Sept. 3, 1968 J. E. CONNOLLY ETAL 3,399,560

METHOD OF COLD FORMING A SOLID RING

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FIG. 1

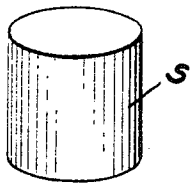


FIG. 4

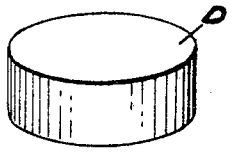


FIG. 5

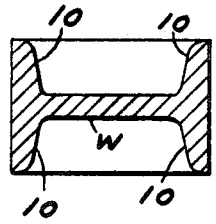


FIG. 6

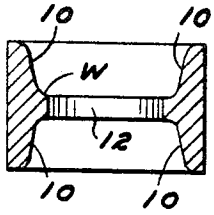


FIG. 7

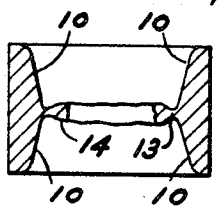


FIG. 8

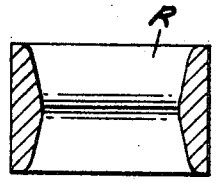


FIG. 2

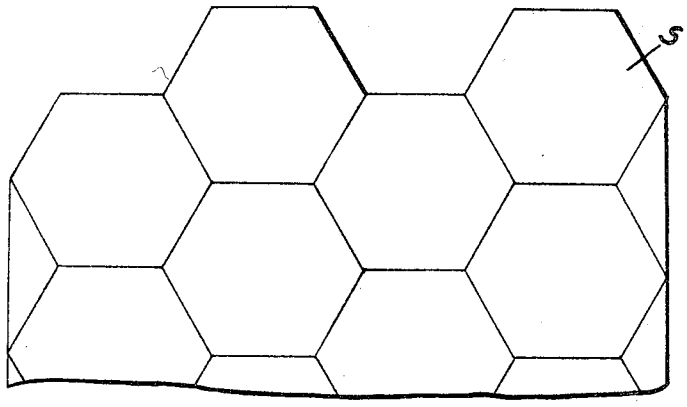
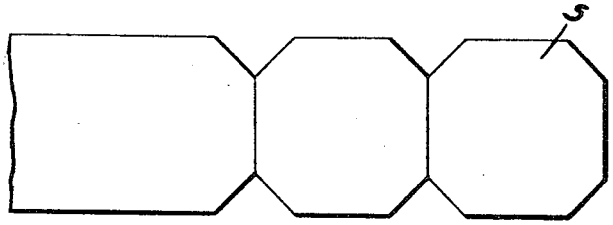


FIG. 3



INVENTORS
JOHN E. CONNOLLY
ABNER C. MICK
BY

Barnes, Kisselle, Raisch & Choate
ATTORNEYS

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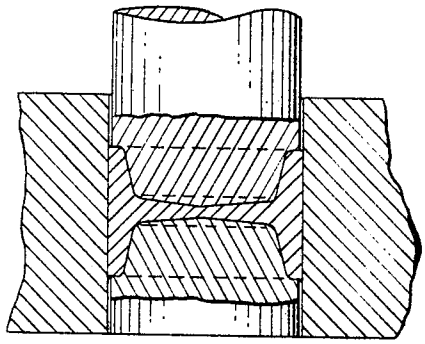

FIG. 9

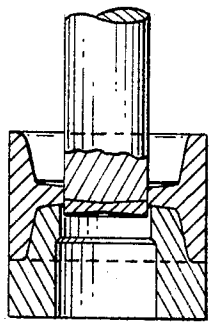

FIG. 10

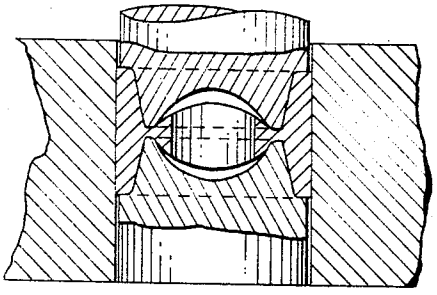

FIG. 11

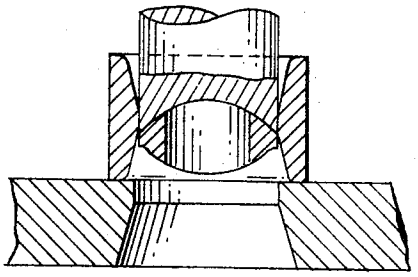

FIG. 12

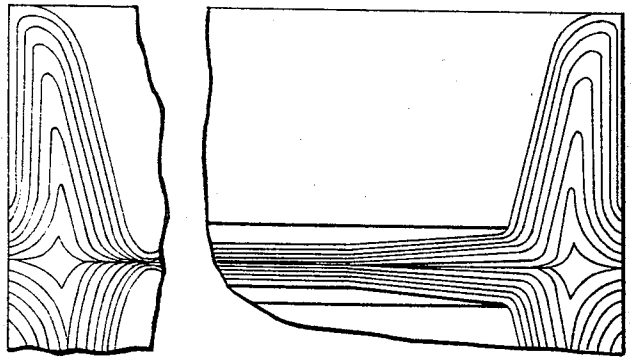

FIG. 14 FIG. 13

INVENTORS
JOHN E. CONNOLLY
ABNER C. MICK
BY
Barnes, Kisselle, Raisch & Choate
ATTORNEYS

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FIG. 15

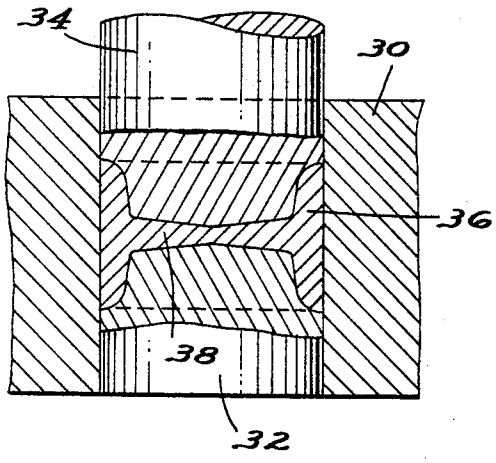


FIG. 16

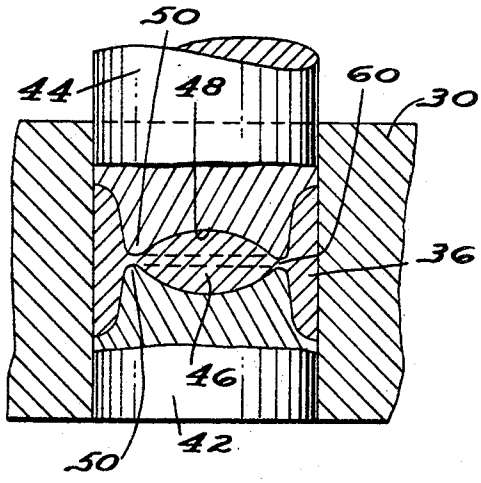


FIG. 17

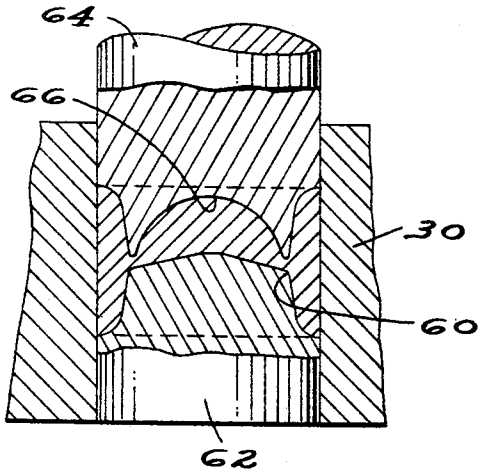
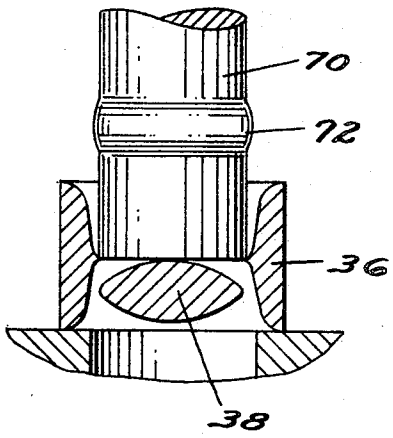


FIG. 18



INVENTOR.
JOHN E CONNOLLY
ABNER C. MICK

BY

Barnes, Kisselle, Raisch & Choate

ATTORNEYS

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3,399,560

METHOD OF COLD FORMING A SOLID RING

John E. Connolly, Hamburg, Mich. 48139, and Abner C. Mick, 3860 W. Outer Drive, Detroit, Mich. 48221

Continuation-in-part of application Ser. No. 36,775, June 17, 1960. This application Nov. 1, 1965, Ser. No. 513,626

10 Claims. (Cl. 72—368)

This application is a continuation-in-part of our copending application Ser. No. 36,775, filed June 17, 1960, now abandoned.

This invention relates to a method of producing an article and to the article itself, namely, a cold-headed ring.

Previously, rings have been hot forged as described in the following U.S. patents: Taylor 1,124,359, dated Jan. 12, 1915; McClintock 1,991,689, dated Feb. 10, 1935; and Brauchler 2,057,669, dated Oct. 20, 1936. The term "cold heading" is used to define a cold-working operation.

The problem is to provide an inexpensive, strong, solid continuous ring which has a higher tensile strength than parts machined from solid bar or hot forgings, and a ring that may be manufactured from materials, such as low carbon open hearth steel, with an analytic content suitable for easy and secure welding. Previously formed rings, formed from welded strip stock, have failed in connection with use on critical automotive parts such as power steering cylinders and shock-absorber cylinders.

In the present invention, we propose to produce steel rings by cold heading which presents entirely different problems in connection with the shaping of the metal than those which occur with a hot-forging operation. It is known that the cold working of steel will greatly increase the normal strength of the material. At the same time, the cold working of steel in progressive steps requires an increasing amount of pressure due to work hardening in the steel. For this reason in a progressive operation of cold working, or cold heading as it is called, it is necessary to direct the metal flow in a manner to overcome the extremely high pressure that would otherwise be required to continue and complete the operations. However, there are distinct advantages in cold heading a part such as a ring.

In the first place, the scale which results from the hot-forming process and the steps of heating and cooling are eliminated. Secondly, the part can be completed with a uniformity of working tolerance and finish which is satisfactory for exacting applications without any final machining whatsoever. Furthermore, an increased hardness and strength can be developed by cold working, which for many applications would be both helpful and desirable. However, the application of the cold-heading process to a ring, is extremely difficult because of the conditions above described where the cold working builds up resistance to further working which must be overcome.

The present invention contemplates the formation of a solid continuous ring in a series of successive steps resulting in a ring having close tolerances and a finished surface which needs no machining operation. The process includes steps which make it possible to continue the process without excessive machine loads due to the manner in which excessively high working pressures are obviated while forming the ring.

The disclosure which follows is accompanied by illustrative drawings, the various views of which are briefly described as:

FIGURES 1, 2 and 3, views of a slug or slugs from which the parts may be produced.

FIGURE 4 illustrates a slug coined for further cold-heading operation.

FIGURE 5 illustrates a sectional view of the part after the first heading step.

FIGURE 6 illustrates the part in section having the center portion removed.

FIGURE 7 illustrates a final heading or sizing operation to bring all the dimensions within allowable tolerance, and to pinch the web severely at the edge to facilitate removal.

FIGURE 8 illustrates the part after the removal of excess metal.

FIGURES 9, 10, 11 and 12 illustrate respectively the four final steps of the formation of the part and the tools used for these steps.

FIGURE 13 illustrates the grain structure of the part of FIGURES 5 and 9 after the first heading step.

FIGURE 14 illustrates the grain structure of the part of FIGURE 7 after the web has been pinched severely at the edge to facilitate removal.

FIGURE 15 illustrates a modified version of the invention showing the dies and the part in the first forming operation.

FIGURE 16 illustrates a second step in the modified process showing the further deformation of the central portion.

FIGURE 17 illustrates an optional second and final forming step prior to knockout.

FIGURE 18 illustrates a knockout step and final forming.

In the performance of the method of producing the article, one may start with a blank which is a round slug S cut from a rod of material, as shown in FIGURE 1, a hexagonal (or round) piece sheared directly from flat stock or bar stock, as shown in FIGURES 2 and 3, or other suitable geometric configuration.

One type of steel which may be used for cold heading rings in accordance with this invention would be low carbon steel such as SAE 1006 or 1008. Such steel should be of high-grade cold-heading quality which is free from laps, pipes, seams, pits, cracks, deep scratches, or excessive out-of-round conditions that might tend to make more difficult or prevent the forming or finishing of a satisfactory ring. It is most important that such steel be normalized or fully annealed after rolling.

By our process, the slug D, shown in FIGURE 4, is coined in a conventional manner from the starting slug S, and is first placed in a die cavity which confines it circumferentially. The slug is then worked from both ends by applying opposed axial punching forces in a backward extrusion operation to create the configuration shown in FIGURE 5, said configuration having inner side walls **10** and a center web W therebetween. The shape of the punches is apparent from the shape of the part and also illustrated in FIGURES 9 to 12. The initial cold-heading and backward extrusion operation subjects the web W to a high degree of cold working. It, therefore, will be appreciated that after the first cold heading operation, to further cold form the web W to reduce its thickness, would require extremely high pressures. Consequently, the next step in the process is intended to overcome the extremely high pressure that would otherwise be required to continue and complete the cold working operations. This step broadly comprises shaping the web W, as by striking the same, to relieve the central portion of the web prior to the hereinafter described subsequent step of applying punching forces to a narrow annular zone **13**, thereby assisting in causing the metal to flow radially inwardly in said subsequent step. More particularly, this relief shaping step comprises applying an axial punching force in one direction to the central portion of the web to axially displace the central portion of the web W from the plane of the outer annular portion **14** of the web. Preferably, this is done by the piercing of the web W by conventional methods to form a hole **12** leaving a residual web **14** comprising just a small edge of the web W. The piercing step is

done by a punch and a die, the die supporting the outer rim of the web on one side adjacent the inner wall of the ring, while the punch is piercing the web from the outer side, FIGURE 10.

The third step in the formation of the part is to strike again the residual edge W of the web in a manner which creates a cold working condition at the periphery **13** of the web wherein the grain is actually flaky or brittle. This is done by a punch with a narrow annular strike area directly adjacent the sides **10** on the interior wall which forces the excess metal of the web into the center in an irregular formation **14** (FIGURE 7), due to the relief shaping of the center portion of the web. Here again, the shape of the punches corresponds with the shape of the part as shown, FIGURE 11. This third step is possible even though the metal is cold worked to a high degree in the first operation. However, in the operations thus far described, the walls **10** are approaching their final dimension and have been shaped to within the allowable tolerances while improving and maintaining the surface finish as required. The metal of the web is reduced in thickness in a narrow annular zone, as shown in FIGURE 7, and the metal at this stage has been cold worked by the successive operations to approximately the yield point.

In the final operation the residual flange **14** is removed by a punch which knocks out the flange and irons the inner wall of the ring. Due to the fact that the material being removed is extremely brittle as a result of the two cold-working operations, it is easily removed. The piercing die for the final operation is preferably only about .002" smaller at the working end than the finished coining die which brought the part to the shape shown in FIGURE 7. The small flash remaining is ironed into the walls of the ring by the shank of the piercing punch which is again to size, FIGURE 12.

The result is a finished product R, shown in FIGURE 8, with final dimensions which require no machining operations to prepare it for immediate assembly by automatic methods. In all steps, except the last, the ring is contained by an outer die pocket to locate the slug and to condition and dimension the outer surface of the ring. In each progressive step, the die size will increase a few thousandths to accommodate slight increase of diameter of the ring. The tools and the four final steps of the process are illustrated in FIGURES 9, 10, 11 and 12.

A slightly modified method is shown in FIGURES 15 to 18 wherein the perforation step shown in FIGURE 6 is eliminated and substituted therefor is a means for moving this metal into a die pocket to achieve the same result. In FIGURE 15, the initial forming step is shown which is similar to the formation shown in FIGURE 5 of the first process wherein the part which is similar to that shown in FIGURE 4 is shaped in a circular recess in die plate **30** by two identically shaped male die portions **32** and **34** having projections which in general form the outside ring portion **36** of the work part with a web formation **38**.

In FIGURE 16, the second step is shown in which the forming dies **42** and **44** are each formed with a concave central portion hollowed out respectively at **46** and **48** and each having a rounded rim portion **50** which move toward each other to form a very narrow annular section **60** just inside the basic ring portion **36**. In forming this thin annular portion, the metal of the web portion **38** moves into the concave pockets **46** and **48** and this severe work hardening at the annular portion **60** creates the brittle grain structure at this area. This process is optionally continued from the first step as shown in FIGURE 17 where dissimilar die members **62** and **64** are provided to further work the annular portion **60**, the lower die member **62** being similar to the lower die in FIGURE 15, somewhat convex in shape, and the upper die member being pronouncedly concave at **66** to receive the displaced metal of the central web portion. A completion of the steps shown in FIGURE 16 or 17 permits the final knockout step shown in FIGURE 18 wherein the central web portion **38** which is attached to the walls of the ring **36** by narrow annular portion is struck from the ring by a knockout punch member **70**, this punch having an annular enlarged portion **72** which will coin the walls of the ring **36** as it moves downwardly through the ring.

Basically, this process creates the same grain effect as in the previously described process and produces the same part, the difference being that in the first described process the central portion of the web was removed to permit the deformation at the annular portion directly adjacent the walls of the ring whereas in the present case the dies are so formed that the metal of the web portion can move into them without creating any undue pressure on the walls of the outer ring.

By our process, we produce parts free from surface scale, which commonly forms when parts are hot forged, and we also eliminate any tool marks which often occur when parts are machined from solid bar. In addition, the tensile strength has been greatly improved over that of the material as received from the steel mill. Other advantages are that the ring produced by our method requires less material than parts manufactured either by hot forging or machined from a solid bar and the tolerances are maintained and more constantly uniform than by other known processes.

Most important, the parts can be produced more economically than the hot-forged parts or the machined parts which is highly desirable in connection with large volume requirements such as that of the automotive and other similar industries. Another advantage is that the ring is a strong ring, although formed from low carbon steel, and because of this analysis it is suitable for production welding operations, requiring no orientation as does the split ring. The grain structure as illustrated in FIGURES 13 and 14 is ideal for strength and stress analysis. The grain flow is in orderly parallel lines compressed together at the web and parallel to the outer conformities of the ring, the lines in the ring being similarly contoured in ever decreasing areas from the surface. The grain flow is generally axial from each end toward an axially intermediate portion of the ring and converging in a radially inward direction as a narrow band at the inner periphery and in the final ring terminating and being generally radially disposed at the inner periphery of the side wall.

What is claimed as new is as follows:

1. The method of producing cold-forged metal rings of close final dimension and high strength suitable for machine parts and as welded elements of a combination which comprises selecting a slug containing sufficient metal to form the ring with slight excess, striking said slug to form a double cup with a common web forming the bottom of each cup as a first step, as a second step, removing the center portion of the web to leave a small residual annular area on the inner walls of the cups whereby a ring having a residual web is formed, as a third step striking the residual web along its outer periphery directly adjacent the ring in a narrow annular pressure area to create an extremely brittle condition of the metal within said residual web adjacent the ring inner wall while shaping the surface of said ring to a final dimension and finish, and as a last step removing said residual web from the inner walls of the ring and coining the severed area simultaneously.

2. The method of cold forming a slug of steel to form a ring having relatively high strength, a smooth finish and close tolerances developed solely by cold working which comprises applying opposed punching forces axially to opposite ends of the slug over a central area of less extent than the end surfaces of the slug to cause the metal to flow outwardly and axially in opposite directions and thereby form a double cup having an annular side wall with a common relatively thick web forming the bottom wall of each cup, removing the central portion of the web from the surrounding outer annular portion of the

web whereby a ring is formed having a residual web comprising the undisplaced outer annular portion of the web, applying opposed axial punching forces to narrow annular pressure zones on opposite faces of the residual web directly adjacent the inner periphery of the annular side walls of the cups to reduce the thickness of the residual web at said annular pressure zone to a relatively thin and readily frangible metal connection between the residual web and the annular side walls of the cups and thereafter removing the residual web by applying a punching force axially in one direction to said thin metal connection to shear the residual web from the side walls of the cups directly adjacent the inner periphery of the side walls of the cups.

3. The method called for in claim 2 including the step of axially ironing out the sheared zone of the annular side wall resulting from removal of the residual web simultaneously with said step of removing the residual web.

4. The method called for in claim 2 wherein the second mentioned punching forces are directed against the web to cause the metal at said narrow annular zone to flow substantially exclusively in a radially inward direction.

5. The method called for in claim 2 wherein said step of removing the central portion of the web comprises piercing a central aperture in the web.

6. The method called for in claim 2 wherein said step of removing the central portion of the web comprises punching the central portion of the web to form an aperture therein, the outer periphery of the aperture being spaced sufficiently inwardly from the inner periphery of the annular wall to accommodate an annular die cooperable with a punch for forming said aperture.

7. The method of cold forming a slug of steel to form a ring having relatively high strength, a smooth finish and close tolerances developed solely by cold working which comprises applying opposed punching forces axially to opposite ends of the slug over a central area of less extent than the end surfaces of the slug to cause the metal to flow outwardly and axially in opposite directions and thereby form a double cup having an annular side wall with a common relatively thick web forming the bottom wall of each cup, relieving the central portion of the web by axially displacing the central portion of the web from the surrounding outer annular portion of the web whereby a ring is formed having a residual web comprising the undisplaced outer annular portion of the web, applying opposed axial punching forces to narrow annular pressure zones on opposite faces of the residual web directly adjacent the inner periphery of the annular side walls of the cups to reduce the thickness of the residual web at said annular pressure zone to a relatively thin and readily frangible metal connection between the residual web and the annular side walls of the cups and thereafter removing the residual web by applying a punching force axially in one direction to said thin metal connection to shear the residual web from the side walls of the cups directly adjacent the inner periphery of the side walls of the cups.

8. The method of cold forming a slug of steel to form a ring having relatively high strength, a smooth finish and close tolerances developed solely by cold working which comprises applying opposed punching forces axially to opposite ends of the slug over a central area of less extent than the end surfaces of the slug to cause the metal to flow outwardly and axially in opposite directions and thereby form a double cup having an annular side wall with a common relatively thick web forming the bottom wall of each cup, displacing the metal of the web away from the side walls of the cup to leave a relatively thin

outer annular portion of the web whereby a ring is formed having a residual web comprising the undisplaced outer annular portion of the web, applying opposed axial punching forces to narrow annular pressure zones on opposite faces of the residual web directly adjacent the inner periphery of the annular side walls of the cups to reduce the thickness of the residual web at said annular pressure zone to a relatively thin and readily frangible metal connection between the residual web and the annular side walls of the cups and thereafter removing the residual web by applying a punching force axially in one direction to said thin metal connection to shear the residual web from the side walls of the cups directly adjacent the inner periphery of the side walls of the cups.

9. The method of cold forming a slug of steel to form a ring having relatively high strength, a smooth finish and close tolerances developed solely by cold working which comprises applying opposed punching forces axially to opposite ends of the slug over a central area of less extent than the end surfaces of the slug to cause the metal to flow outwardly and axially in opposite directions and thereby form a double cup having an annular side wall with a common relatively thick web forming the bottom wall of each cup, applying opposed axial punching forces to narrow annular pressure zones on opposite faces of the web directly adjacent the inner periphery of the annular side walls of the cups to reduce the thickness of the web at said annular pressure zone to a relatively thin and readily frangible metal connection between the web and the annular side walls of the cups and thereafter removing the web by applying a punching force axially in one direction to said thin metal connection to shear the web from the side walls of the cups directly adjacent the inner periphery of the side walls of the cups.

10. The method of cold forming a slug of steel to form a ring having relatively high strength, a smooth finish, and close tolerances, developed solely by cold working which comprises applying opposed punching forces axially to opposite ends of the slug over a central area of less extent than the end surfaces of the slug to cause metal to flow outwardly and axially to form a cup-like shape having a bottom and side wall, applying opposed axial punching forces to a narrow annular pressure zone of the bottom wall directly adjacent the inner periphery of the side wall of the cup to reduce the thickness of the bottom wall at said annular pressure zone to a relatively thin and readily frangible metal connection between the bottom wall and the side wall, and thereafter removing said metal connection by applying a punching force axially in one direction to shear the metal in said pressure zone from the side wall directly adjacent the inner periphery of the side wall of the cup.

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CHARLES W. LANHAM, *Primary Examiner.*

L. A. LARSON, *Assistant Examiner.*