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B. KAUL

2,966,987

PUNCH AND DIE FOR COLD SHAPING OF STEEL

Filed March 29, 1956

3 Sheets-Sheet 1

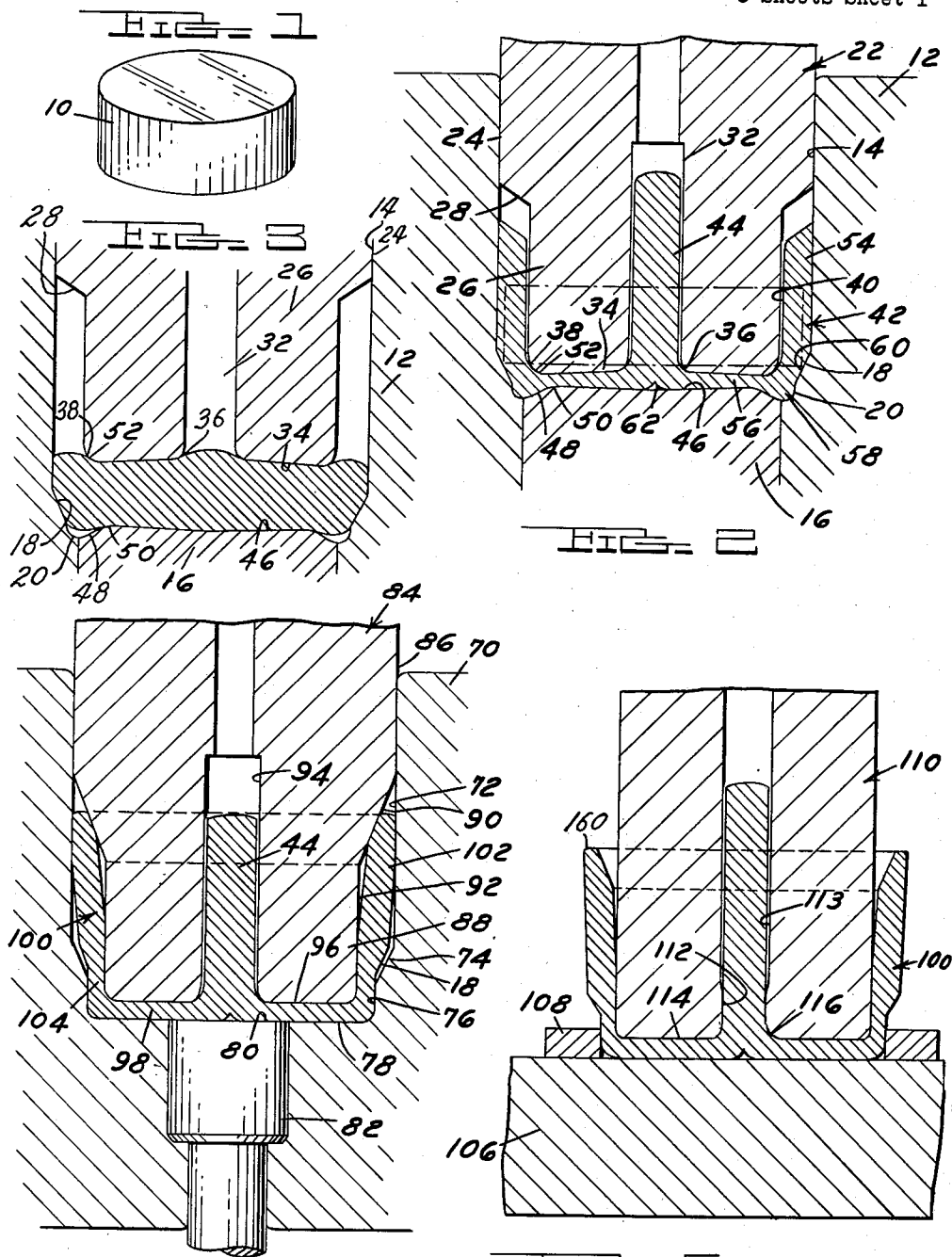


FIG. 4

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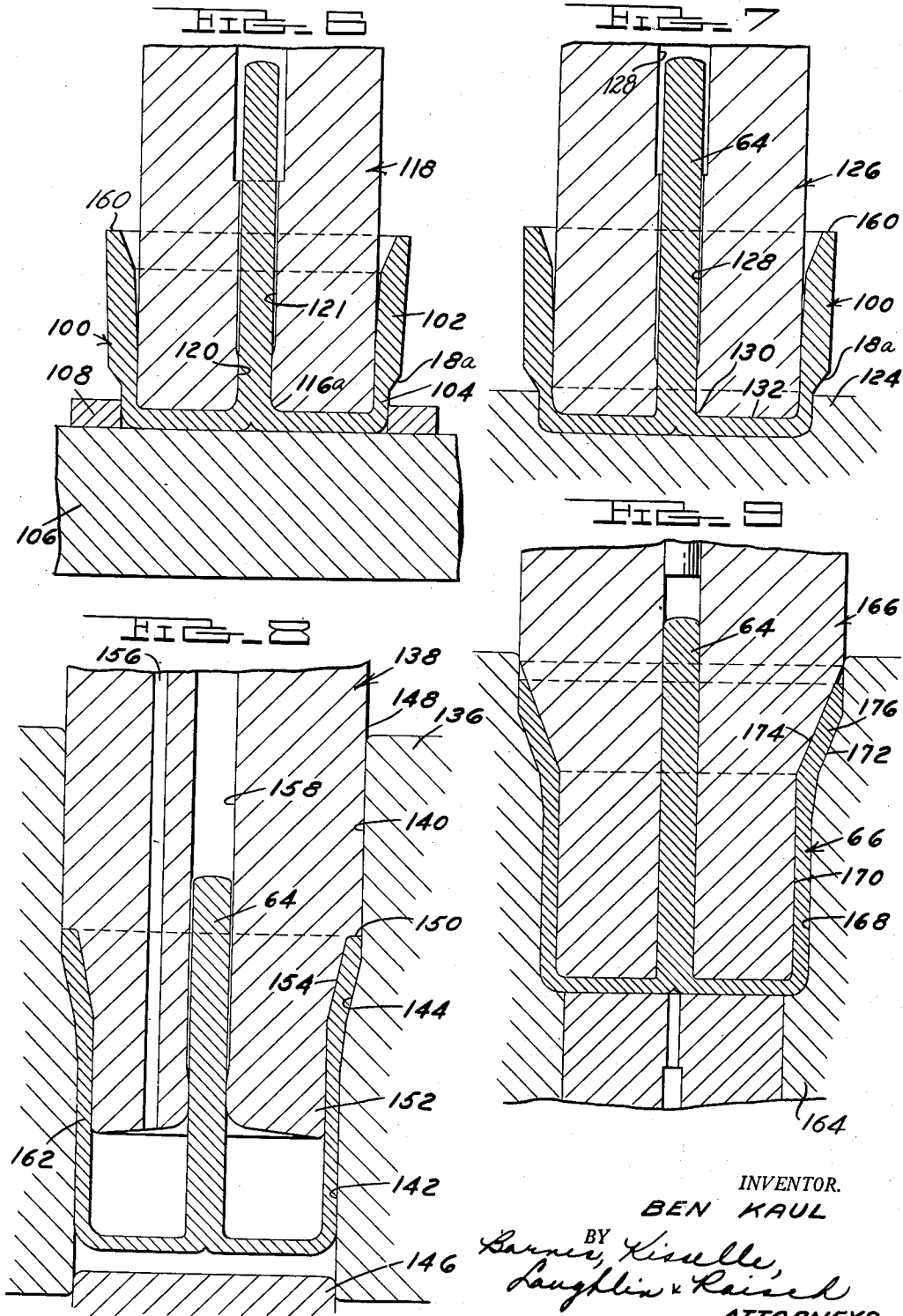
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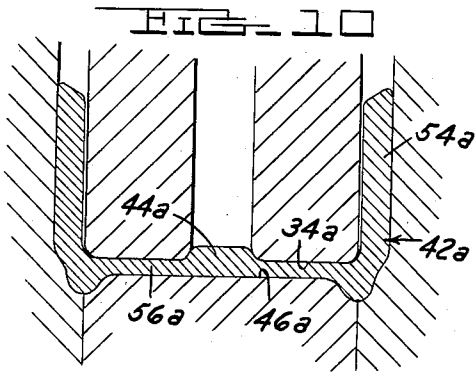
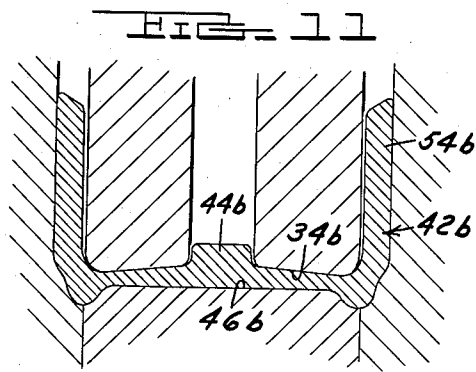
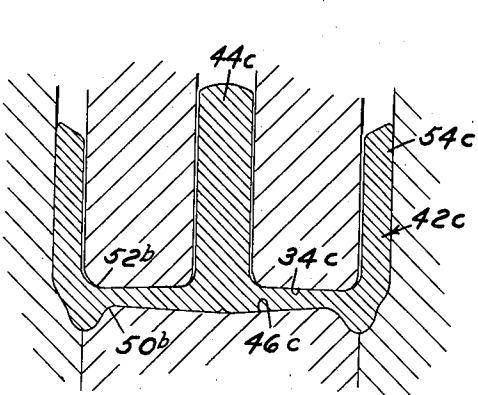
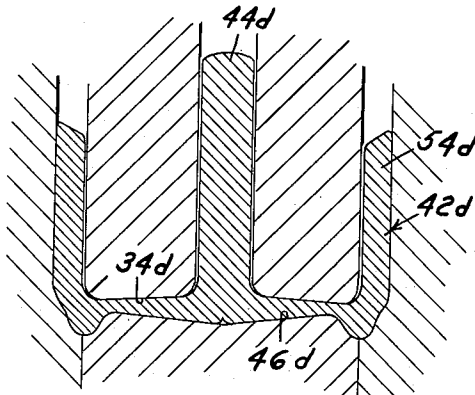
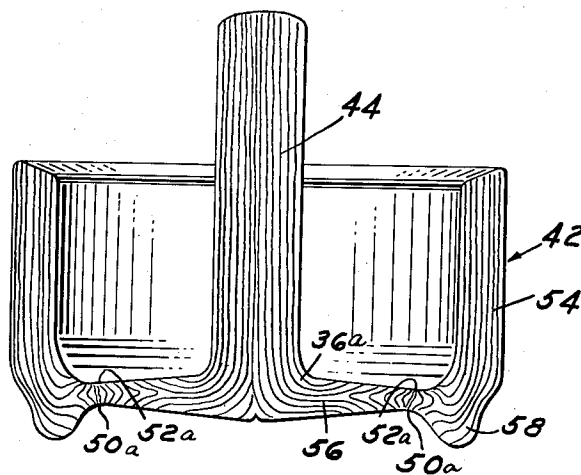
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PUNCH AND DIE FOR COLD SHAPING OF STEEL

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3 Sheets-Sheet 3



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2,966,987

PUNCH AND DIE FOR COLD SHAPING OF STEEL

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3 Claims. (Cl. 207-6)

This invention relates to the cold shaping of steel and more particularly to the cold working of steel from a solid blank, such as might be cut from bar stock, into a cup-shaped member having tubular side walls and a central stem extending upwardly from the bottom wall a substantial height; for example, at least the height of the side walls of the cup.

It is an object of this invention to provide a process for cold forming the article described above in a manner such as to produce a very sound article which requires a minimum amount of machining.

A further object of the invention is to provide a process for cold forming an article such as described above in a manner such as to develop the required hardness substantially uniformly throughout the article by cold working the metal of the blank.

A further object of the invention resides in the provision of novel punch and die structures for producing a cup-shaped article having a central upstanding stem.

In the drawings:

Fig. 1 is a perspective view of the starting blank used for forming the cup-shaped article of this invention.

Fig. 2 is a diagrammatic sectional view showing a die arrangement employed for carrying out the first step of my process.

Fig. 3 is a view similar to Fig. 2 and showing the initial stages of the step illustrated in Fig. 2.

Fig. 4 is a diagrammatic sectional view of the die arrangement employed for performing the second step of my process.

Figs. 5, 6 and 7 are diagrammatic sectional views showing successive steps employed in reducing the diameter of the stem formed on the cup.

Fig. 8 is a diagrammatic sectional view of the die arrangement employed for forwardly extruding the cup formed by the operation illustrated in Fig. 6.

Fig. 9 is a diagrammatic sectional view showing the die arrangement employed for performing the last step in the cold shaping of the cup.

Figs. 10 through 13 are diagrammatic sectional views showing variations in the shape of the cup produced by differently shaped punches and dies in performing the operation illustrated in Fig. 2.

Fig. 14 is a sectional view of the cup produced by the operation shown in Fig. 2 and showing the pattern of the grain flow lines therein.

In forming the cup-shaped article in accordance with the method and apparatus of the present invention, the starting blank comprises a solid slug 10 of steel cut from bar stock, preferably plain carbon steel in the low or medium carbon range, that is, from ingot iron up to about S.A.E. 1040. In the starting blank 10 shown in Fig. 1, the diameter is greater than the thickness of the blank. Blank 10 is dimensioned so that the approximate volume of metal in the finished article is provided in the blank

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and the dimensions are proportioned so that in the process of cold shaping this blank into the finished article, the required hardness of the final article will have been developed substantially uniformly throughout the article by reason of cold working the steel in a controlled manner through a series of successive steps.

The first step in cold shaping the blank 10 into the finished cup-shaped article having the upstanding central stem is illustrated in Figs. 2 and 3. This step is in the nature of a rearward extrusion operation. The blank 10, shown in broken lines in Fig. 2, is placed within a die 12 having a cavity 14 closed at its lower end by a central die post 16 which also serves as a knock-out pin. Adjacent its lower end, cavity 14 is provided with an annular inwardly tapering shoulder 18 which terminates in an annular rounded groove 20. The punch 22 has a cylindrical pilot portion 24 and a cylindrical free end portion 26 connected with the pilot portion 24 by a shoulder 28. Punch 22 is also provided with an axially extending central opening 32 which extends to the leading end face 34 of the punch. Face 34 is connected with the axial opening in the punch by a rounded corner portion 36 and with the side wall of the punch by a rounded corner portion 38. The corner portion 36, and preferably the corner portion 38 are each formed of two different radii, the larger radius being tangent to the leading end face 34 of the punch and the smaller radius merging with the larger radius and being slightly non-tangent to the side walls of the punch and the axial opening 32, respectively. A punch formation of this type is shown and described in my copending application Serial No. 161,760, filed May 13, 1950, now Patent No. 2,748,932, which issued on June 5, 1956. Forming the rounded corner at the leading end of the punch in this manner serves to eliminate or reduce friction between the rearwardly extruding metal and the side walls of the punch and of the opening 32. As explained more in detail in my copending application, by forming the corners 36 and 38 in this manner, the metal below the leading end face of the punch flows upwardly away from the side walls of the punch and the opening 32 so that actually, the bore 40 of the cup 42 has a diameter greater than the leading end 26 of the punch and the stem 44 has a diameter less than the diameter of axial opening 32.

Fig. 3 illustrates the start of the operation which is shown completed in Fig. 2. Die post 16 is a knockout pin; and at the start of the operation, die post 16 is in an elevated position, having knocked out the piece previously shaped in the die. The blank 10 is positioned on the knockout post; and as the punch moves down on the blank 10, this knockout post also moves downwardly, holding the blank 10 horizontally disposed. As the lower corner of the blank contacts the annular shoulder 18 of the die, that is, the position shown in broken lines in Fig. 2, the blank centers itself in the die. The punch 22 contacts blank 10 after the blank is thus centered in the die, and cocking of the blank in the die is thus prevented. The end face 34 of the punch has a slight conical formation. Thus, it tapers slightly upwardly towards the center from the corner 38 around the outer edge of the punch to the corner 36 around the edge of opening 32. The degree of inclination of end face 34 is determined primarily by the required height of the central stem of the work piece. In a work piece having the proportions shown in the drawings, the end face 34 is inclined to the horizontal at an angle of about 2½ degrees. The end face 46 of die post 16 is inclined reversely to the end face 34 of punch 22. Thus, post 16 is fashioned with an arcuate shoulder 48 around its periphery which blends

with the groove 20 at the lower end of the die cavity. Shoulder 48 defines an annular ridge or zone 50 on the end face 46 of die post 16, and ridge 50 in turn defines the periphery of the dish-shaped portion of the end face of the die post. Thus, the portion of face 46 encircled by the ridge 50 is inclined downwardly towards the center and preferably at the same angle as the inclination of the face 34 of punch 22. In the particular arrangement illustrated, end face 46 is inclined downwardly to the horizontal in a radially inward direction at an angle of about $2\frac{1}{2}$ degrees.

When punch 22 is moved downwardly into pressure contact with the top face of blank 10 as shown in Fig. 3, the angularly disposed faces 34 on the punch and 46 on the die post cooperate to cause a substantial portion of the metal between these two angular faces to flow radially inwardly and upwardly into axial opening 32 to form the central stem 44. The annular zone 52 at which the face 34 begins to taper upwardly and inwardly in effect forms a ridge which cooperates with the ridge 50 on the die post 16 to form a circumferentially extending trap which restricts the flow of metal in a radially outward direction. When the punch 22 is driven downwardly, the metal between the end face 34 of the punch and the dished surface 46 of the die post flows freer in a direction towards the center of the punch than in an outwardly direction because of the metal trap formed between the annular zones 50 and 52. Some of the metal will, of course, escape and flow radially outwardly until the gap between the annular zones 50 and 52 is sufficiently closed to make the resistance to outward flow through this gap substantially greater than the resistance to metal flow towards the center of the punch. The metal thus trapped is rendered available for the formation of the central stem of the finished article. As the punch is driven downwardly, a greater portion of the metal between the annular zones 50 and 52 is directed by the inclined faces 46 and 34 in the radially inward direction. This metal is directed upwardly around the corner 36 of the punch into the axial opening 32. As mentioned previously, the shape of corner 36 is controlled so that the diameter of the stem 44 thus formed is less than the diameter of the opening 32; and the stem portion 44 is thus formed without encountering friction between the upwardly flowing metal and the side wall of opening 32.

A portion of the metal between the end face of the punch and die post flows radially outwardly and the blank is thus expanded into contact with the wall of die cavity 14 including the shoulder 18 and the groove 20 to thus completely fill the lower end of the die cavity. As the punch 22 continues its downward movement, the metal extrudes upwardly around the rounded corner 38 to form the annular side wall 54 of cup 42. The bottom wall 56 of the cup has the tapered cross section illustrated in Fig. 2; and around its outer periphery, it is provided with the annular boss 58. The annular shoulder portion 60 connects the side wall 54 with the boss 58 and the bottom wall 56. At the center of the bottom face of bottom wall 56, a slight dimple or indentation 62 is formed. This dimple results from the flow of metal upwardly into stem 44.

In forming a cup-shaped article with an upstanding central stem by cold extrusion, the operation illustrated in Figs. 2 and 3 is a very important one; and the shape of the end faces of punch 22 and die post 16 must be controlled so as to produce a central stem such as shown at 44 of sufficient volume to thereafter form the stem of the finished article of the required length and diameter. The proportion of metal that is flowed radially inwardly and upwardly into stem 44 is determined by the angular inclination of end faces 34 and 46 and by the diameter of the annular zones 50 and 52. If the diameter of the zones 50 and 52 or the angular inclination of the faces 34 and 36 are reduced, a greater proportion of the metal

between the end faces of the punch and knockout post 16 will be permitted to flow in a radially outward direction; and thus, the resulting central stem 44 would be shorter in height.

The effect of specific variations in the shapes of the end faces of punch 22 and die post 16 on the height of the center stem of the cup is illustrated generally in Figs. 10 through 13. More specifically, these figures show the difference in the relative heights of the center stem and the side wall of the cup produced by the same size slug by varying the shapes of the end faces of the punch and the die post. Fig. 10, for example, shows the cup produced when the end faces of both the punch and the die post, faces 34a and 46a, respectively, are flat, that is, normal to the vertical axis of the punch. The cup 42a thus formed has a bottom wall 56a of generally uniform thickness except at the center stem 44a thereof. Since the faces 34a and 46a are flat as the punch moves downwardly into the blank, the metal flows freely in a radially outward direction; and the center stem 44a thus formed is very short.

In the arrangement shown in Fig. 11, the die post has a flat face 46b while the leading end face 34b of the punch is slightly conically shaped. With this arrangement, the face 34b of the punch tends to flow some of the metal in the blank radially inwardly and the cup 42b thus formed has a center stem 44b which is slightly greater in height than stem 44a. The side wall 54b of cup 42b is slightly shorter than the side wall 54a of cup 42a. A center stem having generally the same height as stem 44b would also result if the face 34b of the punch were made flat and the face 46b of the die post were conically shaped to the same extent as face 34b.

Fig. 12 shows an arrangement similar to that shown in Fig. 2 wherein the end faces 34c and 46c are both conically shaped. In this case, the center stem 44c of the cup 42c thus formed is very substantially greater than the center stem 44b and the side wall 54c is shorter in height than the side wall 54b. In this arrangement, there is a very definite metal trap formed between the annular zones 52a and 50b; and this, as explained above, causes a very substantial portion of the metal in the blank to flow in a radially inward direction and then axially upwardly into stem 44c.

Comparing Fig. 13 with Fig. 12 it will be noted that the inclination of the end faces 34d and 46d is substantially greater than the inclination of the faces 34c and 46c. As these angles increase, a greater portion of the metal in the blank is caused to flow radially inwardly and then axially upwardly so that the stem 44d of the cup 42d thus formed is substantially greater in height than the stem 44c and the side wall 54d of cup 42d is shorter in height than the side wall 54c of cup 42c.

That the metal radially inwardly of the zones 50 and 52 is in effect trapped is evidenced by the grain flow lines in the rearwardly extruded cup 42. In Fig. 14, these grain flow lines are generally illustrated. In the side wall 54 and the center stem 44, the grain flow lines are uniformly parallel with the axis of the cup. In the bottom wall 56 of the cup, the grain flow lines at the zones 50a and 52a are distorted and divided. From the zones 50a, 52a, the grain flow lines extend radially outwardly and upwardly around the outer corner 58 of the cup and extend radially inwardly towards the center of the cup and upwardly around the corner 36a into stem 44.

Comparing Figs. 2 and 9, it will be observed that stem 44 resulting from the operations shown in Figs. 2 and 3 is greater in diameter but less in height than the stem 64 of the finished article 66. The size of stem 44 must be calculated with several factors in mind. To begin with, the height and diameter of stem 44 must be such as to provide a volume sufficient to produce the height and diameter of the finished stem 64. At the same time, the diameter of stem 44 must be sufficiently large so that

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the pressures required to form the stem 44 are less than the strengths of the tool steels employed for forming the die and punch components so as to avoid splitting of the punch, etc.

In forming the cup 42 illustrated in Fig. 2, portions of the metal have been stressed to a value approaching the yield point of the steel. Thus, before the cup 42 can be subjected to further cold working, it must be annealed to relieve these stresses and render the metal in the cup relatively soft again. Therefore, the relative dimensions of stem 44 must also be calculated such that upon further cold working of this stem to reduce it to the diameter of the stem 64 and to increase the height thereof as required, the hardness produced by the subsequent cold working should be such as to produce the same hardness in the stem 64 as the hardness produced by cold work in other portions of the finished article 66.

As pointed out above, after the operation illustrated in Figs. 2 and 3, blank 42 is annealed. Since the particular work piece illustrated requires a flat bottom wall of generally uniform thickness, the next step in the operation resides in the straightening out of the tapered configuration of the bottom wall, the configuration necessarily resulting from the formation of the central stem 44. This operation is carried out in the manner and with the apparatus illustrated in Fig. 4. This apparatus includes a die 70 provided with a die cavity portion 72 which is of greater diameter than the outer diameter of the side wall 54 of cup 42. The lower portion of die cavity portion 72 is fashioned with an internally tapered shoulder 74 which terminates in a cavity portion 76 of less diameter than the cavity portion 72. The lower end of cavity portion 76 is defined by a flat bottom wall 78, the center portion of which is provided by the flat end face 80 of a knockout pin 82. The punch 84 is fashioned with a pilot portion having a cylindrical side wall 86 dimensioned to have a close fit with the cylindrical side wall of the cavity portion 72. Punch 84 is fashioned with a cylindrical end portion 88 having a diameter substantially the same or only slightly greater than the diameter of bore 40 of cup 42. A tapered shoulder 90 connects the side wall 86 of the pilot portion of the punch with the side wall 92 of the cylindrical leading end portion 88 of the punch.

The cup formation 42 is inserted in the cavity of die 70 so that the annular shoulder 60 of cup 42 seats upon the annular shoulder 74 in die 70. Punch 84 is then driven downwardly. The axial opening 94 in punch 84 has substantially the same diameter as the axial opening 32 of punch 22. Thus, stem 44 telescopes into opening 94 to permit the flat end face 96 of the punch to contact the bottom wall 56 of cup 42. As the punch continues to move downwardly, the end face 96 of punch 84 tends to flatten out the bottom wall 56 of cup 42; and the annular boss 58 of cup 42 is compressed against the bottom wall 78 of cavity portion 76. A portion of the metal in annular boss 58 flows radially inwardly to thicken the bottom wall 98 of the cup 100 thus formed so that the bottom wall 98 is substantially flat and of uniform thickness. At the same time, however, a portion of the metal in annular boss 58 is extruded upwardly between the side wall 92 of the punch and the side wall of cavity portion 76; and the annular shoulder 18a is bodily moved upwardly in the die cavity. However, the upper end portion of side wall 54 of cup 42 is contacted and expanded by the tapered portion 90 of the punch so that the side wall 102 of the cup formed by the operation illustrated in Fig. 4 flares outwardly as shown.

In reshaping the bottom wall by the operation shown in Fig. 4, it will be seen that the bottom wall 98 of cup 100 is thickened and flattened as compared with the bottom wall 56 of cup 42 and that a portion of the metal is extruded upwardly. The operation illustrated in Fig. 4 does not appreciably alter the height of stem 44. However, the bottom wall 98 and the extruded lower end portion 104 of the side wall are cold worked substan-

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ally so that the hardness thereof is increased to substantially the hardness required of the finished work piece. In the subsequent operations, these two portions of the work piece are not further cold worked to any appreciable extent.

The operation shown in Figs. 5 and 6 are performed solely for the purpose of reducing the diameter and increasing the height of the center stem 44. The apparatus utilized for this purpose includes a die block 106 having a locating or gage ring 108 thereon for accurately positioning the work piece. The punch 110 shown in Fig. 5 has an axial central opening 112 which connects with the flat end face 114 with a nicely rounded corner portion 116. The diameter of punch 110 is dimensioned to have a nice fit in work piece 100. However, the central axial opening 112 is slightly smaller in diameter than the axial opening 94 of punch 84. When the punch 110 is driven downwardly into the cup 100, the rounded corner 116 of the punch engages the stem 44 to reduce the diameter thereof and thereby effect an elongation of the stem. In this operation, in view of the elasticity of the metal, the punch 110 cold works the metal in the stem on the down stroke and also on the up stroke of the punch. Thus, the axial opening 112 is relieved slightly as at 113. On the up stroke of the punch, the central stem is also stretched slightly. The arrangement shown in Fig. 6 is identical with that shown in Fig. 5 with the exception, however, that the punch 118 has a central axial opening 120 which is slightly smaller in diameter than the opening 112 of punch 110. Opening 120 is relieved as at 121. Thus, the operation shown in Fig. 6 further reduces the diameter and increases the length of the central stem of the work piece. It will be appreciated, of course, that the change in dimensions of the central stem between Figs. 5 and 6 can be effected through several stem reducing operations rather than a single operation. The stem of the cup shown in Fig. 6 has been reduced to the desired diameter and no further reduction in cross section is thereafter made. However, in order to effect this reduction in the cross section of stem 44, it is necessary that the corner portions 116 and 116a of the punches 110 and 118, respectively have a fairly large radius. If this radius is larger than desired in the finished work piece, the cup shown in Fig. 6 can be subjected to the operation shown in Fig. 7 wherein the work piece is seated in a die 124 and cold worked by a punch 126. Punch 126 has a central axial opening 128 of substantially the same size as the opening 120, 121 of punch 118. However, the rounded corner 130 which connects the axial opening 128 with the flat end face 132 of the punch has a radius substantially smaller than the corner portion 116a. Thus, in the operation shown in Fig. 7, the configuration of the central stem 64 where it connects with the bottom wall of the article is made to conform with that required of the finished work piece. This operation results in a very slight increase in the height of the stem. Upon completion of the operation shown in Fig. 7, the stem has been shaped to the dimensions required in the finished work piece.

The work piece is now in condition for thinning down the thickened wall portion 102 to the thickness of the previously extruded wall portion 104. This is accomplished by means of a forward extrusion operation illustrated in Fig. 8 wherein the die is designated 136 and the punch as 138. Die 136 is fashioned with a die cavity, the upper portion of which has an enlarged cylindrical wall 140 and the lower portion is of smaller diameter and defined by a cylindrical wall 142. Intermediate the walls 140 and 142, the die cavity is provided with a tapered shoulder 144. The diameter of the cavity portion defined by wall 142 corresponds to the outer diameter of the article shown in Fig. 7 at the extruded wall portion 104 thereof and the diameter of the cavity portion defined by wall 140 corresponds generally to the outer diameter of the thickened wall portion 102 at the upper end thereof. The lower end of the die cavity is provided

with a conventional knockout pin 146. Punch 138 has a pilot portion 148 having a sliding fit with the cavity portion 140. At the lower end of the pilot portion 148, there is provided an abrupt shoulder 150. Shoulder 150 connects with the leading end 152 of the punch by a tapered shoulder 154. The leading end 152 of the punch has a diameter which corresponds to the inside diameter of the article shown in Fig. 7 at the zone of the extruded wall 104. The configuration of the portion 154 of the punch is determined by the shape of the work piece. In the illustrated arrangement portion 154 is conical.

In the forward extrusion operation, the cup 100 is inserted in the cavity of die 136 and allowed to position itself such that the shoulder 18a comes to rest against the extrusion shoulder 144 of the die cavity. The punch 138 which is provided with a vent 156 and with the axial opening 158 to accommodate the stem 64 is driven downwardly into the cup 100 to a position wherein the shoulder 150 abuts against the upper edge 160 of cup 100 and the shoulder 154 engages against the inner surface of wall 102 adjacent the upper portion thereof. Continued downward movement of punch 138 results in a compression and squeezing of the metal in wall portion 102 and the forward extrusion of this metal through the orifice defined between the cylindrical wall 142 of the die cavity and the side wall of the punch at the end 152 thereof. The cup 100 is thus transformed into the cup 162 having a side wall portion of substantially uniform thickness except for the upper portion thereof. The forward extrusion of the metal in the side wall portion 102 results in considerable cold work. The dimensions of the cup are calculated through the various steps shown so that after the cup is forwardly extruded as shown in Fig. 8, the hardness thereof is substantially uniform throughout the walls and the central stem of the cup.

The particular work piece shown herein is for use on an aircraft propeller which requires rigid inspection both as to size and as to flaws in the metal. Fig. 9 illustrates a restriking operation for accurately sizing the article. In this operation, the die employed is designated 164 and the punch as 166. The lower portion 168 of the die cavity and the lower portion 170 of the punch are sized to correspond with the required inner and outer diameters of cup 162. However, the upper portion of the die cavity and the upper portion of punch 166 are flared outwardly as at 172 and 174, respectively, so that the upper side wall portion of cup 162 is expanded slightly as at 176. If there are any hidden seams in the material, they will be opened up by the operation illustrated in Fig. 9.

Thus, it will be seen that I have provided a method of cold working a solid steel blank in a novel manner to produce an article having an integral axially extending central stem. The method involves the cold working of steel in a manner such that the flow of metal is controlled by restricting or locking certain areas of the blank so that the metal will flow more freely in one direction than in another. Furthermore, it will be observed that the method described herein involves the cold working of a solid steel blank in a manner such that the required uniform hardness of the blank is developed solely by cold working the metal in progressive portions of the blank to the same degree. In connection with controlling the direction in which the metal is permitted to flow, it will be further observed that this is effected by a novel punch and die apparatus, the configuration of which can be varied to suit the size and shape requirements of the finished article and particularly the diameter and the height of the central upstanding stem.

Although in the embodiment illustrated in the drawings, the central stem of the article is shown as extending upwardly from the bottom wall of a cup, it will be appreciated that the principle disclosed herein of locking certain areas of the blank so that the metal will flow more freely in one direction than in another can be applied to differently shaped work pieces. For

example, the central stem could be made to extend axially downwardly from the bottom wall of the cup or the central stem could also be made to extend axially in opposite directions from the bottom wall of the cup. Generally speaking, it may be stated that by employing the reverse angles on the punch and the die or the knockout post of the die, a central stem may be caused to project axially from either one or both faces of any disc-like work piece whether it has side walls or not.

I claim:

1. A punch and die apparatus for use in cold forming a solid steel blank into a cup-shaped article having a relatively thin side wall as compared with the diameter of the cup-shaped article and a central stem of relatively small diameter as compared with the diameter of the cup-shaped article extending upwardly from the bottom wall of the cup-shaped article a distance equal to at least the height of the side wall thereof which comprises a die having a cavity dimensioned and shaped to receive the solid steel blank and a punch provided with a leading end face, said punch throughout its active extruding axial length having an outside diameter that provides clearance between said outside diameter and the die cavity when said punch is in said die cavity for receiving the extruded side walls of said cup, means for guiding said punch for concentric relation with said die cavity during the extrusion operation, said punch having a central axial bore extending to and through said leading end face, said central bore having a diameter relatively small as compared with the diameter of the leading end face and said leading end face having a diameter only slightly smaller than the transverse dimension of the die cavity, the die cavity being open at its upper end to receive the punch and having means forming a closed bottom wall at the lower end thereof, the leading end face of the punch having the major portion of its area upwardly concave and conically shaped, the outer periphery of the conically shaped portion of the leading end face being spaced radially inwardly a relatively short distance of the side wall of the punch and being connected with the side wall of the punch by a rounded corner portion, said rounded corner portion being concentric with and located closely adjacent the side wall of the cavity when the punch is inserted in the die cavity so that the vast majority of the top face of the solid blank is engaged by the conically shaped portion of said leading end face when the punch is driven downwardly into the die cavity, the bottom wall of the die cavity being downwardly concave and generally conically shaped, the outer peripheries of the concavities at the leading end face of the punch and the lower end of the die cavity being generally axially aligned whereby to form therebetween and adjacent the rounded corner on the punch a zone of restriction relative to the metal in the blank disposed radially inwardly of said peripheries of the concavities; whereby, when said punch is driven into said die cavity against a blank previously loaded in said die cavity, said blank is extruded up around the outside of said punch and up within said central axial bore, and the opposing concave portions of said punch and said die cavity act to retard work metal and urge the same inwardly to said central axial bore thus making the central stem of the finished product longer than could be effected without said concave portions.

2. A punch and die arrangement as called for in claim 1 including an annular shoulder on the side wall of the die cavity adjacent the lower end thereof, said annular shoulder tapering in a direction radially outwardly and upwardly toward the open end of the die cavity.

3. A punch and die arrangement as called for in claim 2 wherein the outer periphery of the lower end of the die cavity is defined by an annular groove spaced radially outwardly from the outer periphery of the concave cavity in the bottom wall of the die, said groove extend-

ing axially downwardly a distance greater than the depth of said last mentioned concavity.

References Cited in the file of this patent

UNITED STATES PATENTS

498,304	Potter	May 30, 1893
796,223	Kaub	Aug. 1, 1905
1,024,840	Ehrhardt	Apr. 30, 1912
1,642,696	Rateike	Sept. 20, 1927
1,802,843	Singer	Apr. 28, 1931
2,161,419	Kipperman et al.	June 6, 1939
2,235,450	Groene	Mar. 18, 1941

5 2,333,196
2,334,927
2,344,803
2,358,667
2,533,942
2,732,932

10 435,402
49,336
429,216
672,815
842,296

Price	Nov. 2, 1943
Hoern	Nov. 23, 1943
Criley	Mar. 21, 1944
Stern	Sept. 19, 1944
Jongedyk	Dec. 12, 1950
Strock	Jan. 31, 1956

FOREIGN PATENTS

Great Britain	Sept. 17, 1935
Netherlands	Oct. 15, 1940
Germany	May 22, 1926
Germany	Mar. 10, 1939
Germany	June 26, 1952