Feb. 18, 1947. G. R. ECKSTEIN 2,415,940

METAL CUPPING PROCESS

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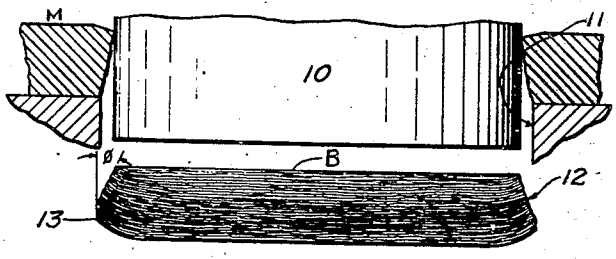


Fig. 1

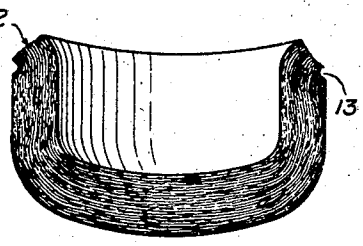


Fig. 2

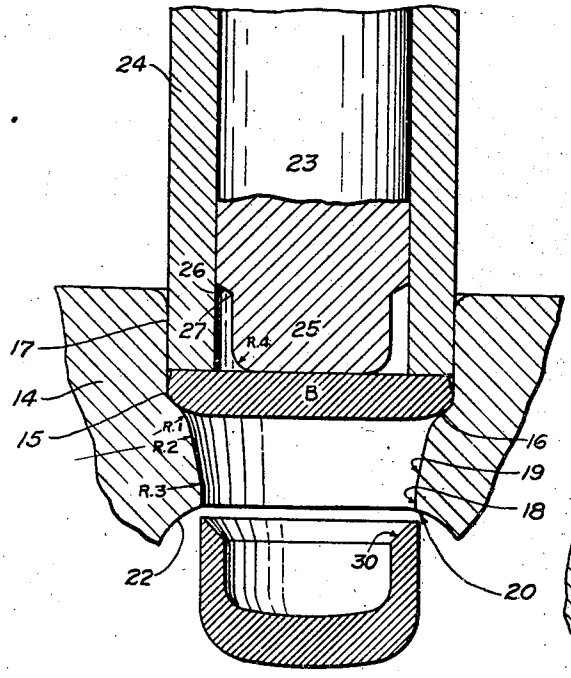


Fig. 4

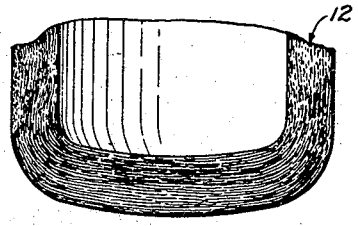


Fig. 3

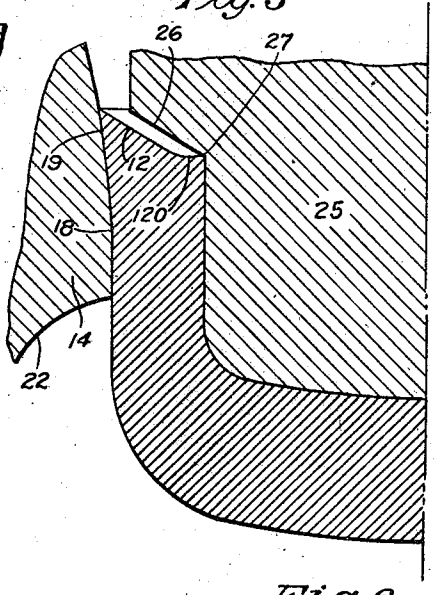


Fig. 6

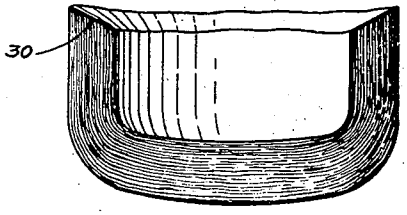


Fig. 5

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METAL CUPPING PROCESS

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3 Claims. (Cl. 29—148.2)

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The present invention relates, in general, to metal drawing, and, in particular, to an improved means and method of forming cups from steel blanks for the manufacture of small arms ammunition components, as, for example, caliber .50 steel cartridge cases.

Cartridge cases have been manufactured from time immemorial by punching a metal blank from a sheet of brass, cupping the blank and subsequently subjecting the cup to a number of deep drawing, annealing and trimming operations to secure the proper shape and dimensions of the case. Brass has been used almost exclusively in the manufacture of cartridge cases because its metallurgical characteristics are such as to render a brass blank amenable to the deformations and stresses which are introduced into the metal during the shaping of the case, and to which the finished case is subjected when fired.

The problem of manufacturing steel cartridge cases in quantity production lots has not been solved heretofore due primarily to the high modulus of elasticity of steel, its low rate of work hardening and its high corrodibility. Other factors such as the heterogeneous nature of steel, the relative difficulty with which it can be worked and the tendency of workpieces to "pick up" or cling to the draw punches have also contributed to the problem of manufacturing steel cartridge cases on a commercially successful basis.

In view of these factors, it is not surprising to find that a steel blank reacts differently than brass during blanking and cupping operations, in fact, a steel blank identical in all respects to a brass blank and cupped by identical tools invariably gives a differently shaped and usually an unsatisfactory cup.

Steel has been used heretofore in deep drawing processes, but, in such instances, the ratio of blank thickness to blank diameter has been within a limited range between 0.001 and 0.003. In general, steel blanks for cartridge cases have a much higher ratio. In particular, a .50 caliber steel cartridge case blank has a thickness diameter ratio of substantially 0.16 which is roughly one hundred and fifty times that heretofore encountered in the manufacture of deep drawn steel articles. As might be expected, therefore, the usual means and method of drawing steel blanks are not applicable to the manufacture of steel cartridge cases.

Moreover, it has been discovered, as a part of this invention, that a large proportion of the defects which have been found in finished steel cartridge cases as heretofore made or which occur

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when such cases are fired have their origin in the cup for whereas malformed brass cups are amenable to correction during subsequent drawing operations any eccentricity, asymmetry or other defects of a steel cup will not be corrected as the cup is being processed. Hence it is of paramount importance that a steel cup have the highest degree of perfection in order to insure satisfactory cases.

Extensive experimentation has demonstrated that of the requisite characteristics of a steel cup for making .50 caliber steel cases, its susceptibility to processing by drawing; exterior walls free from shear surface; and a lip comprising substantially the entire shear surface of the blank and having a prescribed contour, are among the most important.

An object of the present invention is, therefore, the provision of a means and method of forming cups of steel which can be processed successfully to form drawn steel articles. A further object is the provision of steel cups which will yield steel small arms ammunition components equivalent to brass in substantially all respects and in quantity production lots. A still further object is the provision of a means and method of blanking sheet steel and drawing the resulting blank to form steel cups wherein the shear surface of the blank is confined substantially wholly to the lip of the cup. A still further object is to provide a method of drawing steel cups embodying the step of coining the lip of the cup.

These and other objects, features and advantages of the invention will be more fully described in the following specification and illustrated in the accompanying drawing, in which:

Fig. 1 is a representation of a macrophotograph of a sectioned wide angle steel blank showing the flow lines of the metal at the shear surface and includes a fragmentary view of a blanking punch and die assembly.

Fig. 2 is a representation of a macrophotograph of a sectioned steel cup formed from an inverted blank showing the formation of the fracture line in the outer wall of the cup.

Fig. 3 is a representation of a macrophotograph of a sectioned steel cup formed from a noninverted blank, but before the lip of the cup has been coined.

Fig. 4 is a fragmentary side elevation in section of the improved cupping punch and die assembly of this invention.

Fig. 5 is a representation of a macrophotograph of a sectioned steel cup having a planar bevelled

lip which has been made true by the coining action of the cupping punch.

Fig. 6 is an enlarged fragmentary view of the sectioned coining lip of the cupping punch shown at the instant of contact with the lip of a cup.

Referring to Fig. 1 of the drawing, the blanking punch and die assembly comprises a cylindrical member 10, the diameter of which is substantially 1.443 inches and 0.110 inch less than the diameter of the blanking die aperture 11. Due to the difference in diameter of the blanking punch and blanking die aperture, the angle ϕ of the shear surface 12 of the blanked disc B is relatively wide being of the order of 15° which is conducive of a clean cut shear surface. Moreover, the shear surface of the blank hereinafter termed a "wide angle" blank is necked down or pinched during the blanking operation, as shown by the flow lines in Fig. 1, so that the area of the shear surface is reduced. This effect minimizes the tendency of the shear surface to wrinkle during the subsequent cupping operation, which tendency has been found to induce incipient cavities in the lip of the cup and to propagate cold shuts during subsequent drawing operations. Although a blanking punch die clearance of 0.110 inch is preferred, satisfactory wide angle blanks have been formed with a blanking punch and die clearance as small as 0.083 inch.

Heretofore, efforts were made to cup steel blanks in the so called "inverted" position, that is to say, the blank was turned over before cupping so that its top or surface of small diameter seated in the cupping die, a noninverted cup being one whose blank has been seated bottom down in the cupping die.

Fig. 2 shows an inverted cup or cup formed from an inverted blank. It has been found as a part of this invention that inverted steel cups invariably develop a "fracture line" in the outer wall which carries through into the completed cartridge case which may result in case breakoffs during final drawing, ruptures on firing and localized necking. Moreover, this fracture line was found to coincide invariably with the bottom edge 13 of the shear surface 12 of the blank which, as shown by the metal flow lines in Fig. 2, does not form the lip of the cup as might be expected but, due to a nonuniform flow of metal at the top and bottom of the inverted blank, is drawn down over into the outside wall of the cup.

The present invention relates in part to a method and means of eliminating the fracture line in steel cups based upon the concept that by confining the shear surface of the blank to the lip of the cup, the shear surface and fracture line, if such should occur, may be completely eliminated from the drawn case at least by the second cut-off and without a prohibitive waste of material.

It was discovered that an important factor contributing to the confinement of the shear surface of a wide angle blank to the lip of a cup was the concept of seating the blank bottom down or in a noninverted position in the cupping die.

Fig. 3 illustrates a cup formed from a noninverted blank. It will be noted that the shear surface 12 of the noninverted blank has been held substantially to the lip of the cup and that the nature of the flow lines of the metal is such that the bottom edge 13 of the shear surface has not been turned outwardly into the outer wall of the cup as occurs in the inverted cup shown in Fig. 2. This characteristic metal flow of the noninverted blank is due in part to the fact that the larger amount of metal in the bottom of the blank enables the metal to stretch sufficiently before becoming work hardened to permit the lower edge 13 of the shear surface of the blank to gain the lip of the cup. It will be noted that the flow lines of the metal of a noninverted cup run out completely into the lip and that these flow lines are substantially parallel to the inside and outside walls of the cup.

Other factors, however, are influential in shaping the lip of the cup. It will be noted that the lip 12 of the cup shown in Fig. 3 is somewhat concave and during subsequent drawing operations this condition tends to be aggravated resulting in the formation of cold shuts in the mouth of a drawn case. The concave contour of the lip may be due in part to that effect known in the art as "pull up," wherein the outside edge of the lip of the cup is pulled up higher than the inside edge. As a part of this invention, it has been found that the amount of pull up increases with an increase in size of the ledge or shelf of the cupping die hereinafter described, and, on the other hand, a shelf of appreciable size is essential to the stability of the blank which in turn is an important factor in securing wall concentricity. Accordingly, a cupping die was developed as shown at 14 in Fig. 4 which embodies a minimum ledge or shelf 15 comprising a compound curve, the upper portion of which has a radius R_1 of substantially 0.100 inch adapted to blend into the lower portion of the curve, the radius R_2 of which is substantially 0.234 inch.

Referring to Fig. 4, the diameter of the bottom of the blank is shown as substantially equal to the diameter of the cylindrical mouth 17 of the cupping die 14 which in the embodiment shown is substantially 1.555 inches diameter and ½ inch deep. The portion of the cupping die aperture between the lower end of the shelf 15 and the upper edge of the die land shown at 18 is known as the approach surface and comprises a conical surface 19 which makes an angle of substantially 12° with the longitudinal axis of the die. The lower end of the approach surface 19 is blended into the land 18 by a radius R_3 of substantially $\frac{5}{16}$ of an inch. The diameter of the land is substantially 1.177 inches, its depth being substantially 0.090 inch. As is the usual practice, the lower edge 20 of the land is square and sharp to facilitate stripping, a counterbore 22 being provided on the underside of the cupping die 14 to maintain the sharp edge 20 of the land. It will be understood, however, that an independent stripper die may be used.

The particular cupping die contour defined by the shelf 15, the conical approach surface 19 and the radius R_3 which blends the latter into the land 18 has the effect of forming a cup lip which is substantially free from pull up, fringe and cavities, the shelf 15, in particular, insuring sufficient blank stability to guarantee cups having concentric walls and bottoms symmetrical with respect to the walls.

The punch for forcing the blank B through the cupping die 14 is shown at 23 in Fig. 4, the diameter of the punch being at least one inch and preferably slightly larger for greater stability. The punch may be guided in its reciprocable movement with respect to the die 14 by means of a guide sleeve 24 which, in the usual practice, is resiliently mounted and adapted to enter the mouth 17 of the cupping die slightly in advance of the cupping punch. The means for actuating the cupping punch 23 and its guide

24 are conventional and well known in the art and hence has not been shown. The lower end of the punch is reduced to provide a slightly tapered nose 25 which is substantially 0.837 inch in diameter at its lower end and 0.400 inch long. In the present embodiment, the radius R_4 of the end of the nose is substantially $\frac{7}{64}$ of an inch.

The upper end of the nose 25 is substantially 0.847 inch in diameter and is joined to the lower end of the shank 23 by an integral conical shoulder 26, the slope of its surface making an angle of substantially 56½° with respect to the longitudinal axis of the punch.

The conical shoulder 26 of the cupping punch 23 constitutes additional means for controlling the disposition of the shear surface 12 of the blank, but its primary function is to make true the contour of the lip of the cup being formed from the blank.

In order to insure success in subsequent drawing operations, the prescribed contour of the lip of the cup must be either slightly convex or preferably a substantialy planar inwardly sloping bevelled surface 30 such as shown in Fig. 5. A lip having even a very slight concave profile invariably produces a defective piece for drawing.

As pointed out above, a noninverted blank cupped in a die having the contour specified above has its shear surface held to the lip of the cup, the walls of the cup being concentric and the base of the cup substantially symmetrical with respect to the walls. Moreover, the lip of the cup is free from such defects at pull up, fringe and cavities.

It has been found, however, that the lip does not invariably have the prescribed contour for insuring optimum results in subsequent drawing operations. Generally, the lip will comprise a surface sloping from the outer edge of the cup inwardly and downwardly, the profile of the surface being slightly concave adjacent the inner edge of the cup, as shown at 120 in Fig. 6. As a part of the present invention, it was conceived that by providing a suitable shoulder on the cupping punch, the concave portion of the lip could be ironed out so as to make true the optimum lip profile.

To this end, the intersection of the conical shoulder 26 of the cupping punch with its slightly tapered nose portion 25 comprises a relatively sharp corner 27.

Referring to Fig. 6, it will be seen that when this sharp corner strikes the inner edge of the lip of the cup, the metal at this section of the lip will be flattened and simultaneously displaced outwardly toward the outer edge of the cup by the coining action of the bevelled shoulder 26. In this manner, the concave portion 120 of the surface of the lip is eliminated and a substantially planar bevelled surface on the lip will be made true.

The sharpness of the corner 27 and the location on the punch of the shoulder 26, which is hereinafter termed a coining shoulder, has been arrived at by extensive experimentation and constitute features which are essential to the formation of the optimum profile. It has also been ascertained that the coining shoulder resists a tendency of the shear surface of the lip of the cup to move down into the inside wall thereof and that by maintaining a coining shoulder of substantially the dimensions and configuration described, blank thicknesses varying as much as 0.010 inch may be cupped successfully

and considerable latitude may be enjoyed in the cupping die profile.

Fig. 5 shows the effectiveness with which the coining shoulder 26 and the sharp corner 27 of the cupping punch have held the shear surface 12 of the cupped blank from moving down into the wall of the cup while simultaneously coining a substantially flat bevel lip 30 on the cup It will be understood that the resistance sufficient to effect a swaging or coining action is provided by the radial pressure acting between the walls of the cup and the walls of the die aperture during the drawing operation.

During subsequent draws, the lip of the cup and hence the shear surface tend to pull down into the inside wall of the case, but this tendency is relatively slight and all of the shear surface metal is removed by second cut-off leaving the mouth of the case free from shear surface metal or fracture line defects.

The method of blanking and cupping is believed to be clear but may be briefly described as follows: A strip of steel M is fed across the aperture 11 of the blanking die whereupon the blanking punch 10 is driven down onto the metal strip. The blanking punch blanks out a disk B having a sharp clean shear surface 12 which makes an angle of substantially 15° with respect to the top and bottom surfaces of the blank and which is slightly necked as described above. The blank B is removed from the blanking die and may be cleaned and covered with a suitable lubricant or thin copper plating. The blank is then seated bottom down, that is to say, in a noninverted position on the shelf 15 of the cupping die 14. When the cupping punch 23 is driven down onto the top of the blank, the latter will be forced down through the conical approach surface 19 of the cupping die and into the cylindrical land 18. During this interval, the coining shoulder or lip 26 of the cupping punch coins the shear surface 12 of the cupped blank, as indicated in Fig. 6, so as to iron out its profile and make true a planar inwardly and downwardly inclined bevelled surface thereon. On completion of the downward stroke of the cupping punch, the punch is withdrawn from the cupping die. The cup having expanded radially slightly after passing through the land 18 now engages the sharp edge 20 of the land which strips the cup from the cupping punch in the usual manner.

The method and means described for forming a steel cup contemplates the use of separate machines for blanking the disk and cupping the blanked disk and in view of the relatively high working pressures encountered in forming steel cups, the use of separate blanking and cupping machines is recommended. However, it is conceivable that machines of the double action type such as used extensively in blanking and cupping brass may be used for forming steel cups.

It will be understood that the dimensions, proportions, angles and radii given in the foregoing description are those which have been found optimum for making a steel cup to be further processed into a caliber .50 cartridge case and are illustrations of and not limitations upon the invention.

What is claimed is:

1. A method of making a cup-shaped draw piece having concentric walls which are free from shear surface comprising the steps of punching a frusto-conical blank from a sheet, inserting said frusto-conical blank wide base foremost in a draw die, cupping said blank by engaging and forcing

the mid-portion thereof into a reduced diameter portion of said die, and then forcing the cup through and out of the reduced diameter portion of the die while applying to the lip thereof a pressure which induces an outward radial flow of the metal adjacent said lip.

2. A method of making a cup-shaped draw piece having concentric walls which are free from shear surface comprising the steps of punching a frusto-conical blank from a sheet, inserting said frusto-conical blank wide base foremost in a draw die, cupping said blank by engaging and forcing the mid-portion thereof into a reduced diameter portion of said die, forcing all of the shear surface of said blank into the lip of the drawn cup, and then forcing the cup through and out of the reduced diameter portion of the die while applying to the lip thereof a pressure which induces an outward radial flow of the metal adjacent said lip.

3. A method of forming a cup-shaped draw piece having concentric walls which are free from shear surface comprising the steps of providing a flat circular blank having a sheared edge portion of frusto-conical conformation, supporting said blank in a cupping die with its frusto-conical

sheared edge flaring outwardly in a direction facing the die land, cupping said blank by engaging and forcing same through said cupping die with a cupping punch, and simultaneously shaping the sheared edge to define an inwardly beveled lip by engagement with said sheared edge with an inverted frusto-conical shoulder formed on said punch.

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