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Mino et al.

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[54] **APPARATUS FOR PRODUCING AN ANNULAR CORRUGATED SPRING**

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[52] **U.S. Cl.** **72/132;** 72/185; 72/196

[51] **Int. Cl.**[2] **B21F 11/00**

[58] **Field of Search** 72/129, 130, 132, 146, 72/185, 168, 196; 29/173, 156.6, 156.62, 156.63; 277/160, 161, 162; 267/1.5, 167

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Primary Examiner—C. W. Lanham
Assistant Examiner—Robert M. Rogers
Attorney, Agent, or Firm—Fleit & Jacobson

[57] **ABSTRACT**

An apparatus for continuously producing an annular corrugated spring, said apparatus having forming roller means including a plurality of pairs of forming rollers for applying to an elongated band-like spring blank a predetermined radius of curvature in the plane of the blank to provide a circular form therein, means including a pair of co-operating waved rollers having complementarily waved contours for applying corrugated configuration to the blank passing through the rollers, and means for cutting the corrugated blank at a predetermined position to provide an annular corrugated spring.

9 Claims, 8 Drawing Figures

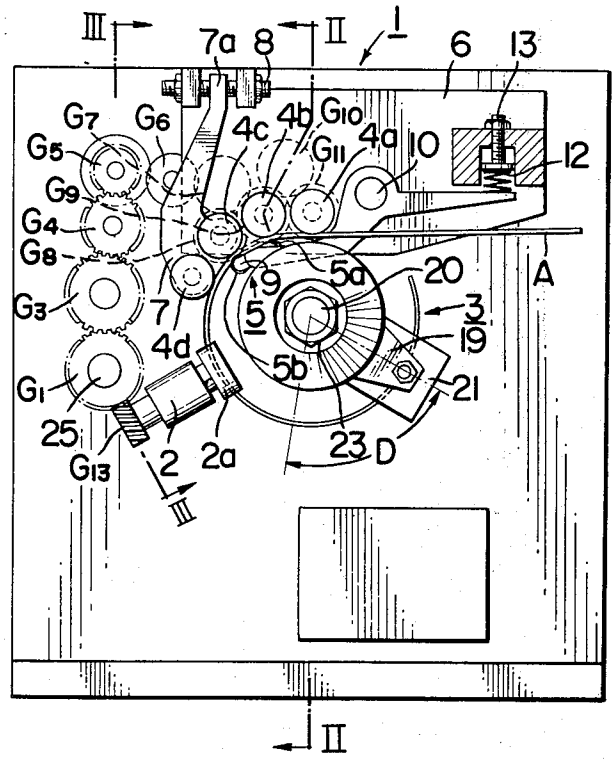
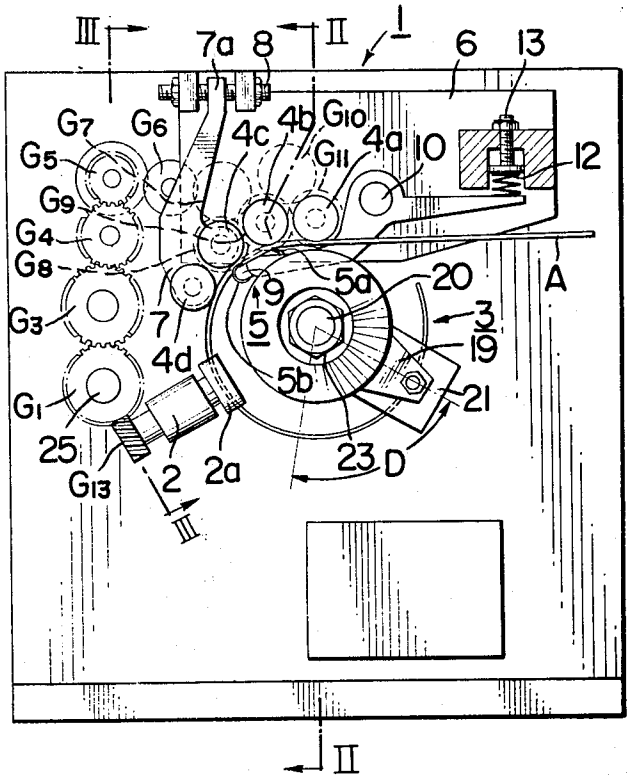


FIG. 1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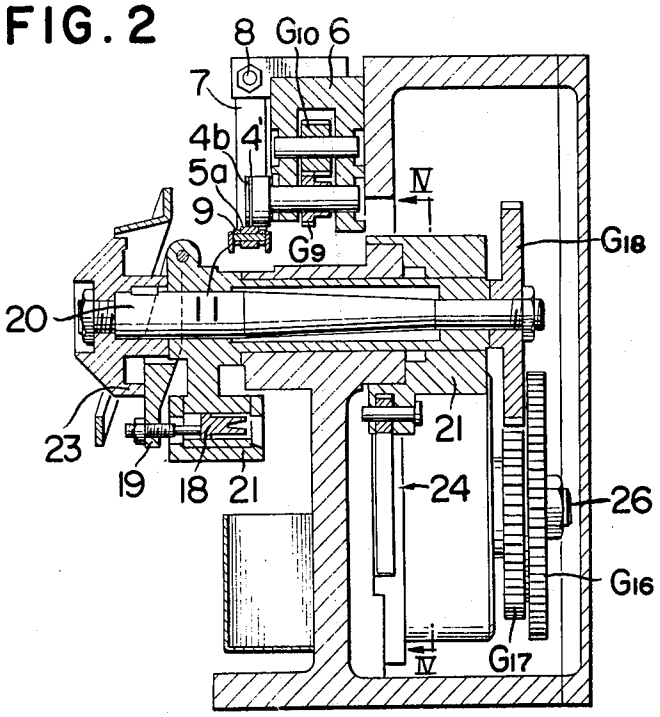
7a
8
II
I
6
13
G7
G6
4c
4b
G10
4a
10
12
G5
G11
G9
G4
G8
9
5a
20
A
G3
7
5
3
19
4d
5b
21
G1
25
23
D
G13
2
2a
III
II

FIG. 2


8
G10
6
7
4b
4
5a
9
IV
G9
G18
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11
23
19
18
21
21
24
26
G16
IV
G17

FIG. 3

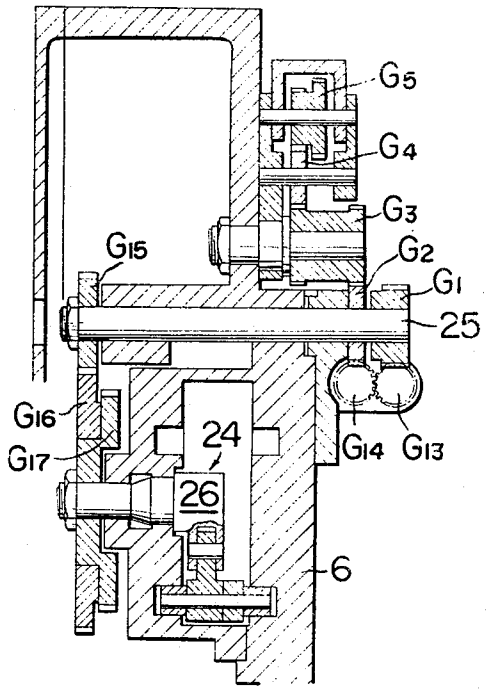


FIG. 4

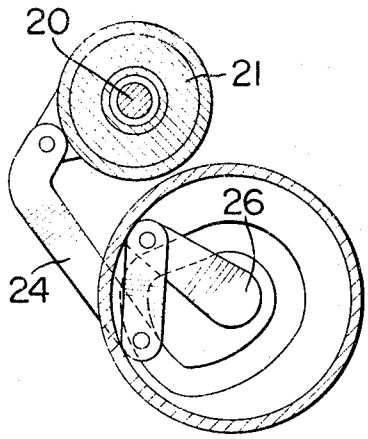


FIG. 5

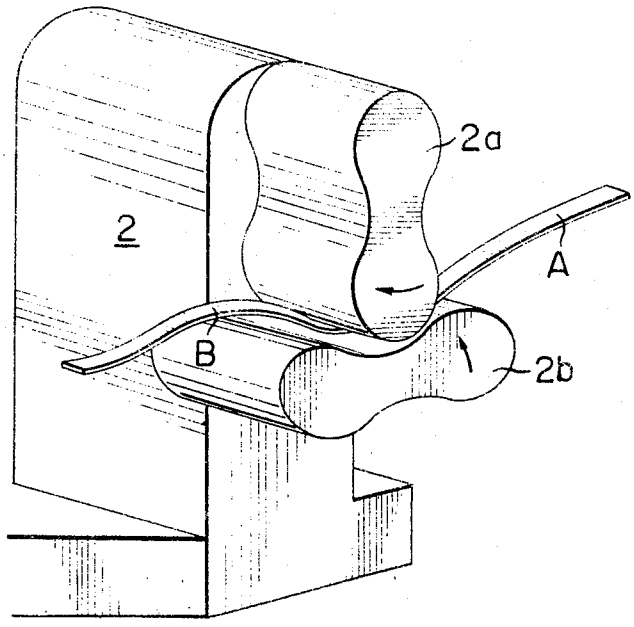


FIG. 6

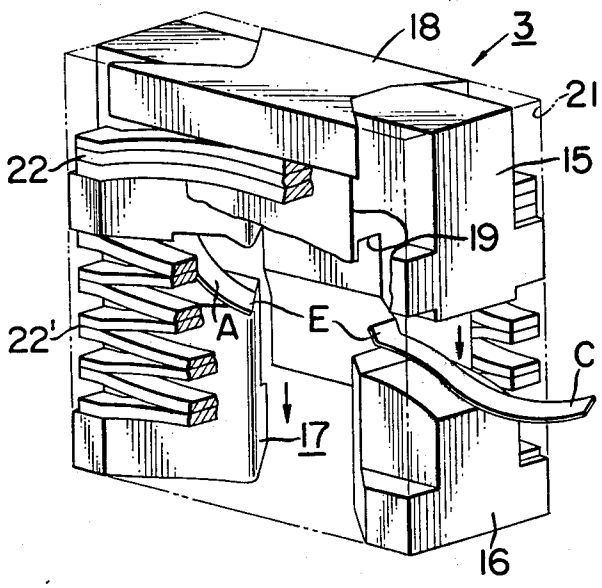


FIG. 8

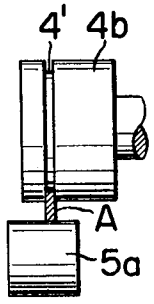
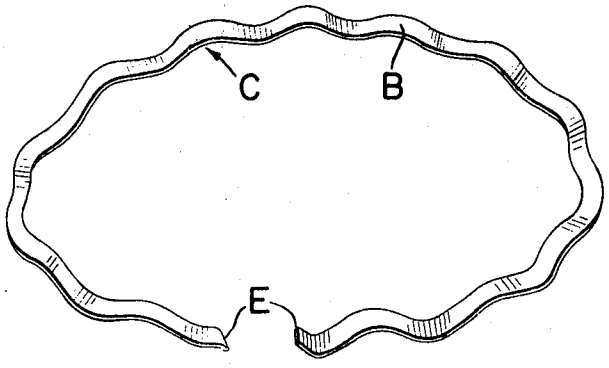


FIG. 7



APPARATUS FOR PRODUCING AN ANNULAR CORRUGATED SPRING

The present invention relates to an apparatus for producing an annular corrugated spring. More particularly, the present invention relates to an apparatus for producing an annular corrugated spring from an elongated flat blank material.

In a rotary piston type engine having a substantially triangular rotor disposed for rotation in a trochoidal cavity defined in a casing, annular oil seal rings are disposed between the side surfaces of the rotor and the adjacent inner surfaces of the casing. For this purpose, the rotor is provided in the side surfaces with annular grooves for receiving such oil seals. In order to force the oil seals into sealing contact with the adjacent surfaces of the casing, an annular corrugated spring is disposed behind each of the oil seal rings.

Hithertofore, such an annular corrugated spring has been produced by separate steps of press forming an elongated band-like blank into a plane annular ring and thereafter applying a corrugated form. However, the conventional process is disadvantageous in that it is time-consuming and requires an increased production cost. Further, since the corrugated form is applied through a pressing operation, substantial deformation is produced after heat treatment due to non-uniform distribution of residual stress.

Therefore, the present invention has an object to provide an apparatus which can continuously perform the steps of forming an elongated band-like spring blank into a plane annular shape and then applying a corrugated form to the blank to form an annular corrugated spring.

Another object of the present invention is to provide an apparatus which can produce an annular corrugated spring having uniform distribution of residual stress.

A further object of the present invention is to provide an apparatus in which an elongated band-like spring blank is applied with a uniform radius of curvature in the plane of the blank.

Still further object of the present invention is to provide novel means for cutting a formed spring blank to provide a substantially annular spring and at the same time forming the cut end of the spring.

According to the present invention, the above objects can be achieved by an apparatus comprising forming roller means including a plurality of pairs of forming rollers for applying to an elongated band-like spring blank a predetermined radius of curvature in the plane of the blank to provide a circular form therein, means including a pair of co-operating waved rollers having complementarily waved contours for applying corrugated configuration to the blank passing through the rollers, and means for cutting the corrugated blank at a predetermined position to provide an annular corrugated spring. Preferably, the forming rollers comprise a plurality of outboard rollers having stationary axes and corresponding number of inboard rollers which are resiliently urged to the outboard rollers for co-operation therewith. The cutting means should preferably be mounted in the apparatus so that it is moved along the path of the formed blank at a speed synchronized with the feeding speed of the blank. It is further preferable that the cutting means is also provided with means for shaping the cut end of the blank.

The above and other objects and features of the present invention willl become apparent from the following descriptions of a preferred embodiment thereof taking reference to the accompanying drawings, in which:

FIG. 1 is a front view of the apparatus in accordance with one embodiment of the present invention;

FIG. 2 is a sectional view taken substantially along the line II—II in FIG. 1;

FIG. 3 is a sectional view taken substantially along the line III—III in FIG. 1;

FIG. 4 is a sectional view taken substantially along the line IV—IV in FIG. 2;

FIG. 5 is an enlarged perspective view of waved roller means used in the apparatus shown in FIG. 1;

FIG. 6 is an enlarged perspective view of cutting means;

FIG. 7 is a perspective view of an annular corrugated spring; and

FIG. 8 is an enlarged elevational view of forming rollers.

Referring now to the drawings, there is shown an apparatus for producing an annular corrugated spring C which is, as shown in FIG. 7, circular but waved or corrugated as designated by B in the direction perpendicular to the plane of circle. The apparatus comprises a plane circle forming section 1 for applying a predetermined radius of curvature to an elongated ribbon-like spring blank A in the plane of the ribbon, a wave forming section 2 for applying the waved or corrugated configuration to the blank, and cutting means 3 for cutting the blank to a predetermined length so as to obtain an annular corrugated spring C as shown in FIG. 7.

The plane circle forming section 1 includes a plurality (four in the case of the illustrated embodiment) of outboard forming rollers 4*a*, 4*b*, 4*c* and 4*d*, and inboard forming rollers 5*a* and 5*b* which co-operate with the outboard rollers 4*b* and 4*c*, respectively. The rollers 4*a*, 4*b* and 4*c* are rotatably supported on the frame of the apparatus and the roller 4*d* is mounted on an arm 7 which is swingable about the axis of the roller 4*c*. The arm 7 has an upward extension 7*a* which is provided with an internally threaded hole for engagement with a radius adjusting screw 8. The screw 8 is rotatably but axially immovably mounted on the frame of the apparatus. The forming rollers 5*a* and 5*b* are supported by a swingable lever 9 which is rotatably mounted at its intermediate portion on an end of a swingable arm 11. The arm 11 is pivotably mounted at its intermediate portion by a shaft 10 on the frame. A spring 12 is disposed to act on the other end of the arm 11 so as to bias it in the clockwise direction. An adjusting screw 13 is combined with the spring 12 so as to adjust the bias force of the spring.

As shown in FIG. 8, the forming roller 4*b* has circumferential groove 4' for receiving one of side edges of the blank A. The roller 5*a* co-operating with the roller 4*b* has a smooth surface which engages with the other side edge of the blank A. It should be noted that the rollers 4*a*, 4*c* and 4*d* have the same configuration as the roller 4*b* and the roller 5*b* has the same configuration as the roller 5*a*, so that they will not be described in detail. The rollers 4*a*, 4*b* and 4*c* are provided with gears G11, G_9 and G_8, respectively and the gears G_8 and G_9 are driven by a drive shaft 25 through gears G_1, G_3, G_4, G_5, G_6 and G_7 so as to positively drive the rollers 4*b* and 4*c*. The rotation of the gear G_9 is transmitted to the gear G_{11} through a gear G_{10} so that the roller 4*a* is also posi-

tively driven. The roller 4*a* serves to guide the blank A between the rollers 4*b* and 5*a*, and the blank A is applied with a predetermined radius of curvature in the plane of the blank as it is passed through the path between the rollers 4*b*, 4*c* and 5*a*, 5*b*. The radius of curvature can be determined by the position of the roller 4*d* which is adjustable through rotation of the screw **8**. When there is any variation in the width of the blank A, the arm **11** is swung about the shaft **10** to accommodate the possible variable.

The wave forming section **2** comprises a pair of rollers 2*a* and 2*b* having complementarily waved contours as shown in FIG. **5**. The rollers 2*a* and 2*b* are driven in the same direction by the drive shaft **25** through gears G_{13} and G_{14} which mesh with the gears G_1 and G_2. As the circularly curved blank A is passed through the rollers 2*a* and 2*b*, a corrugation or waved form is applied to the blank A.

The cutting means **21** comprises a swingable casing **21** mounted rotatably at one end of a rotatable shaft **20** which is driven through gears G_{15}, G_{16}, G_{17} and G_{18}. In the casing **21**, there are disposed a pair of end forming dies **15** and **16** which have co-operating spring end forming portions. The dies **15** and **16** are also provided with shearing edges for co-operation with a cutting punch member **18** which is slidable along the end surfaces of the dies. A leaf spring **22** is disposed between the punch member **18** and the die **15** and a weaker spring **22'** is disposed between the dies **15** and **16**. As shown in FIG. **2**, a swingable actuating lever **19** is provided on the casing **21** and acts on the punch member **18** to force it into cutting operation. The casing **21** is connected through a crank mechanism **24** with a drive shaft **26** which is driven by a gear **16** so that the casing **21** is reciprocatingly swung through the angular distance D shown in FIG. **1**. The shaft **20** has a cam **23** mounted on one end thereof for co-operation with the lever **19**. Thus, in response to the relative movement between the cam **23** and the lever **19**, the latter is forced rightwardly as seen in FIG. **2** to actuate the punch member **18**. In the initial stage of the movement of the member **18**, only the spring **22'** is deflected and the dies **15** and **16** are closed to form the blank A as shown by E in FIG. **6**. During a further movement of the punch member **18**, the spring **22** is deflected so that the member **18** is allowed to move to a position to cut the blank A. It is one of the important features of the invention that the casing **21** carrying the cutting mechanism is moved along the circular path of the blank by the crank mechanism **24** in synchronism with the movement of the blank when the cutting operation is performed, so that the blank can be cut without any local deformation.

From the above descriptions, it will be clear that the invention provides an apparatus which can continuously produce an annular corrugated spring. Although the invention has thus been shown and described with reference to a preferred embodiment, it should be noted that the invention is in no way limited to the details of the illustrated structures but changes and modifications may be made without departing from the scope of the appended claims.

We claim:

1. An apparatus for producing an annular corrugated spring from an elongated flat blank, said apparatus comprising forming roller means including a plurality of pairs of forming rollers for applying to an elongated band-like spring blank with flat faces a predetermined radius of curvature to provide a circular formed blank with the faces of the blank normal to the radius of curvature, means including a pair of co-operating waved rollers having complementary waved contours for applying a corrugated configuration to the circular formed blank passing through the rollers to provide a circular formed corrugated blank with the corrugations being defined inwardly and outwardly of the mean periphery of the blank, and cutting means for cutting the circular formed corrugated blank at a predetermined position to provide an annular corrugated spring.

2. An apparatus in accordance with claim **1** in which said forming roller means include a first set of rollers having stationary axes and a second set of rollers which are resiliently urged to the first set of rollers for co-operation therewith.

3. An apparatus in accordance with claim **2** in which said first set of rollers have circumferential groove for receiving one of side edges of the blank.

4. An apparatus in accordance with claim **2** which further includes a third roller which is adjustable in position with respect to the first set of rollers to determine the amount of radius of curvature applied to the blank.

5. An apparatus in accordance with claim **1** which includes moving means for moving the cutting means along the path of the formed blank in synchronism with the movement of the blank during cutting.

6. An apparatus in accordance with claim **1** in which said cutting means includes die means for shaping the cut end of the blank.

7. An apparatus in accordance with claim **5** in which said moving means includes a swingable member which is reciprocatingly swung in synchronism with the movement of the blank.

8. An apparatus in accordance with claim **7** further including means for actuating the cutting means when it is moved in the direction of movement of the blank.

9. Method for producing an annular corrugated spring from an elongated flat blank comprising the steps of forming an elongated band-like spring blank having flat faces with a predetermined radius of curvature into a circular formed blank with the faces of the blank normal to the radius of curvature, and corrugating the circular formed blank to deform portions thereof inwardly and outwardly of the mean periphery of the blank.

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