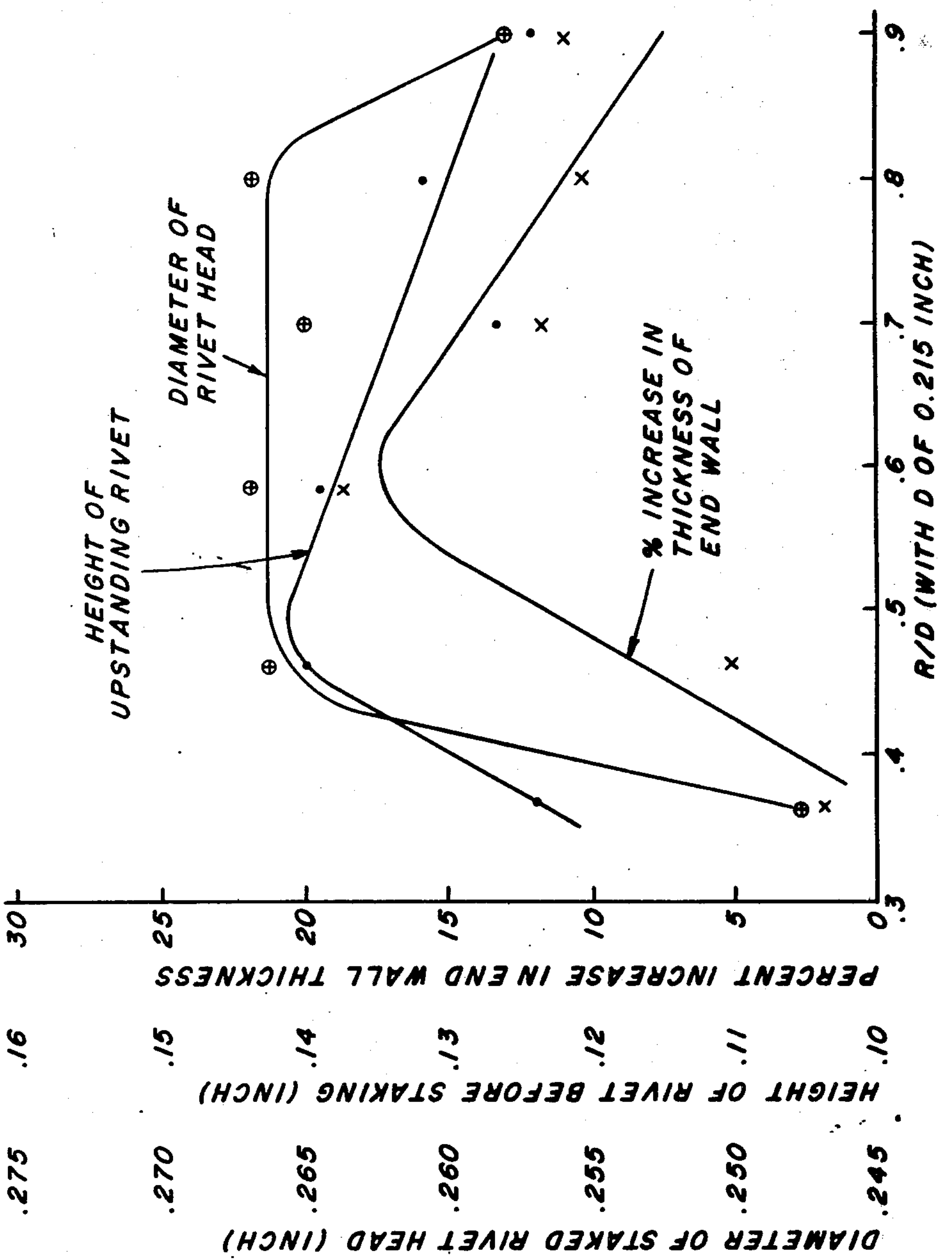

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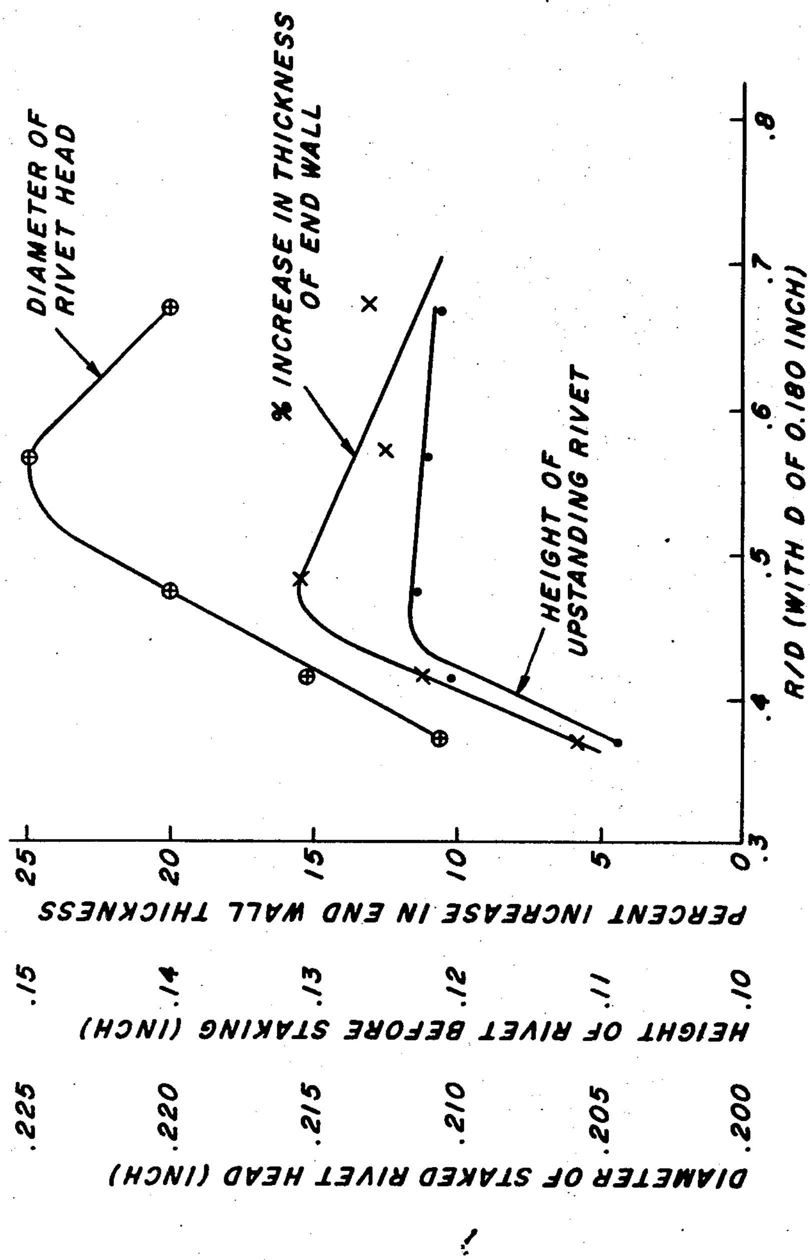
Fig. 14.



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METHOD FOR FORMING A SHEET METAL JOINT

BACKGROUND OF THE INVENTION

It is common practice to form hollow integral rivet joints in sheet metal end closure such as can ends, container closures and the like for attachment of a pull tab to a tear strip in the end closures. The integral rivet joints are usually formed by gathering metal in the end closure to form a bubble or dimple and reforming the bubble into a hollow rivet or boss which is upset or staked to form a head on the rivet. In the heretofore known methods, the sheet metal of the end closure is usually drawn, stretched and thinned to form the hollow rivet, and then further thinned between a punch and an anvil to form a head on the rivet. This metal working may cause uneven thinning of the metal in and around the rivet, and may result in failure of the rivet head during opening. Furthermore, when the end closure has a protective coating thereon, the heretofore known forming and staking methods frequently result in degradation of the coating. Consequently, these end closures may require repair costing to cover the areas of degradation. If not repair coated, the metal under the damaged coating may be subject to attack by the contents of the container, and may develop perforations therein and/or produce undesirable taste in the container's contents.

SUMMARY OF THE INVENTION

According to the invention, an upstanding hollow rivet is formed in a sheet of deformable material, and the rivet staked to compressively fold the material of the rivet outwardly over the material around the aperture through the member being attached thereto, to form a head on the rivet which preferably is thicker and not thinner than the transverse end wall in the upstanding rivet before heading. Basically, the method comprises gathering metal for a rivet by forming a raised bubble in the sheet material by conventional means, reforming the bubble into an upstanding hollow rivet having a substantially cylindrical sidewall and an upwardly arcuate transverse end wall, positioning an apertured member over the hollow rivet, and heading the rivet by positioning a mandrel in the rivet and upsetting it by means of a punch to compressively fold and thicken the transverse end wall of the rivet.

Since the transverse end wall of a rivet produced by this method is thicker than the transverse end wall of the upstanding unstaked rivet, the rivet attachment is quite strong and is not as prone as the heretofore known rivets to failure by stripping of the rivet head. The relatively thick transverse end wall produces a strong resisting lever against the lifting forces which would tend to buckle a weaker end wall. Moreover, forming a rivet by the present invention does not require drastic thinning of metal in the end closure to gather metal for the rivet, and does not require coining metal in and around the rivet. Consequently, a rivet produced by this method is not as vulnerable to corrosive attack as are many of the heretofore known integral rivets with areas of very thin residue material. This is especially true with rivets formed in sheet material that has a preplaced protective coating thereon. Excessive thinning, coining and extrusion of the coated sheet material in the heretofore known methods frequently causes failure of protective coatings, while the method of this invention causes little or no degradation of protective coatings.

A feature of the method of the invention is the combination of forming an upwardly arcuate transverse end wall on the hollow rivet and the avoidance of any thinning of metal between the mandrel and the punch in staking the rivet to form a head thereon. The forming and staking of the arcuate transverse end wall of the rivet results in the introduction of compressive folding forces into the end wall to thicken the same, and the avoidance of any thinning whatsoever during staking insures that the rivet head produced thereby is at least as thick as the end wall of the unstaked rivet. It is noted that a relatively high rivet is also beneficial to the formation of a strong rivet attachment in the invention because a high rivet provides more area of metal to be compressively folded to form a thickened rivet head. While the ability to form a high rivet is dependent on alloy, temper, metal gauge, and tooling precision among other factors, it is also enhanced by forming an arcuate transverse end wall on the rivet in accordance with the method of the invention.

Accordingly, an object of the invention is to provide an improved method of forming a sheet metal rivet joint having a relatively thick transverse end wall.

A further object of the invention is to provide an improved method of forming an integral rivet for attaching a tab to a tear strip in an end closure in which there is a minimum of degradation of the protective coating on the end closure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a container end closure having a tab attached thereto in accordance with the method of the invention.

FIG. 2 is an enlarged, fragmentary, vertical, cross-sectional view through the rivet of the end closure in FIG. 1.

FIG. 3 is an enlarged, fragmentary, vertical, cross-sectional view of dies used to form a bubble.

FIG. 4 is an enlarged, fragmentary, vertical, cross-sectional view of the dies used to reform the bubble into an upstanding hollow rivet.

FIG. 5 is an enlarged, fragmentary, vertical, cross-sectional view similar to FIG. 4 with the reforming operation completed.

FIG. 6 is an enlarged, fragmentary, vertical, cross-sectional view similar to FIG. 5 showing alternative tools for forming the rivet.

FIG. 7 is an enlarged, fragmentary, vertical, cross-sectional view of tools used to stake the rivet shown before the staking operation has begun.

FIG. 8 is an enlarged, fragmentary, vertical, cross-sectional view similar to FIG. 7 with staking initiated.

FIG. 9 is an enlarged, fragmentary, vertical, cross-sectional view similar to FIG. 7 with staking partially effected.

FIG. 10 is an enlarged, fragmentary, vertical, cross-sectional view similar to FIG. 7 with staking completed.

FIG. 11 is an enlarged, fragmentary, vertical, cross-sectional view illustrating the compressive stresses in a button during staking.

FIG. 12 is an enlarged, fragmentary, vertical, cross-sectional view of two punches that could be used to reform the bubble into a rivet.

FIG. 13 is a graph on which is plotted the relationship of some of the various parameters that effect the strength of a rivet formed in accordance with the invention.

FIG. 14 is a graph similar to the graph in FIG. 12 showing the parameters for a smaller rivet.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the drawings, FIG. 1 shows a metal end closure **10** exemplary of a general type having an integral rivet joint made in accordance with the invention. The material of the end closure is preferably aluminum or aluminum alloy container sheet having a gauge thickness in the range of 0.008 to 0.016 inch. The end closure **10** comprises a recessed end panel **12** with a peripheral flange **14** therearound adapted to be secured over the open end of a container **24**. The end closure **10** has a removable tear strip **16** defined by score line **18**, and has a pull tab **20** attached to the tear strip **16** by means of an integral rivet **22** as is hereinafter described. The end closure may be provided with a protective coating on its undersurface to protect the sheet metal of which it is formed from attack by the contents of the container. This coating may be any of several well-known materials that are widely used for this purpose, with epoxy, epoxy phenolic and vinyl resins being nonlimiting examples thereof.

The tab **20** is generally of a lever type and has an aperture therein for receiving the integral rivet **22** for attachment to the tear strip **16**. The tab **20** is lifted to rupture the score line **18** and then pulled across the end panel to sever tear strip **16** from the panel. In accordance with the invention, the pull tab **20** is affixed to the tear strip **16** by an integral rivet **22**, as shown in FIG. **2**, which is formed by the method illustrated in FIGS. **3** through **10**. The method essentially comprises the steps of forming a raised bubble in the end panel, reforming the bubble into an upstanding hollow rivet, positioning an apertured tab over the rivet, and staking or heading the rivet to affix the tab to the end closure.

The object of forming the bubble is to generate additional surface area of metal to be used in the formation of the rivet. To generate this additional area, the metal of the end panel is stretched and thinned to form the bubble. In the preferred method, the diameter of the bubble is approximately twice the diameter of the rivet to be formed therefrom.

As shown in FIG. **3**, the bubble-forming operation is essentially a drawing operation employing a male die or punch **28** having either a conical surface or a hemispherical surface **30**, a holddown member **26** and a female die **32** having a circular die cavity **34** therein with a small radius **36** at its entrance so that the sheet material can be drawn thereover during forming. To form the bubble **38**, the deformable sheet material of the end closure **10** is restrained against the female die **32** by the holddown **26**, and the punch **28** is advanced into the die cavity **34** to draw the deformable material into the cavity and over the surface **30** of the punch. In this operation, the press, not shown, has a preset stop to control the amount of drawing. Preferably, the sheet material is uniformly thinned during the drawing to produce a bubble **38** of substantially uniform cross-sectional thickness.

As an illustration of the bubble-forming step, bubbles were formed in end closures made of aluminum, container sheet alloy of 0.0105-inch gauge in a full hard condition resulting from cold reduction, e.g. rolling, of at least 85 percent of the thickness of fully recrystallized, e.g. annealed stock. In end closures, the bubbles were formed having heights *h*, as indicated in FIG. **3**, in a range of 0.110 to 0.140 inch, and approximately 0.435-inch base diameters. In these bubbles, the metal of the end closure was uniformly thinned to a thickness of 0.0090 to 0.0095 inch over the area of the bubble.

After the bubble **38** is formed therein, the end closure **10** is removed from the dies of FIG. **3** and positioned in the dies shown in FIG. **4** for reforming the bubble **38** into an upstanding hollow rivet. The rivet-forming dies comprise a male die **40** having a punch **42** with an arcuately domed working end **41** shaped to the specification of the rivet to be formed as hereinafter described, and a female die **44** having a die cavity **46** therein designed to coact with the punch. A small radius **48** is provided around the mouth of the die cavity **46** to permit the metal of the bubble **38** to be drawn between the coacting surfaces, and to form a smooth transition in the end closure around the base of the bubble **38**. In order to provide a sufficient area of metal to avoid rupture of the metal during the forming operation, the bubble **38** is usually slightly taller or higher than the hollow rivet to be formed therefrom. This is shown in FIG. **4**, with the bubble **38** extending above the punch **42** used for forming the rivet.

To form the rivet, the bubble **38** is positioned over the punch **42** and restrained by means of a holddown member **43** around the periphery of the bubble, and the female die **44** is advanced against the male die **40** to draw and reform the bubble over the punch **42**. Preferably, the metal in the bubble is only slightly thinned, if any occurs, during the reforming into the rivet **50**. As shown in FIG. **5**, the rivet **50** generally conforms to the shape of the punch **42** and has a substantially cylindrical sidewall **52** and an upwardly arcuate transverse end wall **54**.

In the end closures mentioned above, the 0.110 to 0.145-inch-high bubbles were reformed into hollow rivets of approximately 0.220-inch diameters and heights *H* in the range of 0.130 inch to 0.150 inch, with the higher rivets being formed from the higher bubbles. Measurement of the rivets indicated that there was only slight if any thinning of the sheet metal during the reforming operation, and the transverse end walls of the upstanding, hollow rivets were in the range of 0.0087 to 0.0094 inch thick. This is approximately 0.85 of the section thickness of the end closure in its original condition before formation of the bubble.

FIG. **6** illustrates alternative tools that can be used to reform the bubble into an upstanding rivet. These tools comprise a male die **74** having a punch **76** with an arcuately domed working end **78** and a female die **80** having a die cavity **82** therein designed to cooperate with the punch **76** to form an upstanding rivet **50** similarly to the dies in FIG. **5**. The female die **80** in FIG. **6**, however, has a coining face **84** for extruding metal from around the base of the button **50** into the rivet to increase the height thereof. The tools of FIG. **6** are used primarily on end closures in which a higher rivet is desirable to provide additional metal for forming the rivet head, but in which there is no protective coating or in which the integrity of such coating is not a factor.

After the hollow rivet has been formed, the end closure **10** is transferred to staking dies, and an apertured tab is positioned over the hollow rivet. As seen in FIG. **7**, the aperture in the tab **20** substantially conforms to the outer diameter of the upstanding rivet **50** and fits snugly thereover. The staking dies comprise a bottom die **58** having an upper supporting surface **56** and a fixed mandrel **60** over which the rivet **50** is positioned, a holddown member **62** to restrain the assembly of end closure **10** and tab **20** on the bottom die **58**, and a punch **64** for upsetting the rivet **50** to fold the metal of the rivet over the metal of the tab **20** around the tab aperture. The diameter of the mandrel **60** on the supporting die **58** conforms substantially to the inside diameter of the sidewall of the hollow rivet, and has its upper surface **61** disposed approximately in the plane of the upper surface of the tab **20**. Preferably, the upper surface **61** of the mandrel **60** is disposed slightly above the upper surface of the tab **20** to provide the optimum degree of central support for the rivet as will be explained, but can also be disposed in or below the plane of such surface.

FIGS. **8–10** illustrate in detail the progressive buckling and folding of the rivet **50** during the upset or heading operation, and FIG. **11** illustrates the stresses that are introduced into the rivet during this operation. When the punch **64** contacts the top of the rivet **50**, the arcuate transverse end wall is progressively inverted and buckled to form an upwardly concave configuration therein having a depressed central portion **53** and an annular portion **55** contiguous therewith. The progressive inversion of the end wall proceeds until its depressed central portion **53** bears against the upper surface **61** of the mandrel **60**, which resists further buckling of the rivet and causes the annular portion **55** to be folded outwardly and downwardly to form a head **66** on the rivet as seen in FIG. **10**.

FIG. **11** illustrates the compressive forces that are present in the rivet **50** with the depressed central portion **53** bearing on the upper surface **60** of the mandrel **60**. Force arrows F_1 generally indicate the force of the punch against the top of the rivet, forces arrows F_2 indicate the supporting force provided by the bottom die **58**, and force arrow F_3 indicates the support provided by the upper surface **61** of the mandrel **60**. With these external forces acting on the rivet **50** in combination with the lateral support provided the sidewall **52** of the rivet by the mandrel **60** and the tab **20**, opposed radial compressive forces, as generally indicated by the small force arrows F_4, are introduced into the rivet **50**. It is believed that the resistance to bending of the metal in the arcuate transverse end wall of the rivet which causes the wall to invert and buckle, and the relatively large surface area of metal in the transverse end wall, produces relatively high radially opposed compressive stresses in the metal which tend to thicken the cross-sectional thickness of the metal. If the rivet had an initially flat or relatively flat transverse end wall, there would be little or no bending and buckling such as to produce the compressive forces employed in the invention.

FIG. **10** shows the bottom position of the punch **64** as it completes its downward stroke as controlled by a preset stop in the press, not shown. In the high speed fabrication of container closures, the staking punch **64** moves very rapidly, and does in fact strike the upwardly arcuate end wall **54** of the rivet when staking is initiated. The punch does not, however, compress or squeeze any metal from the transverse end wall of the rivet at the completion of its stroke because the preset stop in the press stops the punch before the transverse end wall is squeezed against the mandrel. At the bottom of the stroke of the punch, there is a clearance or gap **70** between the upper surface **61** of the mandrel **60** and the transverse end wall or head **66** of the staked rivet **22**. The gap **70** may be so small as to be almost nonexistent, just as long as the punch **64** does not move downward so far as to compress and squeeze the metal of the rivet heat **66** between the mandrel **60** and punch **64**. In the preferred method of the invention, the upper surface **61** of the mandrel **60** is in, or slightly above, the plane of surface of the tab **20**, and the punch **64** is stopped slightly over one gauge thickness of metal thereabove. Some air may be entrapped in the hollow rivet above the mandrel **60** and be compressed by the collapse of the rivet during staking. It is believed that leaving the small air gap **70** between the surface **61** of the mandrel and the head of the rivet **22** also provides accommodation for such compressed air. By avoiding squeezing of metal from the transverse end wall, thinning of the end wall is avoided. Consequently, the effect of the staking operation is to thicken the transverse end wall and fold it radially outwardly over the tab **20** to form a head **66** on the staked rivet **22**. As an illustration, when the upstanding rivets on the closures mentioned above were headed, the transverse end wall of the rivets were thickened in the range of 0.0005 to 0.0015 inch.

The importance of the arcuate shape of the transverse end wall of the hollow rivet is borne but by the results of extensive testing that was conducted to determine the criteria for obtaining optimum results in the practice of the invention. The testing as conducted using end closures made of hard rolled, aluminum alloy container sheet of 0.0105-inch gauge, coated with epoxy phenolic resin and baked at 400° F. for 20 minutes, and having tabs affixed to tear strips in the end closures by means of integral rivets formed in accordance with the invention. The rivets in the end closures were formed using a variety of punches **42** on the bottom die **40** in the dies shown in FIG. 4. Two series of end closures were run, one series in which hollow rivets of approximately 0.220 in. inside diameter were formed and one series in which hollow rivets of approximately 0.180 inch inside diameter were formed.

Referring to FIG. **12**, the radius of curvature *R* of the arcuate end **41** of the punch **42** used in reforming the bubble into an upstanding rivet was varied so as to produce rivets having a variety of transverse end all configurations. When the radius of curvature *R* of the end of a punch was less than one-half the punch diameter *D* the punch **42** was blended from its rounded end into the side of the tool as shown in the top half of FIG. **12**. When the radius *R* was more than one-half the punch diameter *D*, the tool was ground on a small radius at the juncture of the rounded end and the side of the punch as shown in the bottom half of FIG. **12**. The dimensions of the taper and of the blending radius are not considered to be critical. The hollow rivets formed by these punches were headed to form rivet attachments as illustrated in FIG. **7** through **10** to affix tabs to the tear strips in the end closures without thinning the metal in the transverse end walls of the hollow rivets.

FIGS. **12** and **13** graphically illustrate the results of tests on the two sizes of rivets. On the graphs, the ratio of the radius of curvature *R* of the punch to the diameter *D* of the punch was plotted against (**1**) the height of the hollow rivet before staking, (**2**) the head diameter of the staked rivet, and (**3**) the percent increase in thickness of the transverse end wall of the rivet during staking. It is seen from the graphs that the maximum rivet head diameters and the maximum increase in the thickness of the transverse end wall of the rivet were achieved using rivet forming punches **42** having *R* to *D* ratios in the range of 0.48 to 0.80 for the larger rivets, and 0.48 to 0.66 for the smaller rivets. With punches having *R* to *D* ratios over 0.80 or 0.66, depending upon the rivet size, it was found that the transverse end walls of the hollow rivets were too flat to produce any significant buckling and folding during staking. The sidewalls of such hollow rivets were driven almost straight down into the closure end panels during staking and did not produce large enough rivet heads to properly attach the pull tabs to the end closures.

Punches having *R* to *D* ratios of less than 0.48, it was found, were too pointed and tended to rupture or pierce the ends of the hollow rivets during reforming of the bubbles into hollow rivets. If not ruptured by such punches, the transverse end walls of the rivets were unevenly thinned and weakened, causing the heads of the staked rivets to be similarly of uneven thickness and unsatisfactory strength.

The coated end closures having the rivets formed therein in accordance with the invention were tested for coating degradation by exposing them to an acidified copper sulfate solution for 30 minutes. To provide a control for comparison, end closures of like alloy and coating, but having rivets formed therein by a known method in which the transverse end wall of the unstaked rivet is other than arcuate and which is thinned during staking, were also exposed to the acidified copper sulfate solution for a like period. Examination of the two sets of end closures revealed severe attack of the metal in the rivets formed by the known method. In fact, the end walls in some of these rivets were completely perforated by the acidified copper sulfate solution. Contrariwise, the test specimens formed in accordance with the invention showed practically no evidence of attack by the acidified copper sulfate solution.

While particular embodiments of the invention have been described for purposes of illustration, it will be apparent to those skilled in the art that numerous variations of the details may be made without departing from the scope of the appended claims.

What I claim is:

1. A method for affixing a tab having an aperture therethrough to a container end closure of deformable sheet material comprising the steps of:

a. forming a raised bubble in the end closure;

b. reforming the bubble into an upstanding hollow rivet by supporting the bubble against a male die having a cylindrical punch with an arcuately domed working end projecting into said bubble, and advancing a female die against the male die to form a rivet with an upwardly arcuate central portion in its transverse end wall over the punch;

c. positioning the tab over the end closure with said upstanding rivet extending through the aperture in the tab; and

d. heading the rivet by moving a punch with a substantially flat working end against the arcuate central portion of the transverse end wall of the rivet while supporting the end closure against a die having an anvil extending into the hollow rivet to approximately the height of the upper surface of the tab, to progressively invert the arcuate transverse end wall and form an upwardly concave configuration therein with a depressed central portion and an annular portion contiguous therewith, and when said depressed central portion contacts and bears against the anvil, to fold the annular portion downwardly and outwardly to form a head on the rivet, the punch stopping before its working surface reaches a position with respect to the upper surface of the anvil equal to the thickness of the head of the rivet away from the upper surface of the anvil to avoid thinning the metal in the transverse end wall of the rivet during heading.

2. A method as set forth in claim **1** in which the closure is made of aluminum alloy sheet, and in said reforming of the bubble into a hollow rivet, the ratio of the radius of curvature of the domed end of the punch to the diameter of the punch is in the range of 0.48 to 0.66.

3. A method as set forth in claim **1** in which the transverse end wall of the rivet is thickened during heading.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,602,980 Dated Sept. 7, 1971

Inventor(s) Robert E. Heffner

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 22 Change "costing" to --coating--.

Col. 3, line 37 After "In" insert --these--.

Col. 5, line 32 After "inch." insert --The transverse end wall of some of the staked rivets were thickened almost to a thickness of the original gauge of 0.0105 inch.--.

Col. 5, line 34 Change "but" to --out--.

Col. 5, line 52 Change "all" to --wall--.

Signed and sealed this 11th day of April 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

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