United States Patent

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Continuation of application Ser. No. 526,496, Feb. 10, 1966, now abandoned.

[54] **METHODS AND APPARATUS FOR SHAPING HOLLOW BODIES**
7 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **72/58,** 72/370
[51] **Int. Cl.** **B21d 39/08**
[50] **Field of Search** 72/63, 393, 355, 465, 370, 58, 61

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ABSTRACT: A method and apparatus for forming an ogive and in which a generally frustoconical hollow metal body is placed within a form having an ogival inner surface, following which a generally frustoconical mandrel formed of deformable but relatively noncompressible material is placed within the body. At axially spaced intervals within the mandrel are compression discs that are connected to relatively telescoping, axially extending sleeves which extend different distances beyond one end of the mandrel so as to be displaced axially and successively to deform axially successive portions of the mandrel radially and reshape the body to ogival form. As successive axial portions of the mandrel are deformed radially, the previously deformed portions of the mandrel are subjected to increasing axially compressive forces so as further to be deformed radially.

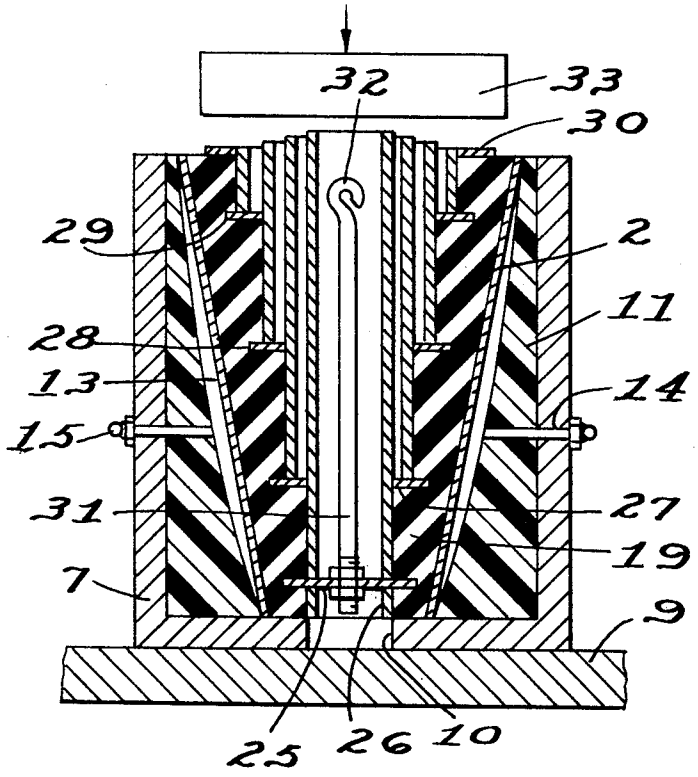


FIG. 1

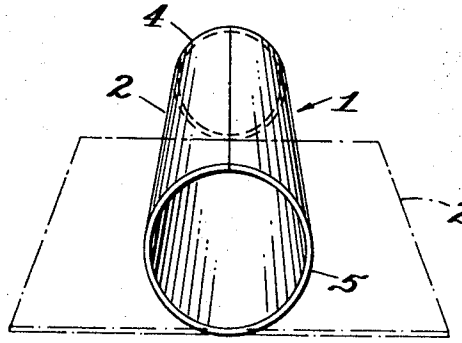


FIG. 2

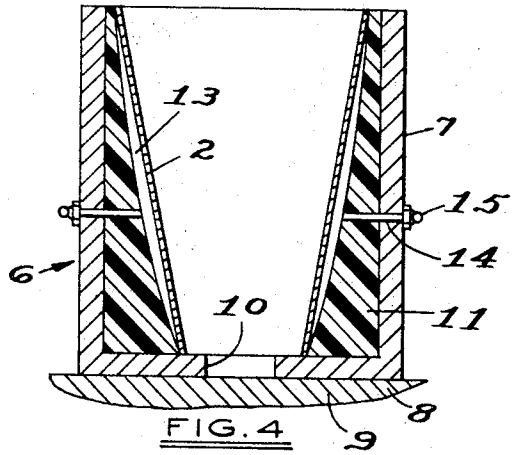


FIG. 3

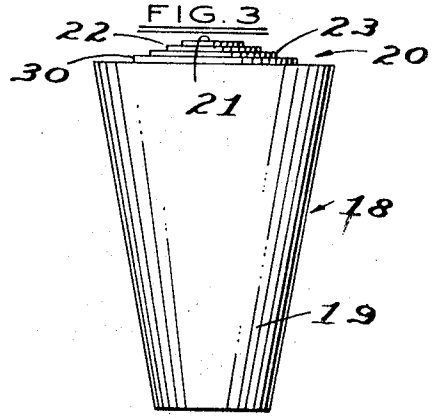


FIG. 4

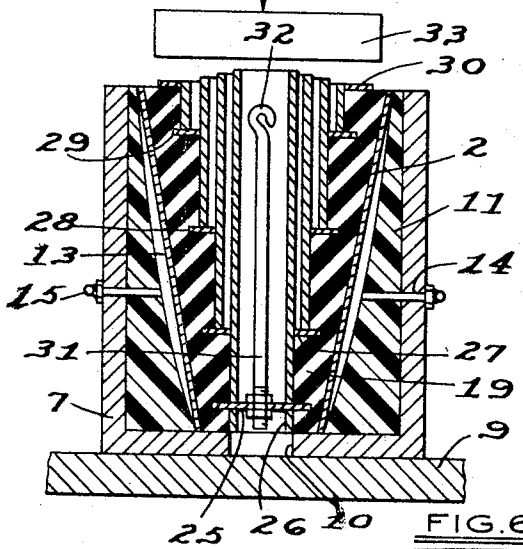


FIG. 5

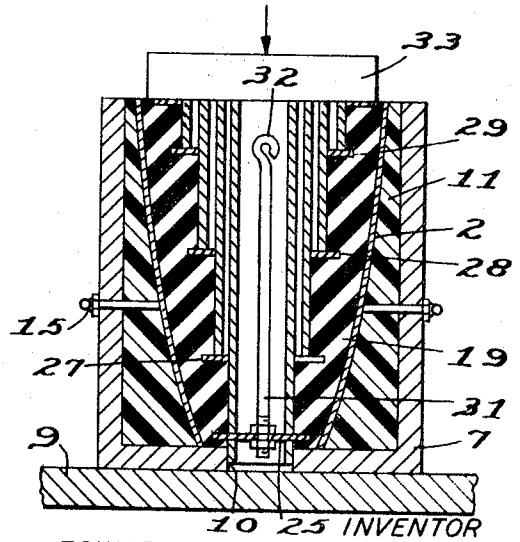
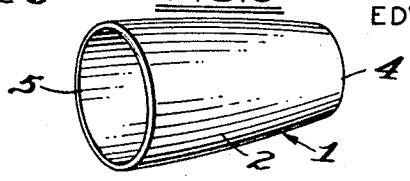


FIG. 6



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METHODS AND APPARATUS FOR SHAPING HOLLOW BODIES

This application is a continuation of application Ser. No. 526,496, filed Feb. 10, 1966, now abandoned. This invention relates to methods and apparatus for shaping hollow bodies and more particularly to apparatus and methods especially adapted for forming ogives of the kind forming parts of missile and other projectile casings.

The shaping of ogives has been accomplished in many ways, including pressing the shell body to be shaped between dies, transmitting to the hollow body via hydraulic fluid a compressive or expansive force, and spinning the hollow body about a rotating mandrel. All of the previously known methods and apparatus for forming ogives are objectionable for one or more reasons. For example, the use of hydraulic fluids is expensive and requires somewhat delicate control mechanisms, whereas the cost of dies is expensive, and the dies are subject to wear which frequently causes imperfect parts to be formed. The spinning of ogives around a mandrel is extremely time consuming and also frequently causes the wall of the body being shaped to be of irregular thickness. In those instances where an ogive is formed by pressing the ogive wall against a form or die, it has been necessary heretofore that the wall material be drawn or stretched to some extent, resulting in nonuniform wall thickness over the length of the ogive. In addition, hollow bodies shaped in this manner frequently are subject to being distorted by so-called springback of the nonuniform wall thickness portions of the body.

An object of this invention is to provide methods and apparatus for shaping hollow bodies and which are not subject to the disadvantages of previously known methods and apparatus.

Another object of the invention is to provide methods and apparatus for shaping hollow bodies much more quickly than they have been capable of being shaped heretofore by previously known methods and apparatus.

A further object of the invention is to provide methods and apparatus of the character described and wherein the shaping of the body proceeds progressively in a direction from one end of the body to the other, thereby substantially eliminating springback and thinning of the material from which the body is made.

Other objects and advantages of the invention will be pointed out specifically or will become apparent from the following description when it is considered in conjunction with the appended claims and the accompanying drawings, in which:

FIG. 1 is a perspective view illustrating the manner in which a hollow body may be prepared for use in methods and apparatus according to the invention;

FIG. 2 is a longitudinal sectional view through a form and illustrating the hollow body therein prior to being shaped;

FIG. 3 is an elevational view of a mandrel for use in shaping the hollow body;

FIG. 4 is a view similar to FIG. 2, but illustrating the mandrel in place within the hollow body and in condition to shape or bulge the latter;

FIG. 5 is a view similar to FIG. 4, but illustrating the mandrel in its operative position and showing the body shaped; and

FIG. 6 is a perspective view of a hollow body shaped by the apparatus shown in FIGS. 4 and 5.

Apparatus constructed in accordance with the invention is disclosed as being adapted for use in the reshaping or bulging of a substantially frustoconical, hollow body 1 formed of metal or other material. The body may be formed from a blank cut to suitable size and shape and rolled to form a wall 2 having its opposite edges joined and welded together as at 3. The weld then may be dressed in a conventional manner so as to form a smooth joint, and the smaller and larger ends 4 and 5, respectively, may, if necessary, be cut to provide smooth ends for the body.

A shaping form designated generally by the reference character 6 is adapted to accommodate the body 1 and comprises a preferably cylindrical outer casing 7 having a wall 8 at one end that is adapted to be mounted on a support 9. The support 9 may be the base or bed of a conventional press (not shown). The end wall 8 is provided with a central opening 10 for a purpose presently to be explained.

Within the casing 7 is a matrix 11 formed of a rigid, hard material such as a suitable epoxy resin, and having its exposed surface 12 contoured to correspond to the configuration to which the wall 2 of the body 1 is to be shaped. The casing 7 and the matrix 11 are annular in cross section and together form an open end cavity 13 into which the body 1 may be telescopingly accommodated. At suitable circumferential intervals hollow tubes 14 communicate with the cavity 13 and are provided at their outer ends with fittings 15 to which compressed air nozzles (not shown) may be attached for a purpose presently to be explained.

Apparatus constructed in accordance with the invention also includes an expandable and contractable mandrel 18 comprising an outer shell 19 formed of molded, relatively noncompressible but deformable material such as rubber, urethane, or similar rubberlike material. The shell is annular in cross section and its size and configuration are such as to enable the mandrel 18 to be accommodated in the body 1 and preferably with the periphery of the shell 19 in engagement with the inner surface of the wall 2 and the smaller end of the shell resting upon the wall 8 of the casing 7.

Means designated generally by the reference character 20 is provided for deforming the shell 19 and comprises a plurality of concentric, freely telescoping tubes or sleeves 21, 22, 23 and 24. To the inner end of the tube 21 is welded or otherwise fixed a compression disc 25 which is of substantially greater diameter than the diameter of the tube 21 so as to form a flange that projects radially from the tube and is embedded in the shell 19. To the disc 25 is welded or otherwise fixed a guide tube 26 which preferably is of the same diameter as the tube 21 and which is adapted to enter the opening 10. The material forming the shell 19 surrounds the guide 26.

The tube 22 is of larger diameter than the tube 21 and has welded to its inner end an annular compression ring or flange 27 which is axially spaced from the disc 25. The ring 27 also projects radially beyond the tube 22 and is embedded in the shell 19. Although the compression members 25 and 27 are embedded in the shell 19, the members 21 and 22, together with their respective compression members, are relatively axially movable as will be pointed out in more detail hereinafter.

The tube 22 is enclosed within the tube 23 which is provided with a compression ring or flange 28 similar to the ring 27 and which also is embedded in the shell 19. The tube 24 also has secured thereto a compression ring or flange 29 which similarly is embedded in the shell 19. Preferably, a compression ring 30 surrounds the tube 24 and rests upon the upper or larger end of the shell 19, and the ring 30 may or may not be secured to the tube 24.

Each of the compression flanges is axially spaced from one another a distance which depends on the degree of radial movement that is to be imparted to the wall 2 at a particular zone. The spacing between the compression rings also depends on the force with which a particular portion of the wall 2 is to be pressed against the surface of the matrix. These factors may be determined by known mathematical processes or empirically.

In the normal or nondeformed condition of the mandrel 18, the upper or outer ends of the tubes 21—34 extend progressively greater distances from the adjacent end of the shell 19. That is, the tube 21 projects the greatest distance from the end of the shell, the tube 22 projects a greater distance than does the tube 23, but less than the distance the tube 21 projects, and so on.

To condition the apparatus for use, the body 1 is inserted in the form 6, as is shown in FIG. 2, and the mandrel 18 then is inserted in the body 1 so that the latter is sandwiched between the form and the mandrel. To facilitate handling of the mandrel, a rod 31 may have one end welded or otherwise secured

to the disc 25 and be provided with a hook 32 at its other end which terminates short of the adjacent end of the tube 21. The assembled form, body and mandrel then may be supported on the press bed 9 beneath a vertically reciprocable platen 33.

To shape the body 1, the platen 33 is moved downwardly or toward the bed 9 by conventional means (not shown). As the platen 33 moves downwardly, it first engages the upper end of the tube 21, displacing the latter and the disc 25 axially relatively to the tubes 22—24. The guide tube 26 enters the opening 10 and is guided by the edge thereof. Axial movement of the tube 21 and the disc 25 causes the material of the shell 19 between the wall 8 and the compression disc 25 to be subjected to axially compressive force. Since the material from which the shell 19 is made is relatively incompressible, but deformable, the material between the wall 8 and the disc 25 is deformed radially outwardly so as to press the smaller end of the body wall 2 into engagement with the adjacent surface of the matrix 11. As the platen continues to move downwardly, it next will engage the free end of the tube 22 and move it and the tube 21 axially relatively to the other tubes so as to exert axially compressive forces on the shell material between the members 25 and 27. Again, this material is caused to be deformed radially outwardly so as to press the adjacent portion of the body wall 2 against the confronting surface of the matrix.

Continued downward movement of the platen 33 effects sequential movement of the tubes 23 and 24 so as to effect sequential radial deformation of the shell material between the compression members 27, 28 and 28, 29 and 29, 30, respectively, thereby effecting successive pressing or bulging of the adjacent portions of the wall 2 into engagement with the matrix surface 12 in the manner shown in FIG. 5. Thus, the body wall 2 is bulged outwardly in successive increments from its smaller end toward its larger end.

When the platen 33 has effected axial movement of all of the tubes 21—24, and of the compression ring 30, the application of the force by the mandrel 18 on the body may be maintained by holding the platen 33 in its adjusted position for as long as desired. Upon return movement of the platen, the inherent resiliency of the material of which the shell 19 is formed will restore the operating tubes to their initial positions and thereby enable removal of the mandrel from the formed body. The formed body then may be removed from the form 6 and it will have the ogive shape shown in FIG. 6. Removal of the body from the cavity 13 is facilitated by injecting compressed air into the cavity via the tubes 14.

The incremental forming or shaping of the body wall 2 is an important characteristic of the invention inasmuch as it has been found that such procedure avoids nonuniform stretching of the wall 2 with its consequent provision of wall portions of nonuniform thickness. It is believed that the incremental forming of the body wall prevents such undesirable characteristics by allowing the upper or larger end portions of the body wall to slide downwardly relative to the matrix 11 and the mandrel 18 as the lower portions of the body are being expanded or bulged. Such sliding is possible because the portions of the wall 2 above the radially deformed shell portion are not tightly gripped between the matrix and the shell.

The successive shaping or forming of adjacent portions of the body wall 2 also results in a formed body which has little or no tendency to spring back following relieving of the forming force. This is believed to be due to the elimination of axial stretching of the body and the creation of nonuniform wall thickness portions.

Another characteristic of the invention is that the force applied to each axial increment of the mandrel 18 is increased as force is applied to each successive increment. Thus, the force applied on the mandrel portion beneath the member 25 increases as force is applied to the mandrel portion between the members 25 and 27, and so on. This necessarily follows inasmuch as the tubes 21 and 22 are moved simultaneously upon engagement of the platen 33 with the tube 22, the tubes 21, 22 and 23 are moved simultaneously upon engagement of the platen with the tube 23, and so on.

Although the disclosure has been concerned primarily with the formation of ogives, it should be understood that the apparatus and methods are equally applicable to the formation of other shapes.

The disclosed methods and apparatus are representative of presently preferred embodiments thereof, but are intended to be illustrative rather than definitive of the invention. The invention is defined in the claims.

I claim:

1. Apparatus for shaping a hollow body having a wall, said apparatus comprising form means having a surface corresponding to the configuration to which the body wall is to be shaped; mandrel means composed of deformable material and normally being spaced from said surface a distance at least sufficient to accommodate said body wall between said mandrel means and said surface; compression means operable to subject discrete portions of said mandrel to compressive forces for deforming said portions toward said surface; and force exerting means acting on said compression means in a direction axially of said mandrel means comprising a plurality of relatively telescoping members each of which projects a different distance from one end of said deformable material, and said compression means comprising at least on flange secured to each of said telescoping members and extending radially into said deformable material.

2. The apparatus set forth in claim 1 wherein said flanges are axially spaced from one another.

3. Apparatus for shaping a hollow body having a wall, said apparatus comprising form means having a surface corresponding to the configuration to which the body wall is to be shaped; mandrel means composed of deformable material and normally being spaced from said surface a distance at least sufficient to accommodate said body wall between said mandrel means and said surface; a plurality of relatively movable, telescoping members extending axially of said mandrel means; and at least on flange secured to each of said telescoping members and extending radially into said deformable material, said flanges being spaced axially from one another and being operable to subject discrete portions of said mandrel means to compressive forces in response to relative axial movement of said telescoping members for deforming said portions of said mandrel means toward said surface.

4. The apparatus set forth is claim 3 wherein said form means and said mandrel means are annular in cross section.

5. The apparatus set forth in claim 3 wherein said mandrel means is radially inwardly of said form means.

6. The apparatus set forth in claim 3 wherein said deformable material comprises a substantially incompressible, rubberlike substance.

7. The apparatus set forth in claim 3 wherein each of said telescoping members projects a different distance from one end of said deformable material.