(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 March 2002 (21.03.2002)

PCT

(10) International Publication Number
WO 02/22288 A2

(51) International Patent Classification[7]: B21D 53/28

(21) International Application Number: PCT/US01/28127

(22) International Filing Date:
7 September 2001 (07.09.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/662,698 15 September 2000 (15.09.2000) US

(71) Applicant: **THE GATES CORPORATION** [US/US]; 900 South Broadway, Denver, CO 80209 (US).

(72) Inventor: **HODJAT, Yahya**; 410 North Baldwin, Oxford, MI 48371-3410 (US).

(74) Agent: **THURNAU, Jeffrey**; The Gates Corporation, Mail Stop: 31-4-1-A3, 900 S. Broadway, Denver, CO 80209 (US).

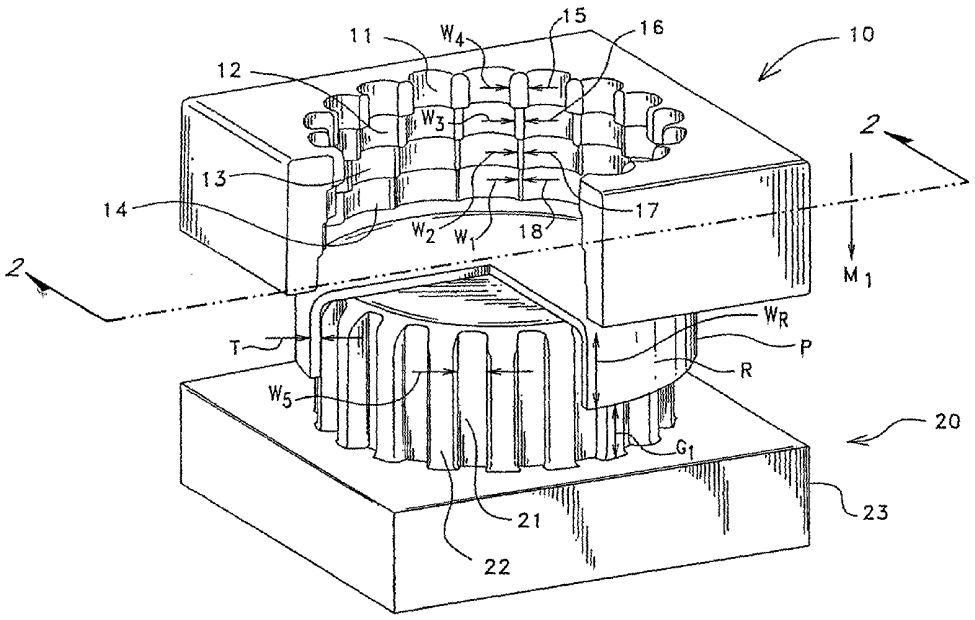
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** A TOOTHED SPROCKET AND METHOD OF FORMING SAME



(57) **Abstract:** The invention comprises a toothed sprocket and a method of forming same. The sprocket is formed from a preform (P), deep drawn cup. The sprocket is formed in a press using a stepped die (10) that forms the teeth or cogs in a gradual incremental movement of the die (10). Each step of the die (10) comprises a coplanar series of protrusions (15, 16, 17, 18) that cooperatively engage longitudinal splines. Each die step comprises a smaller radius as compared to the preceding step, when viewed as one progresses from the die face to the die base. The arrangement of the die steps causes the preform to be plastically formed into a toothed sprocket by the sequential application of each progressively smaller diameter step during the forming process.

WO 02/22288 A2

A Toothed Sprocket and Method of Forming Same

Field of the Invention

The invention relates to sprockets, and more particularly to press formed toothed sprockets using a stepped punch and die.

Background of the Invention

Sprockets are widely known and used as a means of transmitting power between shafts. Power transmission sprockets are made in several ways. Sheet metal types are fabricated by spinning or cam dies. In this method, the teeth or cogs are formed in a perpendicular motion of the die to the pre-form.

Representative of the art is U.S. patent 4,866,831 dated 1989 to Lanzerath et al. which discloses a method of making a support for a synchronizing ring by punching an outer sprocket in the edge of a deep drawn ring shaped core.

The prior art methods suffer from quality problems caused by multi-station die transfer during the fabrication process. The art does not enjoy the advantage of a single station pressing process. Multi-station fabrication necessarily adds cost to the finished part. Further, the prior art methods rely on horizontal forming of sprockets, for example as shown in U.S. patent no. 5,987,952, which does not afford the most advantageous plastic flow of the sheet metal for the application described herein. Further, due to limitations in plastic flow, prior art methods of stamping complex forms in a single stroke limits the

complexity of the shaped surface. The metal tears or wrinkles if it is formed beyond certain limits in a single stroke.

What is needed is a method of press forming a toothed sprocket by a single stepped die. What is needed is a method of press forming a toothed sprocket at a single pressing station. What is needed is a method of press forming a toothed sprocket using vertical forming to allow stamping complex shapes in a single operation. The present invention meets these needs.

Summary of the Invention

The primary aspect of the present invention is to provide a method of press forming a toothed sprocket by a stepped die.

Another aspect of the invention is to provide a method of press forming a toothed sprocket at a single pressing station.

Another aspect of the invention is to provide a method of press forming a toothed sprocket using vertical forming to allow stamping complex shapes in a single operation.

Other aspects of the invention will be pointed out or made apparent by the following description of the invention and the accompanying drawings.

The invention comprises a toothed sprocket and a method of forming same. The sprocket is formed from a pre-form, deep drawn cup. The sprocket is formed in a press using a stepped die that forms the teeth or cogs in a gradual incremental movement of the die. Each die step comprises a smaller diameter as compared to the preceding step, when viewed as one progresses from the die face to the die base. The arrangement of the die steps causes the pre-form to be

plastically formed into a toothed sprocket by the sequential application of each progressively smaller diameter step during the forming process.

Brief Description of the Drawings

Fig. 1 depicts a cross-sectional perspective view of the invention.

Fig. 2 is a side cross-sectional perspective view of the invention along line 2-2 in Fig. 1.

Fig. 3 is a cross-sectional perspective view of a complete sprocket.

Fig. 4 is a cross-sectional view of an alternate embodiment.

Description of the Preferred Embodiment of the Invention

Fig. 1 depicts a cross-sectional perspective view of the invention. Die 10 and punch 20 cooperatively engage to fabricate press formed sprocket from pre-form P.

Die 10 comprises a series of planes or steps 11, 12, 13, and 14. The steps are arranged to have decreasing diameters in a direction of movement of a punch 20. Each step generally describes a single plane. Each step has a characteristic form that further describes an included area. Each included area is progressively smaller as one moves from step 14 to step 11. Therefore, each step has a progressively smaller diameter and included area, while having substantially the same geometric shape. In the preferred embodiment, the form described by each step is circular as shown in Fig. 1.

Each step or plane further comprises protrusions or land portions 15, 16, 17, and 18, each corresponding to steps 11, 12, 13, and 14 respectively. Each of lands 15, 16, 17, and 18 having a width W_4, W_3, W_2, and W_1,

respectively. The width of each land increases sequentially from W_1 to W_4. This is so the increasing width of each land sequentially widens the tooth land being formed in the blank as the die moves across the blank. That is, the lands on the die are progressively creating the corresponding lands in the formed sprocket in a single stroke of the die 10.

Punch 20 comprises a series of splines 22. The splines are parallel to each other and are circumferentially arranged about the outer surface of the circular form of the punch. Parallel longitudinal receiving voids or slots 21 are arranged alternately on each side of splines 22. The slots correspond to and cooperate with the lands on the die.

Slots 21 each have a width W_5. The width W_5 is slightly greater than width W_4 in order to accommodate the width W_4 plus twice the thickness T of pre-from P.

Pre-form P is a cup shaped blank. It comprises a thickness T. Pre-form P has a rim width W_R. W_R is pre-determined so that the proper width is present in the finished sprocket after pressing. Gap G_1 is between the edge of the pre-form and a base surface of punch 20.

The method comprises pressing the die on the punch with the pre-form between each. Die 10 is moved by means known in the art in direction M_1. The movement means can comprise a hydraulic or mechanical lever system known in the art.

Initially, lands 18 of step 14 progressively engage rim R. As the die moves further, lands 18 plastically deform a corresponding portion of rim R into slots 21 and splines 22 by metal forming, imparting the initial form of the die toothed surface to the sprocket. As movement of the die continues, step 14 fully engages rim R. Next, step 13 and the associated lands 17 engage rim R, thereby further metal forming pre-form P into slots 21 and splines 22 with the

form of step 13. As the movement of the die continues, step 13 fully engages pre-form P. Next, step 12 and associated lands 16 engage rim R thereby further metal forming pre-form P into slots 21 and splines 22 with the form of step 12. As the movement of the die continues, step 12 fully engages pre-form P. Next, step 11 and associated lands 15 engage rim R thereby further metal forming pre-form P with the form of step 11.

As the die moves in direction M_1, the width W_R of rim R is somewhat increased because the metal plastically flows in the pressing direction M_1 to accommodate the action of the die in the punch. Further, as each progressively smaller diameter step engages the pre-form, gap G_1 progressively diminishes. The die continues in direction M_1 until step 11 fully traverses across rim R, thereby creating the fully formed toothed sprocket. Once the sprocket is fully formed the die is withdrawn and the sprocket is removed from the punch.

Fig. 2 is a side cross-sectional perspective view of the invention along line 2-2 in Fig. 1. Each step 14, 13, 12, and 11 has a diameter D_1, D_2, D_3, and D_4 respectively. Pre-form P has diameter D_5. Diameter D_5 is larger than the diameter of punch 20 so that a gap G_2 is present between the pre-form and top of each punch spline 22. The diameter of each step is such that each is progressively less than the preceding step in the direction of motion M_1. When step 11 is fully engaged there is a small space between the lands 15 and the corresponding slots 21 in order to properly accommodate thickness T of pre-form P between them.

Fig. 3 is a cross-sectional perspective view of a complete sprocket. Once die 10 has completed its movement in direction M_1, the fully formed sprocket P is removed.

Removal of sprocket P is accomplished by movement in direction M_2. Movement of sprocket P can be effected by any means known in the art, including ejection by use of a hydraulic ram or ejector built into the punch (not shown) other grasping or shuttle device used to lift the sprocket from the punch.

Fig. 4 is a cross-sectional view of an alternate embodiment. The die 100 has a length L_1. Punch post 210 having length L_2. Each ring, 110, 120, 130, 140, has a height H. The height and corresponding length L allow each ring of the die to fully traverse the width of the pre-form rim R before the next ring engages. Once the final ring 110 disengages from the sprocket P, the sprocket is removed from the punch by any means known in the art. Die 100 is then retracted from punch 200, ready to receive another pre-form. It is also available for the finished sprocket to be ironed, that is, a ring having the minimum diameter is used on the sprocket, in this case ring 110, a number of additional cycles to further assure close tolerances as necessary, or to counter any springback of the formed metal. This embodiment otherwise operates as described in the foregoing figures.

Even though this description addresses fabrication of toothed sprockets, one skilled in the art can appreciate that the method of using a stepped die and punch can be adapted to stamp parts having any geometry, and is therefore not limited to only a circular geometry.

Although a single form of the invention has been described herein, it will be obvious to those skilled in the art that variations may be made in the construction and relation of parts without departing from the spirit and scope of the invention described herein.

Claims

I claim:

1. A method of forming a sprocket comprising the steps of:

forming splines describing longitudinal voids about a circumference of a first member;

forming protrusions about a second member, the second member describing a hole and the protrusions arranged about an outer surface of the hole and the protrusions cooperatively engaging the longitudinal voids, the first member axially engagable with the second member;

placing a blank to be formed between the first member and the second member;

pressing the hole of the second member axially over the blank and the first member; and

forming a sprocket.

2. The method as in claim 1, wherein the steps of:

forming a second member having protrusions further comprises the step of using a plurality of protrusions arranged in a form about an axis; and

forming a first member having longitudinal voids further comprises the step of using a plurality of longitudinal voids arranged in a form about an axis such that the longitudinal voids cooperatively engage corresponding protrusions.

3. The method of claim 2, wherein the step of forming a second member having protrusions further comprises the step of:

using a plurality of layers of coplanar protrusions having an included area, each coplanar layer having an

included area less than an adjacent coplanar layer in a direction of movement of the first member.

4. A punch and die comprising:

a punch having a plurality of parallel longitudinal voids spaced about a surface; and

a die having a plurality of parallel protrusions describing a plane, the protrusions spaced about a surface of the die, the protrusions arranged to cooperatively engage the longitudinal voids.

5. The punch and die as in claim 4, wherein the protrusions are coplanar.

7. The punch and die as in claim 6, wherein the die further comprises:

a plurality of parallel planes of protrusions, each plane of protrusions having a different diameter than the adjacent plane of protrusions.

8. The punch and die as in claim 7, wherein:

a plane of protrusions having an included area less than the included area of an adjacent plane of protrusions, each adjacent protrusion plane describing substantially the same geometric shape.

9. The punch and die as in claim 8, wherein:

each protrusion in a plane having a width not equal to the width of a protrusion in any other plane.

10. The punch and die as in claim 9, wherein:

each protrusion in a plane having a width that is greater that the width of the protrusions in an adjacent plane having a smaller diameter.

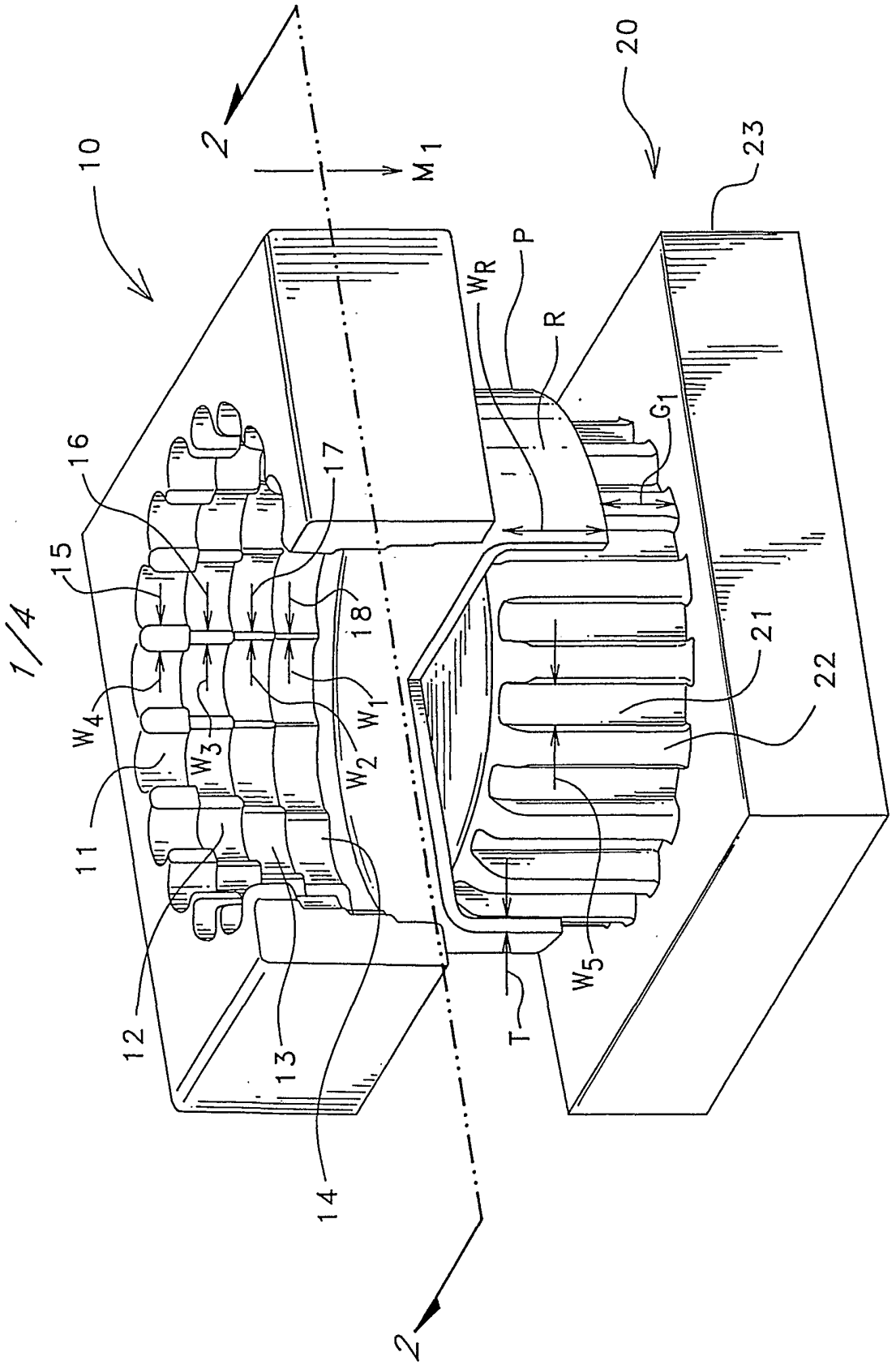


FIG. 1

1/4

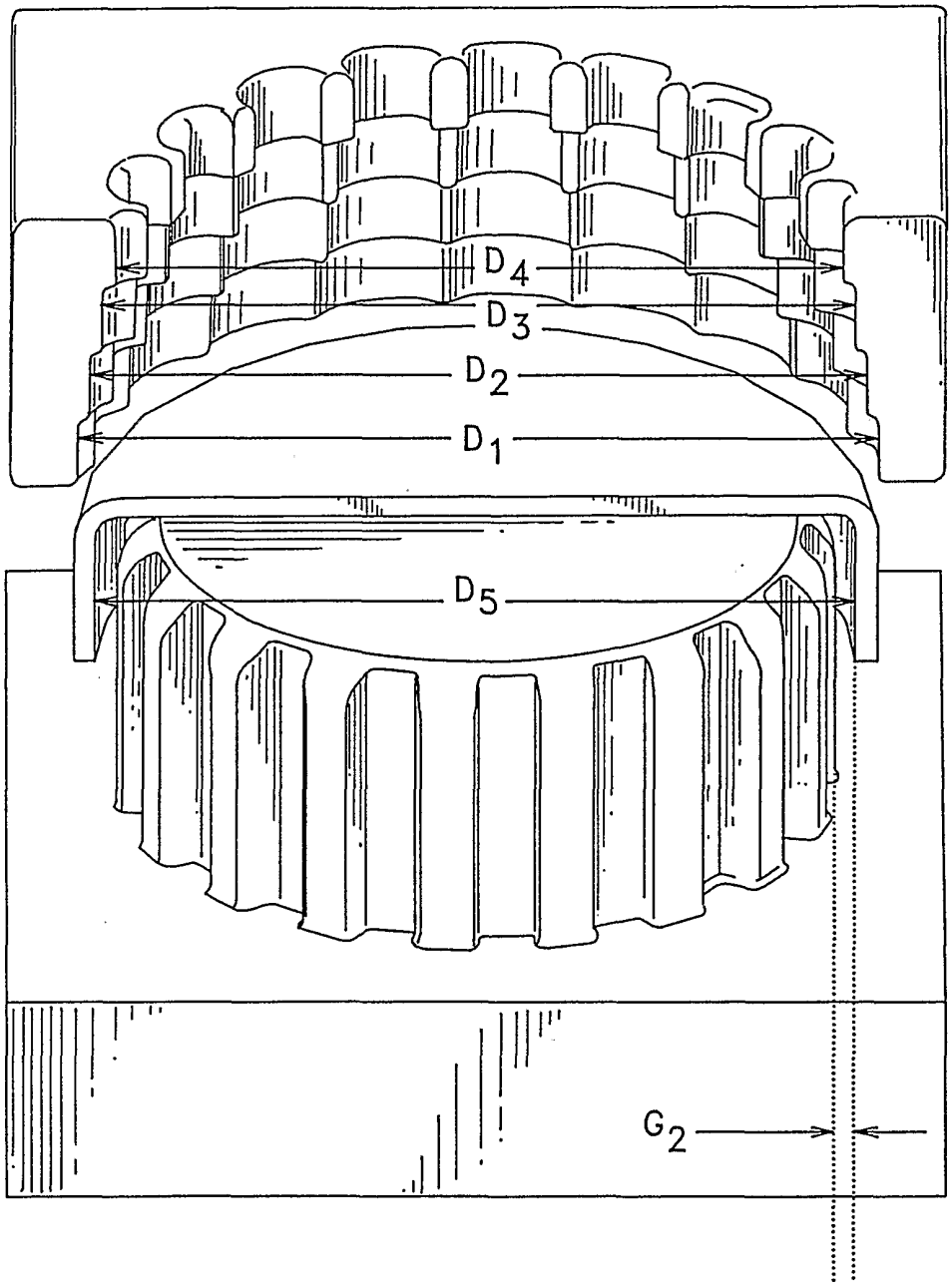


FIG. 2

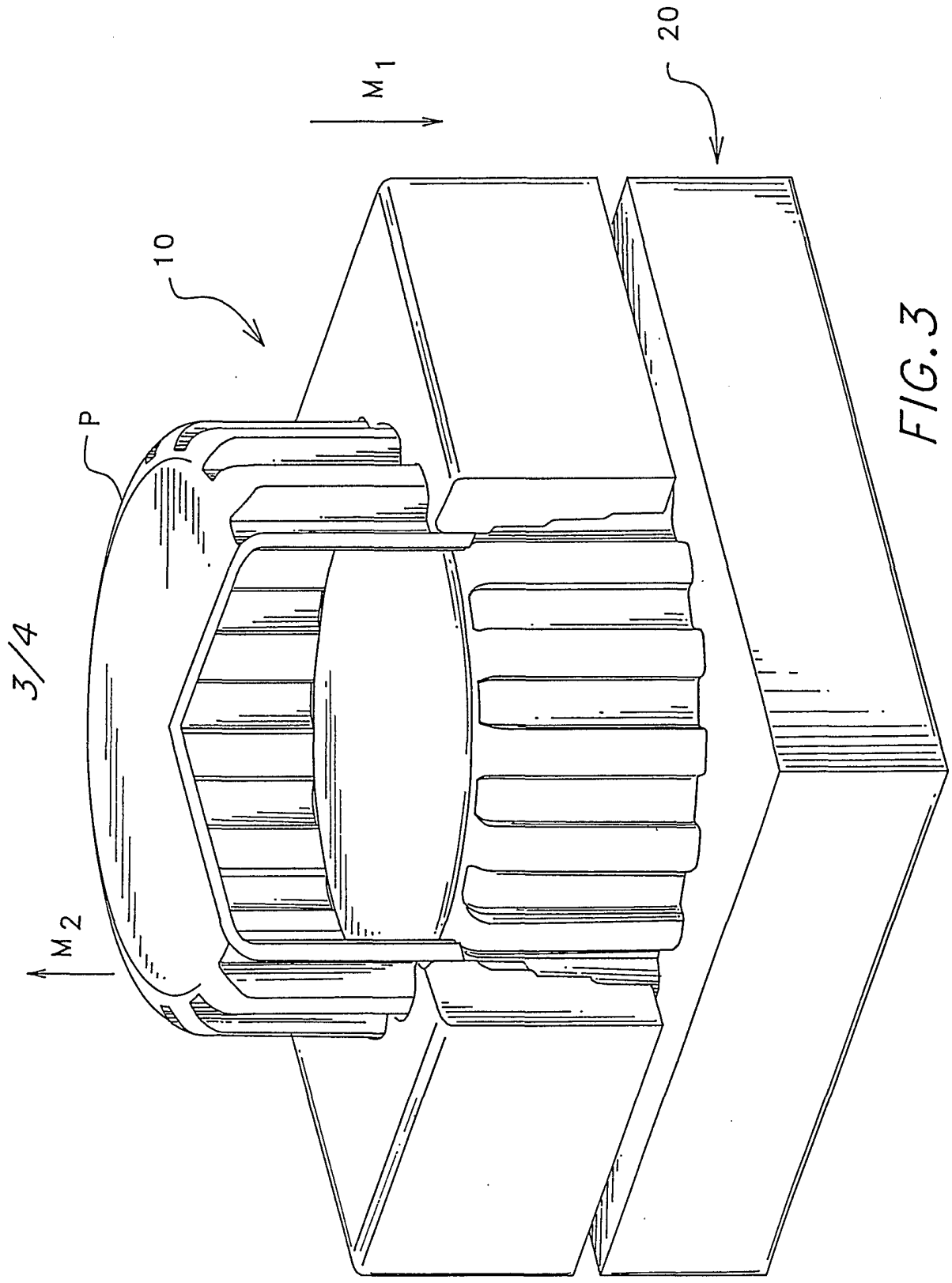


FIG. 3

3/4

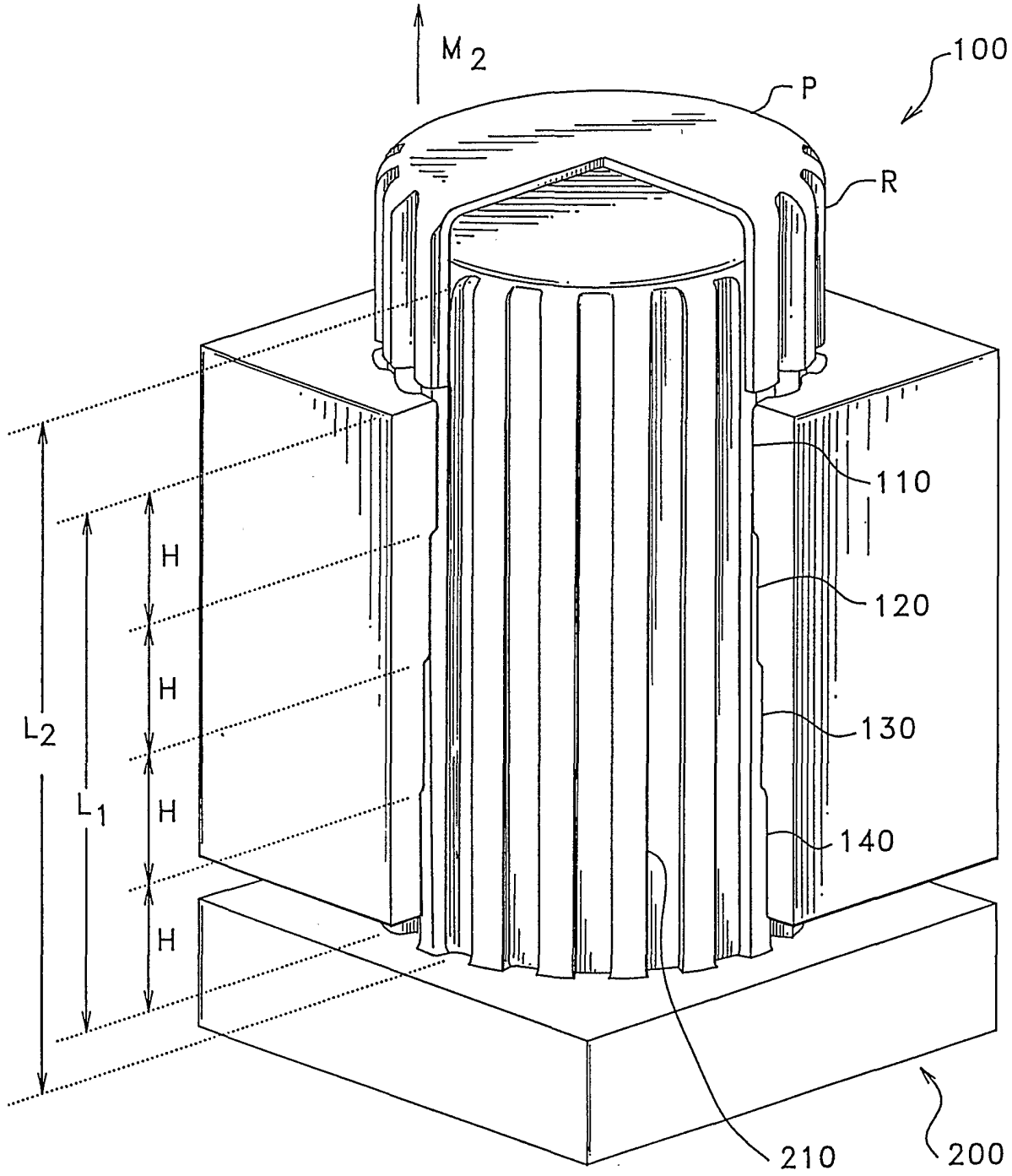


FIG. 4