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DEEP DRAWING OF CYLINDRICAL SHAPES

Filed Nov. 28, 1956

4 Sheets-Sheet 2

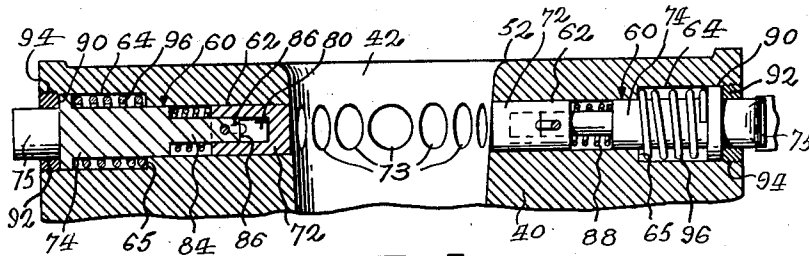


Fig. 3

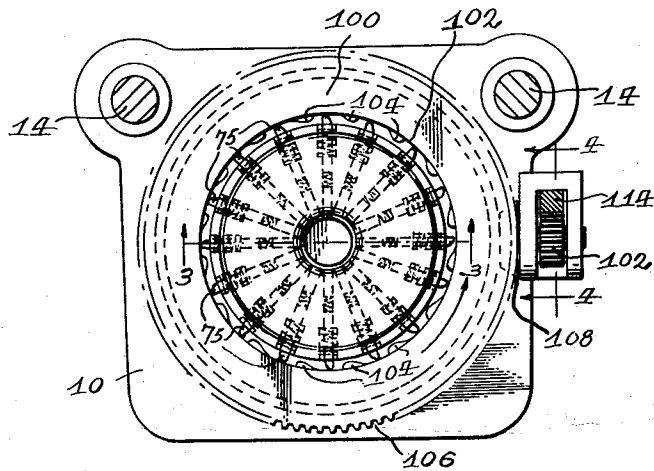


Fig. 2

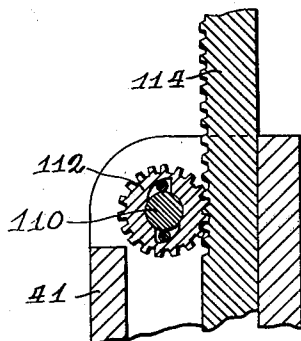


Fig. 4

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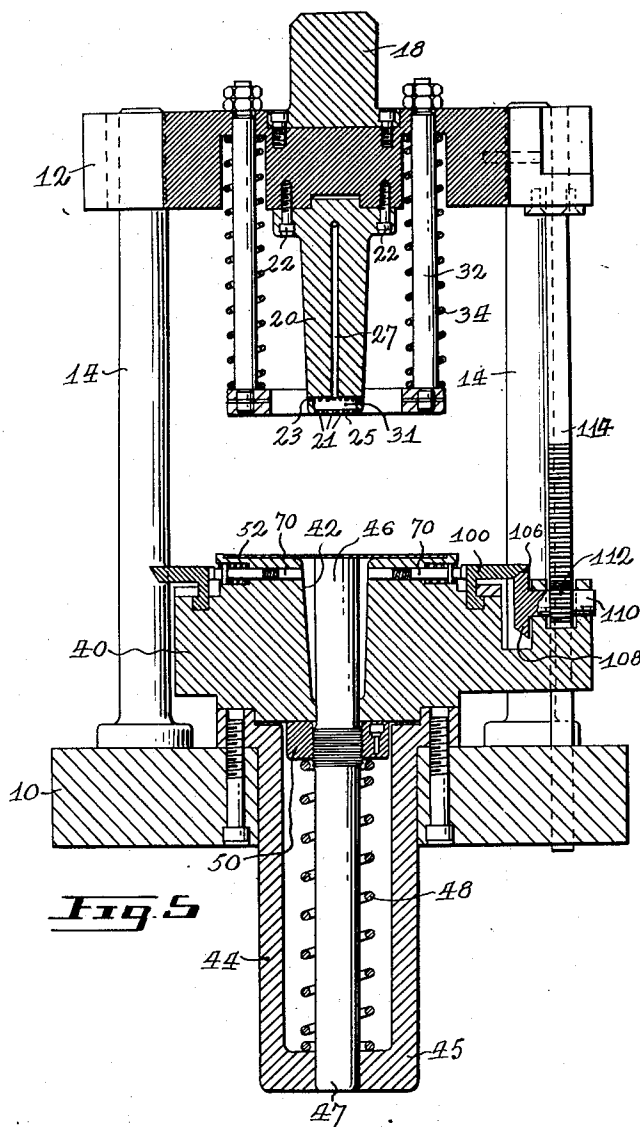
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

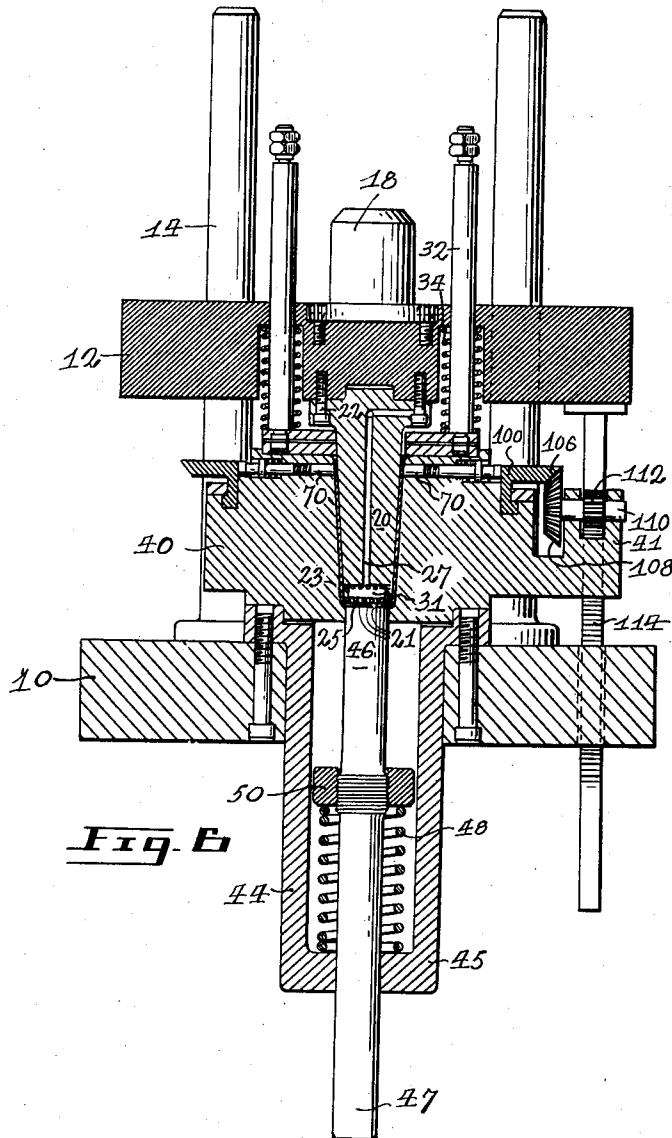


Fig. 6

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1

2,901,995

DEEP DRAWING OF CYLINDRICAL SHAPES

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9 Claims. (Cl. 113—38)

The invention is concerned with an improved method of deep drawing cylindrical shapes from a flat blank.

A single step deep drawing of blanks from sheet metal or metal foil has been the aim of considerable prior art research in tool design.

Various attempts have been made involving the use of various types of blank trapping rings and special means of lubrication to accomplish the purpose of forming, in one continuous step and from a flat blank, a cylindrical shape preferably having a closed end.

This desired result has not been achieved as far as is known to the applicant without involving multiple stage heat treatments and step by step dies.

The present invention provides a means of accomplishing one step forming from a flat blank into a cylindrical shape.

In accordance with the invention, this is accomplished by a forming punch and die arrangement which includes a die having a centrally located spring biased work-supporting mandrel, and a forming punch shaped to correspond with the die cavity, and having a spring loaded pressure ring surrounding the punch for the purpose of retaining the material as it is drawn within the die. A main feature of the present structure is in the provision of an encircling pressure applying member, which co-operates with the forming punch and is located about the top periphery of the die cavity, so as to surround and be adapted to continuously work the material as it is drawn into the die by the downward progress of the punch. This pressure applying member, in one preferred construction, comprises of a plurality of resiliently biased pistons or hammers which are mounted radially about the die cavity and are adapted, by mechanical means, to be reciprocated toward the central axis of the die and against the material being drawn down into the die by the punch.

Motion transmitting means, preferably in the form of a rack and gear arrangement, are adapted to transmit the stroke or forming motion of the punch relative to the die into a driving motion to the pressure applying pistons. This is accomplished in one preferred form by having a planetary type gear mounted on the die so as to surround the die cavity and driven through a pinion gear. The pinion gear in turn is driven by a toothed rack extending between the punch and die. With this arrangement, the forming movement of the punch towards the die drives the rack against the pinion, and rotation of the pinion, through the bevel gear, turns the planetary gear. The inside surface of the planetary gear is provided with a plurality of circumferentially spaced apart cams or cam teeth which are adapted to come into actuating contact with the ends of the pressure punches, continuously and in sequence.

The inner ends of these reciprocating punches impart a pulsating pressure or hammering action against the surface of the material as it is being drawn into the die cavity. This pulsating action is in step sequence with the forming action of the punch relative to the die and

2

is controlled, by the mechanical drive, so that the material which is being formed is alternatively held and released as it is being drawn into shape, or in other words is being worked as it is being drawn, so as to maintain the wall thickness of the shape being formed while permitting the drawing of the material into the desired cylindrical outline. This action may be broadly described as being analagous to the effect applied to a metal blank when it is spun onto a forming mandrel in standard metal spinning processes.

Having thus generally described the nature of the invention, particular reference will be made to the accompanying drawings, wherein there is shown by way of illustration a forming punch and die embodying the features mentioned above, and in which:

Figure 1 is a view in front elevation of a punch and die arrangement adapted to carry out the forming method of the invention;

Figure 2 is a plan view partially in cross-section of the die construction shown in Figure 1 along the line 2—2 to illustrate the relative position and arrangement of the driving gears and the radial spoke-like pressure applying members;

Figure 3 is an enlarged cross-sectional view of Figure 2 along the line 3—3 to show the individual pressure applying members in more detail;

Figure 4 is a cross-sectional view of Figure 2 along the line 4—4 to show the rack and pinion drive in more detail;

Figure 5 is a longitudinal view of the construction shown in Figure 1, partially in section, to illustrate the relative position of the punch, the material restraining draw ring, the die and cooperating die mandrel, and the pressure applying members with the driving means;

Figure 6 is a view corresponding to Figure 5 with the punch shown in the terminal position of the forming stroke.

With particular reference to Figures 1 and 5 of the drawings, the punch and die apparatus of the invention is shown as being mounted on a suitable die set having a base portion 10 and a top portion 12. The movement of the top portion 12 relative to the base portion 10 is guided in the usual manner by die standards 14 which are secured to the base 10 and extend through suitable bearings provided in the top 12.

The forming punch of the apparatus is indicated at 20. This is attached to the top portion 12 of the die set by suitable machine bolts 22, the central lower face of the die set portion 12 being relieved to accommodate the upper end of the punch. The top portion 12 of the die set is provided with the usual shaft or shank 18 for attachment to the ram of the punch press. The shank 18 is centrally disposed and is in axial alignment with the punch 20.

A draw or pressure ring 30 is provided and is mounted on supporting shafts 32 which slidably pass through the top die set portion 12, shown most clearly in Figure 5. Resilient springs 34 surround each shaft 32 so that the pressure ring 30 is normally urged into alignment with the bottom or lowest extremity of the punch 20 so that it will be the first portion of the punch arrangement to come into contact with the blank to be drawn, thereby to resiliently retain it against the drawing or pulling motion of the punch.

The main die body into which the punch 20 is adapted to draw the material being formed is indicated at 40. This die body 40 is mounted to the die set base 10 with the die cavity 42 in axial alignment with the punch 20. The die body 40 is provided with a cylindrical extension 44 which fits directly beneath the die body 40 and acts to support a die mandrel 46 in axial alignment with the die cavity 42. The extension 44 is of hollow cylindrical

3

formation and fits within a central opening 11 in the die set base 10. The mandrel 46 is mounted concentrically within the extension 44 with the lower end portion 47 fitting in and adapted to slidably move through and out of the lower end portion 45 of the extension 44 under the pressure of the punch 20. A coil spring 48 acts against an adjustable bushing 50 so as to normally maintain the mandrel 46 within the die cavity 42 with the top surface flush with the top surface of the die body 40.

The upper surface of the die body 40 is suitably recessed to provide a material receiving cavity 52 adapted to receive a blank of the desired size and contour for the drawing operation. This recess 52 corresponds substantially to the outline of the draw ring 30 so that when the draw ring 30 engages with the blank or material, the material is held between the upper surface of the die body 40 in the recess 52 and the lower surface of the draw ring 30 where it is resiliently restrained by the action of the coil springs 34 on the draw ring supporting arrangement.

In accordance with the present invention, the upper portion of the die body 40 surrounding the die cavity 42 directly beneath the blank locating recess 52 is bored to provide a plurality of radially extending recesses 60. Each of the recesses 60 has a first major portion 62 of constant diameter and a further portion 64, adjacent the outer periphery of the die body, of greater diameter so as to provide a shoulder 65 therebetween. A two-piece pressure piston or hammer 70 is mounted within each of the recesses 60, so that the inner ends 73 form an aligned encircling ring about the inner surface of the upper end of the die cavity 42. Each of the piston members 70 comprises of a first portion 72 having the shaped end 73 which is adapted to engage directly with the material, and a slidably connected second portion 74, the end 75 of which extends beyond the outer periphery of the die body 40 at this point and is adapted to be engaged for reciprocal movement as will be described later.

As shown most clearly in Figure 3, each piston portion 72 includes an axial recess 80 wherein a reduced diameter extension 84 of the portion 74 slidably fits. A lost motion connection is made between the mating ends of the portions 84 and 72 by a slot and pin arrangement indicated at 86. A coil spring 88 surrounds the portion 84 and is adapted to resiliently act between the interconnected piston portions 72 and 74. The outer end 75 of each portion 74 is provided with an upstanding flange 90 which is adapted to slidably fit within the enlarged diameter portion 64 of the bore 60. By the threading engagement of an annular nut 92 within the corresponding tapped end 94 of each of the bores 60 the piston members 70 are each retained within the die body for restricted sliding movement. A further coil spring 96 is provided which acts between the flange 90 and the shoulder 65 of the recess 60 so as to withdraw the inner ends 73 of the member 70 after each stroke.

In order to impart the desired reciprocal motion to each of the pressure applying pistons 70, a planetary type gear 100 is mounted on the upper face of the die body 40 so as to concentrically surround the die cavity 42 and be capable of driven rotation about the ends 75 of the pressure pistons 70. The inner face 102 of the gear 100 is provided with a plurality of circumferentially spaced apart cam surfaces or teeth 104 which, upon rotation of the gear 100, are adapted to act against the protruding ends of the pressure member 70 urging them in sequence towards the centre of the die cavity. The outer periphery of the gear 100 is provided with suitable teeth 106 in the form of a bevel gear. The teeth 106 of the gear 100 are in meshed engagement with the teeth of a pinion gear 108 mounted on a shaft 110 journaled for rotation on an extension 41 of the die body 40. A driving pinion gear 112 is also mounted on the shaft 110 and is in meshed engagement with an elongated driving rack 114. The driving rack 114 has its upper end secured to

4

the top portion 12 of the die set with the bottom end being supported for sliding movement through the extension 41 of the die body 40, as shown in Figure 4.

With this arrangement, descent of the upper portion of the die set 12 first brings the pressure ring 30 into engagement with a blank of material supported on the recess 52 of the die body 40. The continued descent of the punch 20 presses the centre portion of the material against the upper face of the die mandrel 46 so that the material is now firmly trapped between the upper face of the mandrel 46 and the bottom of the punch 20 while being resiliently restrained about the outer periphery by the pressure ring 30. As the punch 20 descends it draws the material into the die cavity 42, while the pressure piston arrangement described causes the pressure pistons 70 to rapidly reciprocate in turn against the material, working it against the outer face of the punch 20.

Suction or vacuum pressure is also applied to the interior surface of the blank as it is engaged and drawn into the die through a plurality of circumferentially spaced apart openings 23 provided in the punch 20 adjacent the lower end and also through the openings 21 in a perforated plate 25 provided in the lower face of the punch 20. The punch 20 is recessed inwardly from the lower face to provide a cylindrical air chamber 31 with the perforated plate 25 closing off the open face of this chamber across the bottom of the punch. An axial boring 27 leading through the punch connects with the chamber 31 and a source of vacuum and air pressure is connected to the top end 29 of the boring 27 through a suitable conduit means, not illustrated. A known type of valve arrangement, not illustrated, is used to control the suction or vacuum pressure applied in sequence with air pressure so that on the down or forming stroke of the punch suction is applied through the openings 23, 21 and maintained until the latter portion of the up stroke when the vacuum pressure is cut off and air pressure applied.

It will be appreciated that due to the tapering shape of the punch 20 the initial forming strokes of the pressure plunger 70 will be greater than when the punch 20 is near to or at the end of its stroke. This variation in stroke is compensated for by the two-piece construction of the individual piston members 70, the springs 88 taking up the difference in stroke as the plunger portion 70 is telescoped towards the plunger portion 74. As the punch 20 continues to descend the surplus material created by the graduated reduction in diameter is being constantly worked about the circumference of the punch so as to free it for flowing under the drawing action, avoiding the usual excessive reduction in wall thickness as is normally caused by a single step straight draw in draw types dies.

When the drawing operation is complete, as shown in Figure 6, the raising of the punch 20 permits the mandrel 46 to follow the punch upwards through the die cavity 42 while the pressure plungers 70 again act to work on or smooth out the outer surface of the drawn article as it is being withdrawn. When the punch is withdrawn to the position shown in Figure 1 the article is ejected from the punch by the air pressure supplied through the openings 23, 21 in the punch body.

I claim:

1. An apparatus adapted for deep drawing of cylindrical shapes from flat blanks, comprising a forming punch and a die block having a forming cavity mounted in registered alignment for reciprocal movement relative to each other, a resiliently biased draw ring mounted adjacent to and surrounding said punch, means to actuate said punch, pressure actuated material working means mounted on said die about said die cavity and including portions extending within said die cavity adapted to exert pulsating forming pressure to the material of a blank drawn into said die cavity by said forming punch, and driving means adapted to actuate said material working means in progressive sequence with the forming motion of said punch relative to said die cavity, said pressure ac-

tuated material working means including a plurality of circumferentially spaced pressure pistons extending radially outwards from said die cavity, one end of each of said pistons being located at the inner surface of said die cavity with the other end extending beyond the surface of said die block at that point, said driving means including a planetary gear mounted for rotation on said die block surrounding said pressure piston extended ends and having an internal surface provided with spaced cam projections adapted to contact said pressure piston ends in sequence on rotation of said gear, and cooperating rack and gear means mounted on said punch and die adapted to drive said planetary gear.

2. An apparatus, as claimed in claim 1, including a resiliently biased supporting mandrel mounted for sliding movement co-axially of said die cavity and having a top surface normally in register with the upper peripheral edge of said die cavity.

3. An apparatus, as claimed in claim 1, wherein said punch is provided with a plurality of spaced openings leading inwardly from the external surface of said punch adjacent the free end thereof and an axial bore constituting a main fluid passage connected with said openings said punch fluid passage being adapted for connection to a source of fluid pressure whereby said fluid pressure may be applied to the interior of a blank supported on said punch.

4. An apparatus adapted for deep drawing of cylindrical shapes from flat blanks, comprising a forming punch having an external contour corresponding to the contour of the article to be formed, a forming die block having an internal die cavity corresponding in shape to the external contour of said punch, said forming punch being mounted in axial register with said die block cavity for reciprocal engagement therein, a resiliently biased draw ring mounted adjacent to and encircling said punch adapted to engage the surface of said die block surrounding said cavity, means to actuate said punch towards and away from said die block a resiliently biased mandrel mounted for sliding movement co-axially of said die cavity and having a top surface normally in register with the upper peripheral edge of said die cavity, a plurality of circumferentially spaced pressure pistons mounted for sliding movement in said die block and extending radially outwards from said die cavity, one end of each of said pistons extending within said die cavity with the other end extending beyond the outer surface of said die block at that point, and driving means adapted to engage said pistons extended ends and actuate said pistons other ends inwardly towards the axis of said die cavity in progressive sequence with the forming movement of said punch relative to said die.

5. An apparatus, as claimed in claim 4, wherein said pistons each comprise two telescopically interconnected portions and spring means are provided between said portions to resiliently maintain said portions in extended position.

6. An apparatus, as claimed in claim 4, wherein said driving means comprises a planetary gear mounted on said die block spaced from and concentric with said die cavity and encircling said pressure pistons extended ends, each of said pistons having two telescopically interconnected portions and spring means provided between said portions to resiliently maintain said piston end portions in extended position, said planetary gear having a toothed external surface, an internal surface provided with regularly spaced cam projections adapted to contact said pressure piston ends in sequence upon rotation of said gear, a bevel gear in meshed engagement with the external teeth of said planetary gear, said bevel gear being mounted for rotation on a common shaft with a pinion gear, and a toothed rack in meshed engagement with said pinion gear, said rack being mounted between said punch and die and adapted for travel with said punch during its reciprocal movement relative to said die.

7. An apparatus, as claimed in claim 4, wherein said punch is provided with a plurality of spaced openings leading inwardly from the external surface of said punch adjacent the free end thereof and an axial bore constituting a main fluid passage connected with said openings, said punch fluid passage being adapted for connection to a source of fluid pressure, whereby fluid pressure may be applied to the interior of a blank supported on said punch.

8. A method of accomplishing one stroke deep drawing of a flat one-piece blank of deformable material into a hollow cylindrical shape, comprising, progressively applying forming pressure to the centre portion of said blank while resiliently restraining the portions of said blank surrounding said centre portion so as to draw the material of said blank evenly and progressively between spaced concentric parallel inner and outer forming surfaces of cylindrical formation, and in sequence with said application of forming pressure continuously applying external pulsating material working pressure on an annular portion of said blank material and against said inner cylindrical forming surface as said material is drawn between said inner and outer forming surfaces, reversing said forming pressure to withdraw said formed blank on said inner forming surface from engagement with said outer forming surface, and finally removing said formed blank from said inner forming surface.

9. A method of accomplishing one stroke deep drawing, as claimed in claim 8, including the step of applying suction pressure through said inner supporting surface to the inner face of said blank during said drawing operation.

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