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Molloy et al.

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[54] **METHOD OF MANUFACTURING DRAWN CUP BEARING RACES WITH CROWNED PATHWAYS**

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[73] Assignee: **General Motors Corporation**, Detroit, Mich.

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[21] Appl. No.: **181,427**

[52] **U.S. Cl.**.....**113/117**, 29/148.4 C, 72/348

[51] **Int. Cl.**.....**B21d 53/12**

[58] **Field of Search**.....113/117; 29/148.4 C; 72/347, 348, 349

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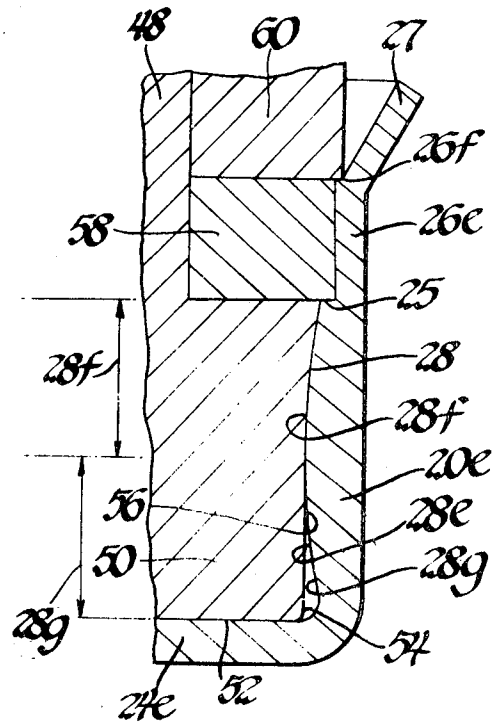
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Attorney—J. L. Carpenter et al.

[57] **ABSTRACT**

A method for manufacturing a thick walled, drawn cup bearing race having a crowned pathway and integral radial flanges at opposite ends of the pathway includes the step of drawing an open ended cup in such a manner that the side wall of the cup increases in thickness from the corner of the cup toward its open end. This increasing thickness is taken advantage of to provide the inner half of the crowned pathway. The outer half of the crowned pathway at the open end of the cup is produced by reforming the cup with a punch having a concavely tapered forming surface. The radial flange at the open end of the cup is preferably formed without any internal support to further accentuate the crown on the pathway.

7 Claims, 15 Drawing Figures



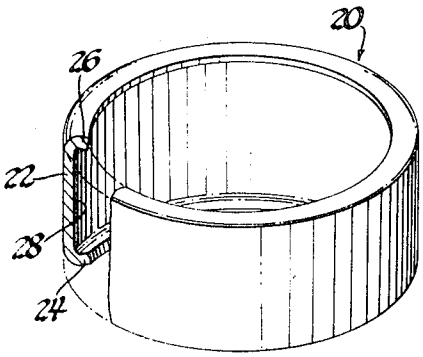


Fig. 1

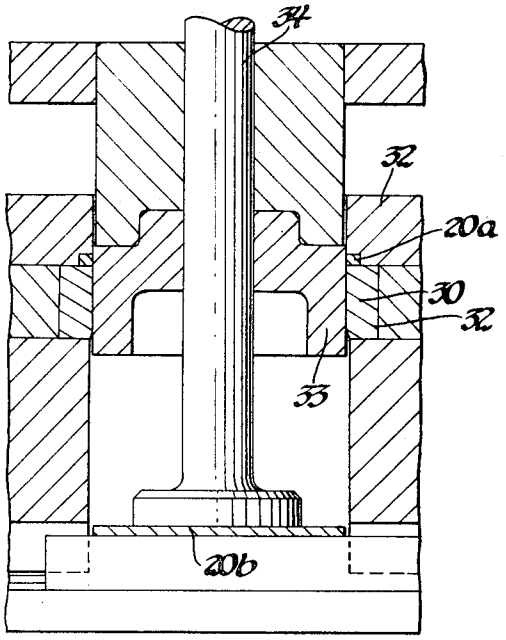


Fig. 2

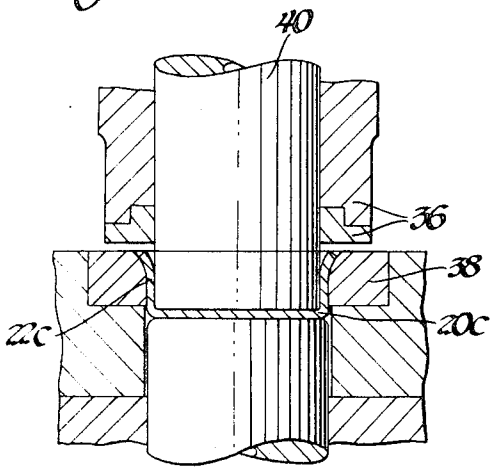


Fig. 3

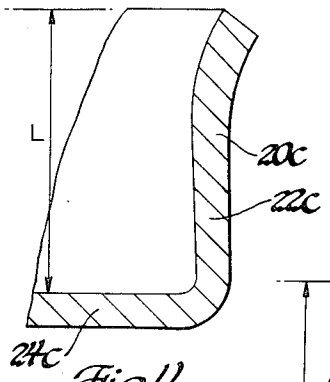


Fig. 4

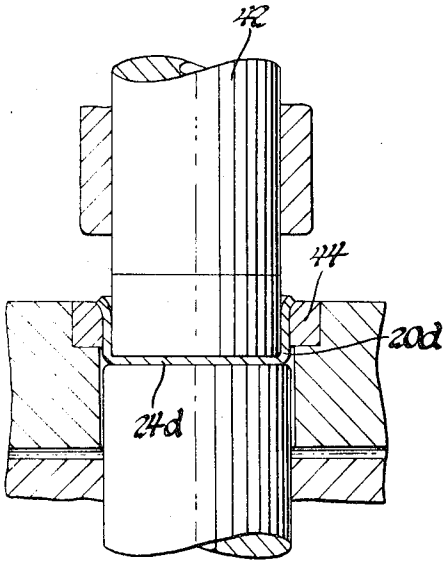


Fig. 5

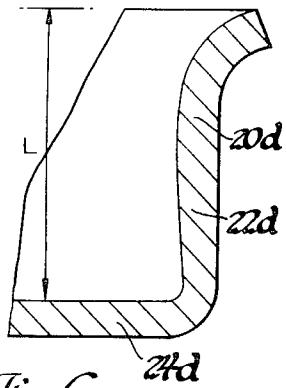


Fig. 6

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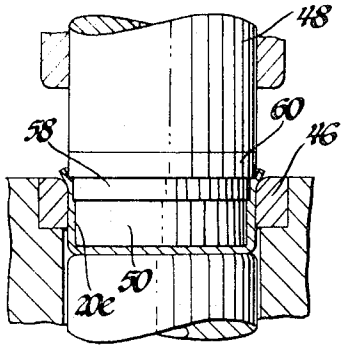


Fig. 7

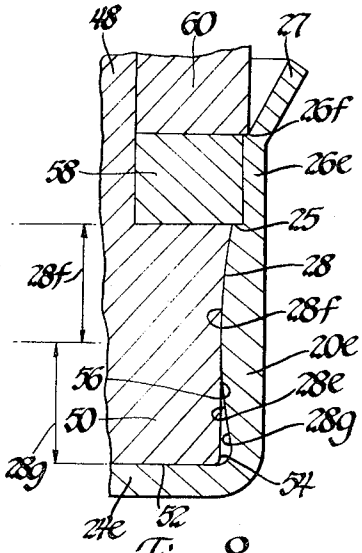


Fig. 8

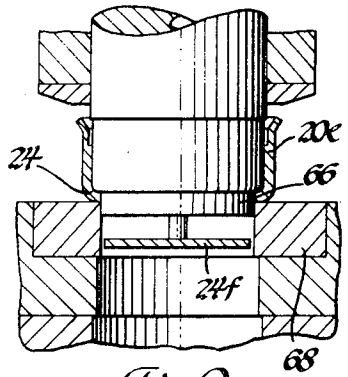


Fig. 9

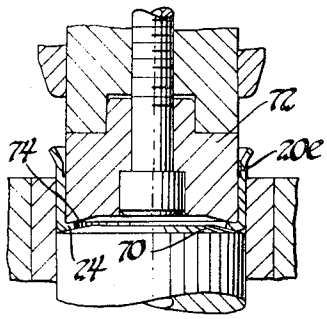


Fig. 10

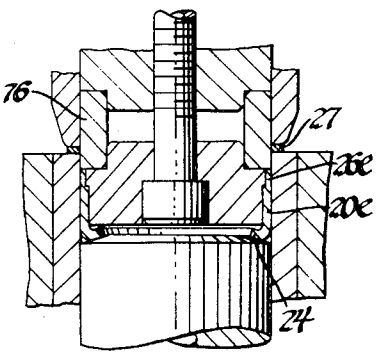


Fig. 11

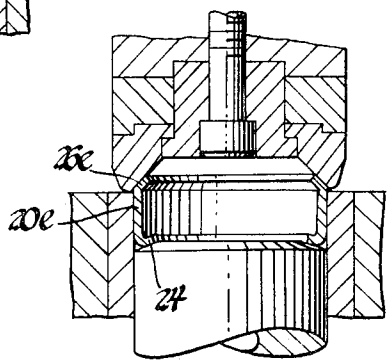


Fig. 12

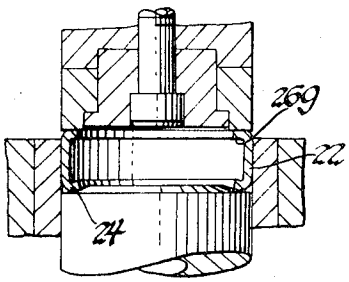


Fig. 13

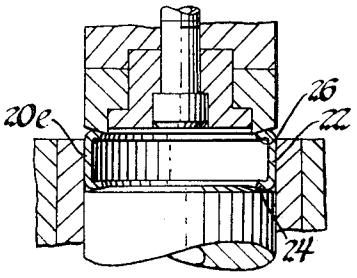


Fig. 14

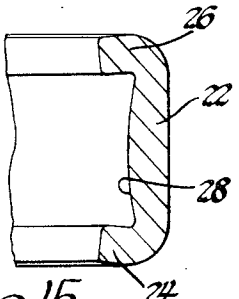


Fig. 15

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METHOD OF MANUFACTURING DRAWN CUP BEARING RACES WITH CROWNED PATHWAYS

This invention relates generally to a method of manufacturing a bearing race, and more specifically, to a method of forming a thick walled drawn cup bearing race from sheet metal.

The forming of flanged bearing races from flat sheet metal blanks by a metal forming process which avoids expensive machining and grinding operations is well known in the bearing art as exemplified by the U.S. Pat. No. 2,038,475 issued to Edmund K. Brown on Apr. 21, 1936, for an Antifriction Bearing And The Method Of Making The Same.

It has been the practice in the bearing industry to manufacture such "drawn cup" bearing races with relatively thin walls having a thickness of the cup in the range of 0.035 to 0.040 of an inch and with the roller pathway as nearly as cylindrical as possible. In recent years, however, increased demand in the load carrying capabilities of bearings in general and of economically produced types in particular has resulted in drawn metal technology being applied to the production of heavier walled "drawn cup" bearing races. In forming heavier walled "drawn cup" bearing races (with a wall thickness on the order of 0.080 of an inch), difficulty in maintaining the pathway cylindrical is encountered. The tendency is for the pathway to hollow out into a concave profile. Such a concave profile on the roller pathway overloads the roller ends causing excessive wear, lowers load carrying capabilities and shortens bearing life.

This invention results from realization that the tendency for thicker walled "drawn cup" bearing races to have hollow pathways is best resolved by crowning the roller pathway. The crowning of the roller pathways and its attendant advantages of eliminating roller end loading and accommodating misalignment is an accepted design practice in the production of machined, hardened and ground races. In crowning the inner pathway of the heavy walled drawn metal bearing cup according to this invention, advantage is taken of the natural tendency for the radial wall on the cup to stretch from the corner of the cup and to increase in thickness as it progresses toward the open end of the cup during the initial cupping and drawing of the flat blank. This increasing thickness is accentuated and maintained to provide the inside half of the pathway crown. The outside half of the crown pathway is directly formed on the interior of the cup wall by a concavely shaped die punch.

Other features of this invention preferably include the forming of the bottom flange of the cup at a slight layback angle to prevent interference between the roller end corners and the corner on the inside of the cup, simultaneous forming of a thinned axial flange with the formation of the outer half of the pathway crown, and a column loading of the cup side wall during the subsequent forming of the radial flange at the open end of the cup to further accentuate the crown on the pathway.

Other objects and features of the invention will become apparent to those skilled in the art as the disclosure is made in the following detailed description of preferred embodiments of the invention as illustrated in the accompanying sheets of drawing in which:

FIG. 1 is a perspective view partially sectioned of a drawn cup bearing race made in accordance with this invention.

FIG. 2 is a fragmentary sectional view taken through a first operation station showing a flat circular blank being punched from a sheet metal strip.

FIG. 3 is a fragmentary sectional view showing the blank being initially cupped and drawn into a first preform cup.

FIG. 4 is an enlargement of the first preform cup shown in FIG. 3.

FIG. 5 is a fragmentary sectional view showing the first preform cup being redrawn to a second preform cup of a smaller diameter.

FIG. 6 is an enlarged view of a portion of the second preform cup shown in FIG. 5.

FIG. 7 is a fragmentary sectional view showing the second preform cup being reformed into a cup with an internal crowned pathway.

FIG. 8 is an enlargement of a portion of FIG. 7 showing the detail of the reformed cup and the punch used in reforming the cup.

FIG. 9 is a fragmentary sectional view showing the center of the reformed cup bottom being pierced out.

FIG. 10 is a fragmentary sectional view showing the bottom flange of the reformed cup being bent to a slight layback angle.

FIG. 11 is a fragmentary sectional view showing the upper end of the reformed cup being trimmed away.

FIG. 12 is a fragmentary sectional view showing an initial stage in the progressive forming of the flange at the open end of the reformed cup.

FIG. 13 is a fragmentary sectional view showing a second stage in the forming of the flange at the open end of the reformed cup.

FIG. 14 is a fragmentary sectional view showing the final forming operation to produce a double flanged "drawn cup" bearing race.

FIG. 15 is an enlargement of a portion of FIG. 14 showing the detail of the completely formed "drawn cup" bearing race.

Referring now to the drawings and more particularly to FIG. 1, this invention is directed to a process for making a "drawn cup" bearing race 20 comprising a side wall 22, an integral bottom flange 24 and an integral top flange 26. The flanges 24 and 26 extend radially inwardly from an internal roller pathway 28 which is crowned. The crowned pathway 28 is shown more clearly in FIGS. 8 and 15. An explanation of the forming of the crown on the pathway 28 follows in conjunction with FIGS. 2 through 15 which show the various stages of manufacturing the "drawn cup" bearing race 20 from a sheet metal strip.

FIG. 2 shows a typical punch press in which a strip 20*a* is located over a blanking die 30 by a stock guide 32 and a flat circular blank 20*b* is pierced therefrom by a ram actuated blanking punch 33. A central knockout plunger 34 in the blanking punch 33 removes the blank 20*b* from the blanking die 30.

The completed first forming operation on the circular blank 20*b* is shown in FIG. 3. Initially, the circular blank is placed between a hold down 36 and a die ring 38. It is cupped and drawn into a first preform cup 20*c* by an overhead punch 40 descending into the die ring 38. The punch 40 is substantially flat nosed, that is, the lower end thereof is flat except for a small corner radius of conventional die punch design practice. The die

ring 38 has a relatively large bell mouth opening and the travel of the die punch 40 is such that the side wall 22*c* in the first preform cup 20*c* has a correspondingly large bell mouthed opening as is more clearly shown in FIG. 4. The force of the punch 40 is related to the force on the hold down 36 and the friction on the interior and exterior surfaces of the side wall 22*c* as it is being drawn so that the bottom wall 24*c* remains substantially flat and of uniform thickness while the side wall 22*c* increases in thickness from the corner of the cup. The variable thickness of the side wall 22*c* results from a thinning or stretching of metal at the corner of the cup. Here the thinning is maximum becoming progressively less pronounced with increased distance from the cup corner. In some instances, there may be a thickening of the side wall toward the open end of the cup. Such occurrence of a progressively thicker radial wall being formed is well known in the art. However, it has been the general practice in the past to minimize the variation in wall thickness by minimizing the severity of the draw in an effort to produce a substantial cylindrical bearing pathway. According to this invention, the variation is not minimized but rather accentuated. It is well within the skill of an ordinary die designer to so design dies to not only ensure that variable wall thickness occurs but to some degree accentuate the variation in wall thickness by increasing rather than decreasing the severity of the draw. See for instance, Eary and Reed. "Techniques Of Pressworking Sheet Metal — An Engineering Approach To Die Design," pp. 85–91. Prentice Hall, Inc., Englewood Cliffs, N.J., 1958.

The preform cup 20*c* is redrawn to a smaller diameter second preform cup 20*d* as shown in FIGS. 5 and 6. In the redrawing operation again a square nosed punch 42 is used in conjunction with a bell mouthed die ring 44. The die ring 44 has a smaller diameter than the die ring 38 and the bell mouth opening thereof is less pronounced so that the second preform cup 20*d* is of reduced diameter and has less bell mouth at its flared open end. Due to the additional cup depth created in the redrawing operation mainly because the open end bell mouth is reduced, the side wall 20*d* is thinner than the side wall 20*c*. However, the dies used in the redrawing operation shown in FIG. 5 are designed to maintain the variation in wall thickness on the side wall 20*d* which increases from the inside corner of the cup toward the open end. In a particular set of dies in which the practicality of this invention was demonstrated, the first two drawing operations were such that the overall height L of the cup was substantially maintained through the second drawing operation with the deepening of the preform cup 20*d* and thinning of the side wall 22*d* being produced by reduction in bell mouthing at the open end of the cup. In the redrawing operation some slight dishing of the bottom wall 24*d* may result in increasing the height L slightly.

In the operations shown in FIGS. 3 and 5, it is not essential that the wall thickness increase to the open end of the respective preform cups. It is essential, however, the dies be designed such that the side wall thickness increase from the corner of the cup to a point beyond the anticipated mid point of the roller pathway because this increasing thickness provides the inner half of the crown on the pathway. Stated another way, the increasing progressive thickness in the side wall 22*d* must be extended beyond the mid point of the anticipated pathway 28 to form the inner half of the crown prior to the forming of the outer half of the pathway crown.

FIGS. 7 and 8 show the forming of the outer half of the pathway crown. In this operation, the cup 20*e* is reformed from the second preform cup 20*d*. In the reforming operation, a die ring 46 of still smaller diameter and a multi surface forming tool 48 are used. The lower end of the multi surface forming tool 48 is a punch 50 with a substantially flat bottom 52 joined by a corner radius 54 to a concavely tapered cylindrical forming surface 56. Just above the punch 50 is a forming ring 58 of larger diameter above which is a second ring 60 of still larger diameter. The multi surface forming tool 48 and the die ring 46 cooperate to transform the preform cup 20*d* shown in FIG. 6 to the reformed cup 20*e* with a crowned roller pathway 28*e* as shown in FIG. 8. The outer half of the crown 28*f* is formed by the concavely tapered cylindrical forming surface 56, the inner half of the crown 28*g* having been formed in the previous drawing operations.

Thus far, this description discloses the invention as in its broadest concept, namely the forming of a crowned pathway on a "drawn cup" bearing race. However, such bearing cups are usually of the double flanged type and this invention further contemplates the convenient forming of the flange at the open end of the cup as well as other benefits and features. Simultaneously with the forming of the outer half 28*f* of the crowned pathway 28*e*, an intermediate thinned axial portion 26*e* separated by a shoulder 25 from the crowned pathway 28 is also formed by the ring 58. Above the portion 26*e*, an internal scoreline 26*f* produced by the lower edge of the ring 60 segregates the excess metal into an outwardly flared portion 27. The reformed cup 20*e* is reduced in diameter from the preform cup 20*d* and also the maximum thickness of the side wall 20*e* at the peak of the crown 28*e* is less than the maximum thickness of the side wall 22*d* in the second preform cup 20*d*.

It is to be understood that the curvatures and the spaces shown in FIG. 8 as well as FIGS. 3 and 5 have been exaggerated for purposes of clarity. In actual practice the concave forming surface 56 has a radius of curvature the order of 10 times the cup diameter and the crown height is on the order of a thousandth of an inch on the upper half and somewhat less on the lower half.

Referring now to FIG. 9, the bottom flange 24 is formed by punching out the central portion 24*f* of the bottom wall with a cutting punch 66 and ring 68. This step makes irrevelant the slight dishing of the bottom wall which may occur in redrawing the preform cup referred to previously. In those instances where a blind end bearing cup is being processed, this operation may be eliminated or replaced by some other bottom wall forming operation.

In FIG. 10, the reformed and punched cup 20*e* is disposed in a die cavity with the bottom flange 24 resting on a conical surface 70 therein. A punch 72 with a similar conical surface 74 bends the flange 24 slightly toward the interior of the reformed and punched cup 20*e*. This provides a layback angle on the flange 24 as can more clearly be seen in FIG. 15. The setting of the cup flange at a layback angle is conventional to prevent interference of the corners of the bearing cup with the roller ends.

FIG. 11 illustrates the trimming away of the excess metal in flared portion 27 by the cutting dies 76 prior

to the forming of the thinned portion 26*e* into a radial flange.

The top flange 26 at the open end of the completely formed race cup 20 shown in FIGS. 14 and 15 is progressively formed as shown in FIGS. 12, 13 and 14.

FIG. 12 shows the flange 26*e* partially bent at about 45°. In FIG. 13, the flange bent perpendicular to the side wall 22 is identified at 26*g*. The bearing width is usually adjusted at the process step shown in FIG. 13. In FIG. 14, the top flange 26 is also set at a layback angle.

While progressive forming of the flange at the open end of the cup is conventional, it is likewise conventional to provide internal lateral support for the side wall 22 during the forming. However, preferably no internal support is used in connection with the practice of this invention as the lack of internal support effects a column loading of the side wall 22. The column loading tends to buckle the side wall inwardly slightly thereby further accentuating the crown on the pathway 28.

We wish it to be understood that we do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

We claim:

1. The process of manufacturing a drawn cup cylindrical bearing race having a convexly crowned internal surface comprising the steps of:

forming a preform cup from a flat circular blank, said forming involving cupping of a bottom wall with a small radius corner and drawing of a side wall from said corner, said drawing entailing sufficient force to produce a stretching of the side wall of the cup so that a portion of the side wall increases in thickness from the corner of the cup and has an internal inwardly tapering surface extending from the corner to a point beyond a mid point of a crowned internal surface to be formed on the side wall, and

reforming said preform cup with a die ring and a punch having a concavely tapered nose into a cup with a crowned internal surface comprising a lower half and an upper half, said concavely tapered nose being radially spaced from said lower half and forming said upper half cooperatively with said die ring during said reforming operation.

2. The process as defined in claim 1 further including the step of buckling said side wall inwardly slightly by applying an axial load to said side wall without any internal support for said side wall whereby the crown on said internal surface is accentuated.

3. The process of manufacturing a thick walled, drawn cup bearing race having a crowned pathway comprising the steps of:

forming a flat bottomed preform cup from a flat circular blank with a die ring and a substantially flat nosed punch, said forming involving cupping of a bottom wall with a small radius corner and drawing of a side wall from said corner and entailing sufficient force to cause a stretching of the side wall of the cup so that it has a thickness which increases from said corner of the cup to a point well beyond the mid point of the side wall,

reforming said preform cup with a die ring of smaller diameter than said first die ring and a punch having a lower concavely tapered forming surface terminating in a substantially flat bottom into a deeper bearing cup of reduced diameter and with a crowned internal surface, and

applying an axial load to said side wall while maintaining lateral support only on the outside thereof to buckle said side wall slightly and increase the crown on said internal surface.

4. The process as defined in claim 3 including forming a thinned axial flange on said side wall simultaneously with reforming said preform cup, and

bending said thinned axial flange into a radial flange to provide a bearing cup with two integral end walls, said axial load being applied during said bending of said axial flange.

5. The process of manufacturing a thick walled, drawn cup bearing race having a crowned pathway comprising the steps of:

forming a first flat bottomed preform cup from a flat circular blank with a die ring and a substantially flat nosed punch, said forming involving cupping of a bottom wall with a small radius corner and drawing of a side wall and entailing sufficient force to cause a stretching of the side wall of the cup so that it has a thickness which increases from the corner of the cup to a point well beyond the mid point of the side wall,

drawing a second deeper preform cup of reduced diameter with a second die ring of smaller diameter than said first die ring and a substantially flat nosed punch, said drawing further stretching said side wall and reducing its thickness while maintaining an increasing thickness from the corner of the cup to a point well beyond the mid point of the side wall, and

reforming said second preform cup with a die ring of smaller diameter than said second die ring and a punch having a lower concavely tapered forming surface terminating in a substantially flat bottom into a deeper bearing cup of still further reduced diameter and maximum thickness with a crowned internal surface.

6. The process as defined in claim 5 including forming a thinned axial flange on said side wall while reforming said second preform cup, and

progressively bending said thinned axial flange into a radial flange to provide a bearing cup with two integral radial end walls, said progressive bending being performed without any internal support for said side wall whereby said side is buckled slightly accentuating the crown on said internal surface.

7. The process of manufacturing a thick walled, drawn cup bearing race having a crowned pathway and integral radial walls comprising the steps of:

Forming a first flat bottomed preform cup from a flat circular blank with a die ring and a substantially flat nosed punch, said forming involving cupping of a bottom wall with a small radius corner and drawing of a side wall and entailing sufficient force so that said side wall increases in thickness from the corner of the cup to a point well beyond the mid point of the side wall,

drawing a second deeper preform cup of reduced diameter with a second die ring of smaller diameter than said first die ring and a substantially flat nosed punch, said drawing stretching said side wall and reducing its thickness while maintaining an increasing thickness from the corner of the cup to a point well beyond the mid point of the side wall,

reforming said second preform cup with a die ring of smaller diameter than said second die ring and a multiple surfaced punch having a lower concavely tapered forming surface terminating in a substantially flat bottom, a juxtaposed ring having a forming surface of larger diameter than the maximum diameter of said concavely tapered forming surface and a scoring edge immediately adjacent the upper end of said ring into a deeper bearing cup of reduced diameter and maximum thickness with a crowned internal surface, a thinned axial flange adjacent its open end and a score line on the interior surface of the thinned flange,

severing the open end of said third cup at said score line, and

progressively bending said thinned axial flange into a radial flange without any internal lateral support for said side wall whereby a column effect is produced on said side wall hollowing its external surface slightly and increasing the crown on its internal surface.

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