March 22, 1938. D. M. SOLENBERGER 2,111,574

RING FORMING MACHINE AND METHOD

Filed April 8, 1935 3 Sheets-Sheet 1

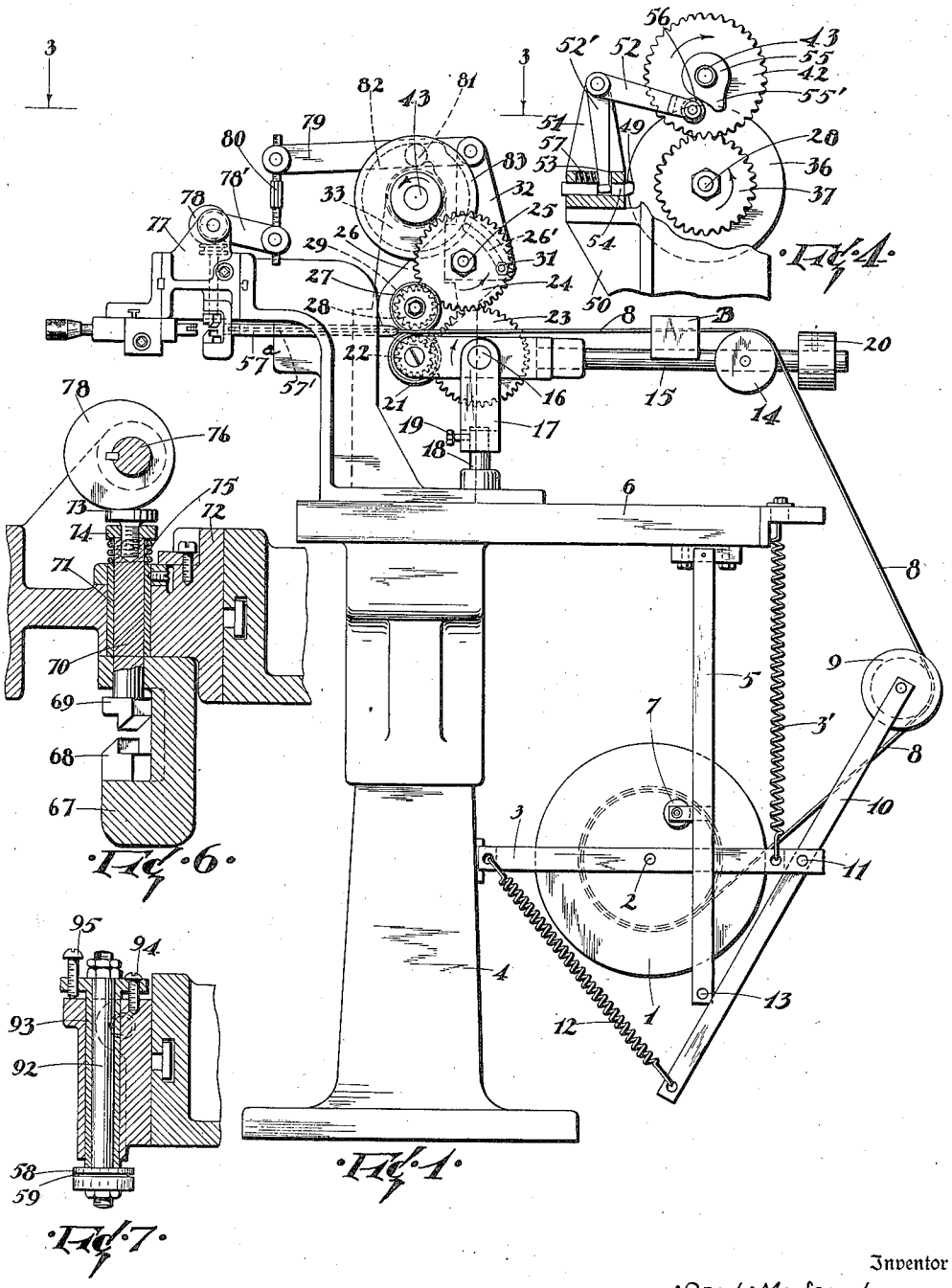

Fig. 1.

Fig. 6.

Fig. 7.

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RING FORMING MACHINE AND METHOD

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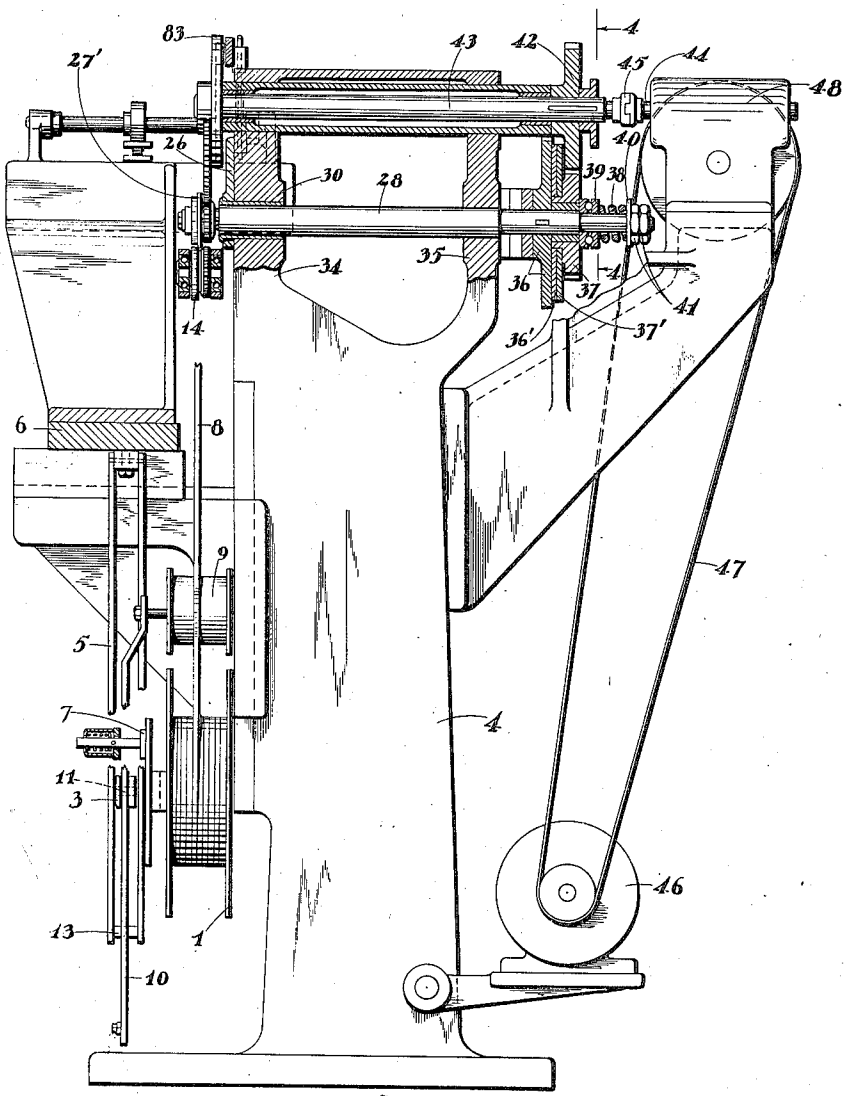

Fig. 2.

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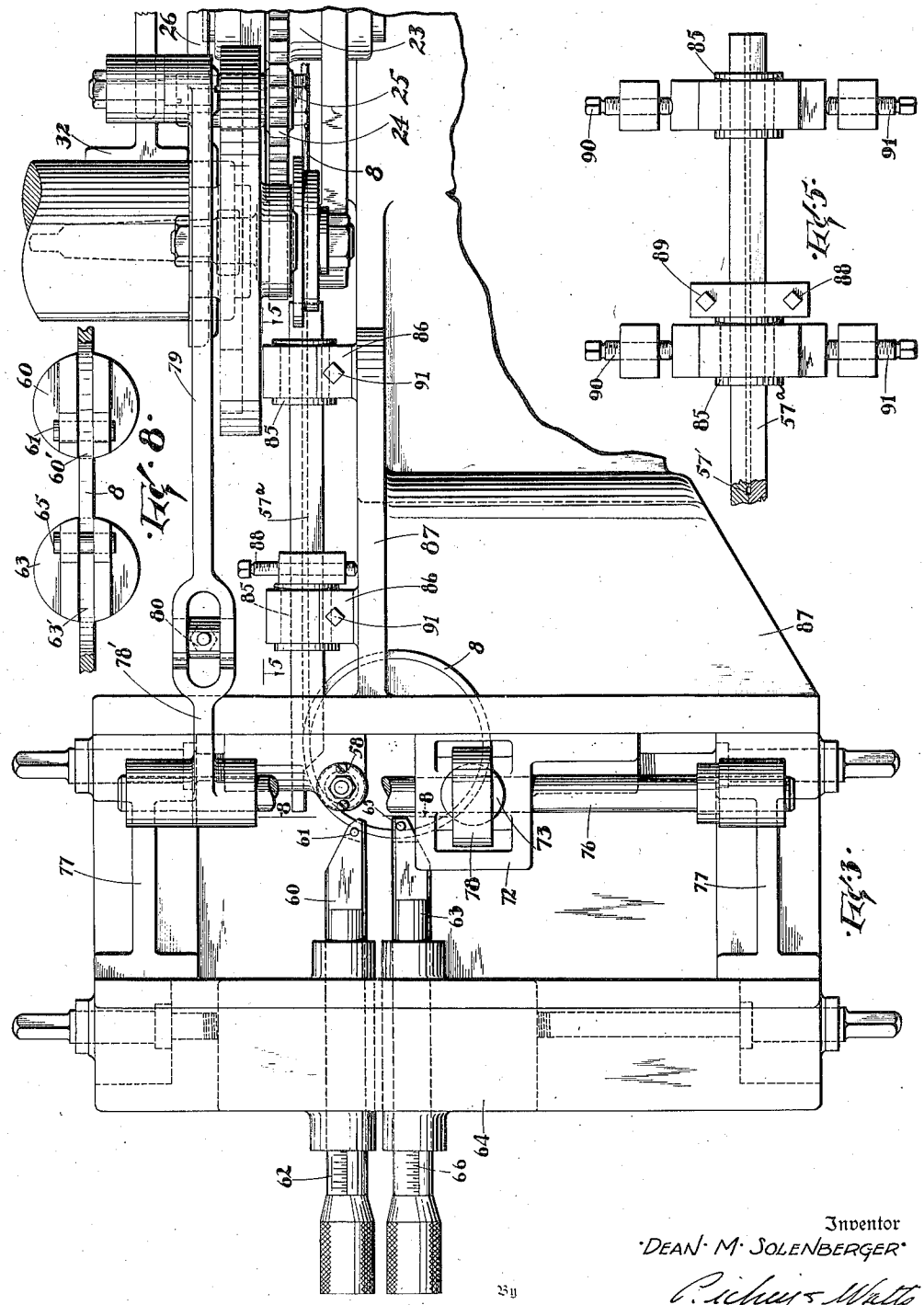

Fig. 8.

Fig. 5.

Fig. 3.

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UNITED STATES PATENT OFFICE

2,111,574

RING FORMING MACHINE AND METHOD

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Application April 8, 1935, Serial No. 15,356

30 Claims. (Cl. 140—88)

This invention relates to an improved method of and apparatus for forming accurately sized rings from metallic strip, ribbon, wire or the like.

In my co-pending United States patent application, Serial No. 8,322, filed February 26, 1935, I have illustrated and described an improved type of rolling mill which is particularly adapted to roll a flat metallic wire or ribbon of extremely accurate cross sectional dimensions. In forming metallic rings according to the present method and with the herein described improved apparatus I prefer to use ribbon rolled on the type of rolling mill described in my said co-pending application.

This application is a continuation in part of my co-pending application, Serial No. 7,121, filed February 18, 1935.

Rings formed from metallic ribbon by my improved method and apparatus are particularly adapted for use in laminated piston rings for forming a seal between a piston and its cylinder wall in an internal combustion engine or the like.

I am aware that laminated packing or piston rings have been previously proposed. These rings ordinarily are made up of a plurality of relatively thin flat rings which are fitted into a groove in the piston and which engage the cylinder wall to form the desired seal. Prior to my invention laminated piston rings have not been entirely satisfactory because it has not been possible to manufacture the individual relatively thin ring sections with the required accuracy or of suitable material. It is necessary that each ring be held within very close limits as to diameter, cross sectional thickness and cross sectional width. It is particularly necessary that the diameter of each individual ring of a built up laminated piston ring be substantially exactly the same so that all of the individual rings will engage the piston wall in the same manner. It is also essential that the thickness of the metal of each individual ring be held within extremely close tolerances (for example plus or minus .0001") because any variation or error in the thickness of the individual rings will be multiplied in a built up laminated ring. Thus, if each individual ring were .001" oversize and five rings were necessary to fill the piston groove, the entire assembly of rings would be .005" oversize which would be prohibitive as it would be impossible to insert the rings in the groove. If all of the rings were undersize the error would accumulate in like manner and a loose or sloppy fit would result which would cause the ring to wear out very quickly and become ineffective for its intended purpose.

With my improved apparatus and by my improved method I am able to rapidly and accurately produce, from a long coil of ribbon of the proper cross sectional shape, the individual rings necessary to build up a laminated piston ring.

In order to form the ribbon into ring form it may be passed between a pair of driven feed rolls and then caused to be bent into ring form by engagement with a stationary pin or other obstruction. It will be evident that by properly positioning such an obstruction in the path of a ribbon moving in the direction of its length and by properly guiding the ribbon to prevent undesired twisting, the ribbon will be bent into a ring the diameter of which will depend upon the position of the obstruction and the force which it exerts against the moving ribbon. If rings thus generated are not severed the ribbon will be bent into a coil.

I have found, however, that when the procedure just outlined is carried out successive rings will not be of the same diameter but will vary to such an extent that they are unsuitable for piston ring purposes. It is my opinion, based on my work in this field, that this variation is due to variations in the metallic structure, hardness, cross sectional dimensions, etc. of the ribbon which is being fed through the feed rolls, and that if a ribbon of absolutely uniform dimensions and characteristics could be obtained the rings or coils so formed of such ribbon would be absolutely uniform in diameter. However, it is a practical impossibility to obtain such a ribbon and it has therefore been necessary to develop my improved process whereby a succession of rings can be continuously formed from a ribbon, said rings being maintained within extremely close diametral dimension limits.

It is therefore among the objects of my invention to provide an improved method for forming rings from metallic ribbon or the like whereby each successive ring will be of the same diameter, within very close tolerances, regardless of variations in the cross sectional dimensions, hardness or other characteristics of the ribbon from which the rings are formed.

Other objects of my invention are: the provision of a simple and effective apparatus for automatically and continuously forming a length of metallic ribbon into accurately sized rings and severing each ring as it is formed; the provision of an automatic ring forming machine which may be readily adjusted to make rings of various

sizes; and the provision of a simple and inexpensive means for rapidly and accurately producing rings of the type described.

The above and other objects of my invention will appear from the following description of the preferred steps of my method and one embodiment of my improved apparatus for carrying out my method, reference being had to the accompanying drawings, in which—

Figure 1 is a side elevation of my ring forming machine with a reel of ribbon stock in position to be formed into rings.

Figure 2 is a side view, partly in section, of the machine shown in Figure 1.

Figure 3 is an enlarged plan view, taken substantially on line **3—3** of Figure 1, illustrating the ribbon feeding and forming mechanism.

Figure 4 is a cross-sectional view of my forming machine taken on line **4—4** of Figure 2 and illustrating the stop latch and its actuating cam.

Figure 5 is an enlarged view, taken on line **5—5** of Figure 3, illustrating the adjusting mechanism for the ribbon guide.

Figure 6 is an enlarged cross-sectional view of the ribbon cut-off mechanism and its actuating cam.

Figure 7 is an enlarged cross-sectional view of the adjustable ribbon guide roll.

Figure 8 is a view taken on line **8—8** of Figure 3, illustrating the guiding slots and bending pins in the ends of the bending bars.

I have described above a simple method of continuously forming rings from an elongated strip of metal and have pointed out the objectionable features of this method insofar as the manufacture of uniformly accurate rings for laminated piston rings is concerned. I have found that I can obtain the desired accuracy in the dimensions of successive rings if, after forming the rings as noted above to a certain diameter by a primary bending operation, I then re-form the rings to another diameter by a secondary bending operation. In carrying out my method, for example to produce a ring of 3" diameter, I preferably first exert a primary bending force on the ribbon (while the ribbon is being moved in the direction of its length) sufficient to form a ring of substantially 2¾" diameter. As noted above the 2¾" rings, due to variations in the characteristics of the ribbon being fed against the bending pin, will not be maintained accurately at 2¾" diameter but may vary from about 2⅝" to 2⅞" in diameter. If a soft spot in the ribbon, or a portion of smaller cross section, is encountered the metal will bend more readily and will, therefore, form a ring of smaller than the desired (2¾") diameter while if a hard or oversize portion of the ribbon is encountered the ring will not bend so readily and the result will be a ring of greater than the desired diameter.

In order to overcome this defect I re-form the said 2¾" diameter ring by bending it outwardly in the reverse direction from the first or primary bend by a secondary bending force until a ring of 3" diameter is formed. This second bending operation, as will later clearly appear, is done continuously and before the first or 2¾" ring is completely formed. I have found that this re-bending or reforming of the ribbon to a diameter different from that to which it was originally formed greatly reduces the diametral variation between successive rings and enables me to produce rings within the necessary commercial limitations of say plus or minus .002".

I attribute the results obtained to the fact that the relatively soft portions of the ribbon, which were formed into a relatively small diameter ring in the first bending operation because of the ease with which the metal takes a set, will, for the same reason, be re-bent to a relatively great degree during the secondary re-bending or re-forming step. Likewise, the relatively hard portions of the ribbon which would not take the normal degree of bending in the first ring forming operation will likewise resist the re-bending operation and will not take what may be termed the normal degree of set or bend. In other words, the portions of the ribbon which may be considered to be of normal size and characteristics will be bent to a diameter of substantially exactly 2¾" during the first bend and will be re-bent to a diameter of substantially exactly 3" during the re-bending operation. The normal diametral change in the second bending operation is thus ¼". Portions of the ring which are softer or smaller in cross-sectional area than normal will be bent to a diameter of say, for example, 2⅝" during the first bending operation but will also be re-bent in the second bending operation from 2⅝" to 3" diameter, due to the greater ease with which the soft or small section material bends. In this case the second bending changes the diameter ⅜". In like manner the relatively hard or oversize portions, which may have been bent to a diameter of 2⅞" during the first bending operation, will resist the re-bending operation more than the normal stock and will also be bent to a diameter of 3" during the re-bending operation. The change in diameter in the second bending of the hard stock will thus be only ⅛". It will be noted that the finished ring in the above example is approximately 8% larger in diameter than the average ring or arc formed by the primary bending operation. I have found that satisfactory results may be obtained if the difference in diameter between the ring or arc formed by the first or primary bending and the finished ring diameter is maintained between 5% and 15% of the finished diameter. However, I do not wish to be limited to this particular range of percentage as it may be found that with some materials and in some cases a greater or less degree of re-bending will be effective to produce a ring of the desired accuracy.

It will be seen from the above that the re-formed rings will be of a uniform 3" diameter regardless of variations in the characteristics of the ribbon. It will also be understood that this re-bending operation might be repeated a number of times and that in each repetition of the operation the accuracy and degree of uniformity of the resulting rings would be increased. I have found, however, that for commercial purposes, utilizing bronze or steel ribbon suitable for piston rings, one rebending operation is sufficient to obtain the desired accuracy.

In order to carry out the above described method, I have developed the apparatus illustrated in the drawings. Referring particularly to Figure 1, the ribbon stock **8**, which has previously been rolled to the desired accurate cross-sectional dimensions preferably in a rolling mill of the type described and claimed in my co-pending application, Serial No. 8,322, filed February 26, 1935, is wound upon a reel **1** rotatably supported at **2** by the horizontal arm **3**. The arm **3** is secured at its left hand end to the base **4** and is supported at its right hand end by the spring **3'** which extends downwardly from the table **6**. A friction braking device **7** is mounted on the bar

5 and is adapted to be spring pressed into engagement with the side of the reel 1 and exert a predetermined braking effect thereon in order to prevent the reel 1 from overrunning and unwinding the ribbon too fast.

The ribbon 8, after leaving the reel 1, passes over the idler guide pulley 9 which is rotatably mounted on the end of an arm 10. This arm 10 is pivotally supported at 11 on the outer end of the arm 3 and a spring 12 extends from the bottom end of the arm 10 to the inner end of the arm 3. It will be seen from the above description that the idler roll 9 is resiliently mounted and that any shocks or jerks upon the ribbon 8 as it is fed into the machine will be absorbed by the spring 12. A pin 13, mounted on the lower end of the bar 5, serves as a stop for the arm 10 and limits the movement of the roller 9 in clockwise direction.

After the ribbon 8 leaves the roller 9 it passes upwardly over another guide roller 14 carried by the lever arm 15 which is pivotally mounted at 16 on a bracket 17 supported on the base 6 of the machine. The bracket 17 is preferably made so that it is susceptible to vertical adjustment to accommodate different sizes of feed rolls for rolling various ring sizes, the upper portion being adapted to slide on the supporting rod 18 and be held in the desired position by a set screw or other suitable means 19. A box B filled with waste or the like and saturated with a suitable lubricant may be mounted on the lever 15 in the line of travel of the ribbon. The ribbon passes through the box and is lubricated by contact with the waste. This facilitates the passage of the ribbon through the various rolls and guides.

The pivot 16 forms the fulcrum of the lever 15. On the long end of this lever, beyond the roller 14, is mounted an adjustable weight 20 and the feed roll 21 is rotatably mounted on the short end of the lever 15. A driving gear 22 is secured to the roll 21 and is rotatable therewith. This gear 22 meshes with the large driving gear 23 which is rotatably mounted on the shaft which forms the pivot 16 for the lever 15. Another driving gear 24 meshes with the gear 23 and is rotatably mounted on shaft 25 which is carried by the adjustable bracket 26.

The top feed roll 27 is mounted on the end of the shaft 28 and is driven thereby. The driving gear 29 is also carried by the shaft 28 and is rotatable with the roll 27. This gear 29 meshes with the large gear 24 and it will be seen that the bottom feed roll 21 will be driven with the top feed roll 27 through the gears 29, 24, 23, and 22. Inasmuch as the gears 29 and 22 and the gears 24 and 23 are identical, the rolls 21 and 27 will rotate at exactly the same speed. The weight 20 on the end of the lever arm 15 will maintain the desired pressure on the ribbon 8 as it passes between the rolls 21 and 27. By moving the weight 20 toward or away from the fulcrum 16 the pressure exerted on the ribbon by the feed rolls can be varied. As it is desired to obtain the greatest possible feeding force without distorting or reducing the cross-sectional dimensions of the ribbon, it is important that the frictional engagement between the feed rolls 21 and 27 and the ribbon 8 be maintained at a point just before distortion of the ribbon occurs.

The bracket 26 carries the feed roll 24 and is supported at its lower end by the bearing bushing 30 (Fig. 2) which forms one of the bearings for the shaft 28. This bracket 26 is slotted at 26' and a bolt 31 extends through the slot 26'. This bolt 31 is secured to the bracket 32 which in turn is mounted on the head frame 33 of the machine.

The bracket 26 may be given a certain degree of rotational movement about its support on the bearing bushing 30, and may be clamped in the desired position by the nut on the end of the bolt 31. In this way the position of the gear 24 relative to the gear 23 can be adjusted to compensate for any change in the vertical position of the pivot pin 16 and the gear 23 to take care of different sizes of feed rolls 21 and 27.

As is best seen in Figure 2, the shaft 28 is supported by bearings in the upwardly extending front arm 34 of the top frame 33 and the upwardly extending rear arm 35. The end of the shaft 28, which projects behind the arm 35, carries the clutch disc 36 which is keyed or otherwise secured to the shaft 28. As will later appear, this clutch disc 36 is provided with a notch in its periphery which is effective in securing the desired intermittent rotational movement of the shaft 28.

Another clutch disc member 37 is rotatably supported on the shaft 28. The disc 36 has a friction face 36' and the disc 37 has a similar friction face 37'. These frictional surfaces are held in engagement by the spring 38, which is maintained in compression between the ball thrust bearing 39 and the washer 40, which is held on the end of the shaft 28 by lock nuts 41. The outer periphery of the friction disc 37 is formed with gear teeth which engage a gear 42 on the drive shaft 43. The gear or disc 37 is smaller than gear 42 for reasons which will later appear. Shaft 43 is secured to the shaft 44 by the coupling 45. In the illustrated embodiment of my invention the driving motor 46 is mounted at the bottom of the base 4 and the driving connection to the shafts 44 and 43 is effected through the belt 47 and suitable gearing in the gear box 48.

In the operation of my improved ring-forming machine it is preferable to rotate the driving rolls 21 and 27 intermittently, stopping the rolls for a short time between each complete revolution thereof in order to permit the cut-off operation to take place while the ribbon is stationary. This movement is accomplished by the mechanism which is best seen in Figures 2 and 4. The clutch, which is made up of the discs 36 and 37 and their friction faces 36' and 37', is continuously held in engagement by the spring 38 and, unless some outside force is interposed, the shaft 28 would be continuously rotated by the shaft 43 which is continuously driven from the motor 46. In order to cause the shaft 28 and the feed rolls 21 and 27, driven thereby, to rotate intermittently, I form a notch 49 in the periphery of the disc 36 (see Fig. 4). Supported on a suitable bracket 50, adjacent the disc 36, is a bracket 51. A bell crank lever having arms 52 and 52' is pivotally mounted at the top of the bracket 51. The arm 52' extends downwardly through a slot 53 in the bracket 51 and engages a latch pin 54 which is slidably supported in a suitable slot in the base of the bracket 51.

As is seen in Figure 4, the end of the latch pin 54 is adapted to fit nicely in the notch 49 in the rim of the disc 36. When in this position movement of the disc 36 and the shaft 28 to which it is secured, is prevented and the clutch faces 36' and 37' will slip. As soon as the pin 54 is withdrawn from the notch 49 the disc 36 and the shaft 28, together with the feed rolls 21 and 27, will immediately start to revolve, and the feeding of the ribbon will be continued. The movement of the pin 54 is controlled by the cam 55 carried by the shaft 43. This cam is engaged by a roller 56 carried at the outer end of the bell crank arm

52. The spring 57, disposed in the slot 53, exerts a force tending to move the arm 52' to the right and to cause the latch pin 54 to move into the slot 49.

The cam 55 is so contoured and positioned that the latch 54 will ride upon the peripheral surface of the disc 36 during the major portion of a revolution thereof but is permitted to drop into the notch 49 when the notch and latch pin become aligned. After the latch 54 has remained in notch 49 a time sufficient to permit the cutting-off operation to be completed, as will be explained later, a projection 55' on cam 55 pushes the arm 52 downwardly causing the arm 52' to move to the left and withdrawing the latch pin 54 from the notch 49. When this occurs the disc 36 immediately starts to rotate due to the continuous engagement of the clutch faces 36' and 37' and the notch 49 will move out of alignment with the pin 54. As soon as this initial movement of the disc 36 has taken place, the cam 55 will permit the pin 54 to again be pushed by spring 37 into engagement with the periphery of the disc 36 upon which it will continue to ride until the notch 49 comes around again, when the above described cycle will be repeated.

It will be seen from the above, that the feed rolls 21 and 27 will be caused to rotate through one complete revolution, stop for a predetermined length of time and then continue their rotation for another revolution, this cycle being repeated so long as the driving motor 46 is operated.

After the ribbon 8 passes between the feed rolls 21 and 27 it enters the guide 57a. As is seen in Figure 5 this guide 57a is formed with a rectangular aperture 57' which guides the ribbon and holds it in the desired plane. As the ribbon leaves the end of the guide 57a it passes around the slotted guide roll 58. As is best seen in Figure 7 roll 58 is vertically adjustable to properly align the ribbon before it enters the bending section of the machine. The groove 59 in the roll 58 is preferably just slightly wider than the thickness of the ribbon and just slightly deeper than the width of the ribbon so that it prevents the ribbon from twisting as it is bent into ring form. From the roll 58 the ribbon passes through a slot 60' (see Fig. 8) in the end of the first bending bar 60. A pin 61, preferably of hardened steel or the like, extends across the slot 60' and engages the outer edge of the ribbon. The end of the bar 60 opposite the pin 61 is provided with a micrometer adjustment indicated at 62 so that the pin 61 can be accurately positioned and moved toward or away from the center of the roll 58. By adjusting the position of the bar 60 and the pin 61 to impose the proper bending force on the ribbon 8 a ring of the desired diameter can be formed. This bar 60 and pin 61, with their associated parts, may be said to constitute a primary bending means. However, this single forming operation, as has been pointed out above, will not produce a series of rings which are consistently of the same diameter due to variations in the ribbon stock. In order to overcome these irregularities a second forming bar 63 is provided. This bar extends through and is mounted in the frame 64 in the same manner as and adjacent to the bar 60. The end of bar 63 is also slotted at 63' and provided with a pin 65. As is clearly seen in Figures 3 and 8 the ribbon 8 passes between the pin 65 and the bottom of the slot 63'. The bar 63 is so adjusted by means of the micrometer adjustment indicated at 66 that the pin 65 pulls outwardly on the ribbon which has previously been bent inwardly by the pin 61. The bar 63 and pin 65, with their associated parts, may be said to constitute a secondary or re-bending means. By properly adjusting the bars 60 and 63 and their pins 61 and 65 by means of their micrometer mountings in the frame 64, the ribbon 8, which is fed by the feed rolls 21 and 27, would be formed into a continuous spiral or series of rings of uniformly accurate diameter in in the absence of any cut-off mechanism.

In order to form the bent ribbon into separate rings which are adaptable for use in laminated piston rings I provide a cut-off mechanism which cuts off each complete ring as it is formed. This cut-off mechanism includes an anvil member 67 (see Fig. 6) which supports the bottom cutting knife 68. The upper cutting knife 69 cooperates with the bottom knife to shear the ribbon and is carried by a plunger 70 which extends through a suitable bushing 71 in the adjustable frame 72 and is provided at its upper end with a flanged headed screw 73 on which is mounted an adjustable disc 74. A spring 75 is held in compression between the disc 74 and the top end of the bushing 71. This spring tends to maintain the cutter 69 in its lifted position, as seen in Figure 6. A cutter operating shaft 76 (see Figs. 3 and 6) is rotatably supported at its ends in bearings in the bracket member 77 which is mounted on the frame of the machine. An eccentrically disposed cam member 78 is keyed to the shaft 76 directly above the head of the screw 73 and is adapted to engage the head of said screw. Arm 78' (see Fig. 1) is keyed to the shaft 76 adjacent the rear bearing of the bracket 77. This arm 78' is connected to the arm or lever 79 by an adjustable link 80 which has pivotal connections at the ends of the arms 78' and 79. Lever 79 is pivoted at its opposite end to the bracket 32 and carries a follower roller 81 which rides in the cam groove 82 of the cam 83. The cam 83 is secured to the front end of the shaft 43 and the cam contour 82 is such that the lever 79, link 80 and lever 78' will be operated once during each revolution of the shaft 43 and the cam 83 to give an oscillatory movement to the shaft 76.

Referring to Figure 6, this oscillatory movement of shaft 76 will be first in counter clockwise direction and then in clockwise direction. During the counter clockwise movement of shaft 76 cam 78 will push the plunger 70 and cutter 69 down, cutting off the stock between the cutters 69 and 68. As is seen in Figure 3 the ribbon which has been formed into a ring slides over the cutting edge of the cutter 68 as it is being fed through the machine and thus is always in position to be cut off during the cutting stroke of the knife 69. It will be understood that it is necessary to time the movement of the cutter 69 so that it occurs while the latch 54 is in the notch 49 and the feed rolls 21 and 27 and ribbon 8 are stationary.

The cams 55 and 83 are mounted on the same shaft 43 and therefore the feed rolls will be stopped and the cut-off mechanism actuated in definite timed relation. As is seen in Figure 4 the gear 42 is larger than the gear 37. In designing the machine just enough more teeth are provided on the gear 42 than on the gear 37 to permit of a complete stop and cut-off operation. The gear 37, the disc 36 and the shaft 28 will rotate together for a complete revolution and then the shaft 28 and disc 36 will stop while the gear 37 and gear 42 continue to rotate

through the angular distance necessary to effect a complete stop and cut-off operation. As soon as the cut-off stroke is completed the latch 54 will be withdrawn from the notch 49 and the disc 36 and shaft 28 will be immediately picked up by the clutch and the stock feeding movement resumed.

It will be understood that by varying the sizes of the feed rolls 21 and 27, rings of different diameter may be formed. The circumference of the rolls 21 and 27 should be substantially the same as the length of the ribbon making up a single ring. The position of the cut-off mechanism can be adjusted by moving the frame 72 and the cam 78 along the shaft 76. Likewise the position of the bending pins 61 and 65 can be adjusted by the micrometer screws in order to accommodate rings of a considerable range of sizes.

As is seen in Figures 3 and 5 the guide member 57a is mounted in cylindrical bushings 85 which are carried in brackets 86 on the supporting frame 87. The guide 57a may be given a rotary movement by adjusting the set screws 88 and 89 and its vertical position may be adjusted by the set screws 90 and 91. These adjustments are provided so that the guide 57a can be positioned to receive the ribbon from different sizes of feed rolls and also so that it can be adjusted to properly deliver the ribbon to the guide roll 58 and the bending pins 61 and 63.

As is seen in Figure 7 the guide roll 58 is mounted on a vertical shaft 92 which fits within a sleeve 93. The vertical position of the sleeve 93 and the shaft 92 can be regulated by the screws 94 and 95, screw 94 having threaded engagement with the frame and screw 95 being adapted to abut against the frame.

In the operation of my improved ring forming machine it is merely necessary to place a reel of ribbon on the arm 3 and feed the ribbon up over the guide rolls 9 and 14 and between the feed rolls 21 and 27. Preferably the ribbon is formed slightly thinner on one edge than on the other and the reel is so arranged that the thin edge of the ribbon is toward the front as is seen in Figure 1. The surface of the feed rolls 21 and 27 may be contoured to fit this tapered section ribbon and the top roll 27 is provided with a flange 27' (Fig. 2) to prevent the ribbon from running off the rolls. The desired frictional engagement is obtained between the ribbon and the rolls by the action of the adjustable weight 20 on the lever arm 15. As both the top and bottom feed rolls 21 and 27 are driven the maximum driving effort can be produced with a minimum pressure on the ribbon and in this way the ribbon can be fed without distorting its cross-sectional dimensions. After it leaves the feed rolls the ribbon passes through the guide 57a. In starting the machine in operation the end of the ribbon is bent by hand around the guide roll 58, past the primary bending pin 61 and between the secondary bending pin 65 and the inner end of the groove 63' in the bar 63. After this initial manual bending the motor 46 may be started and the ribbon will be fed by the feed rolls and bent by the pins 61 and 65 into a ring of accurate diameter. As soon as a complete ring has been formed the feed rolls will stop and the cut-off knives will act to sever the ring. The feed rolls will then again start and feed through the machine a length of ribbon sufficient to form one complete ring. When this has been done the machine will again stop and the cut-off operation will be repeated. This cycle will be continued until the roll of ribbon is exhausted or the driving motor is stopped.

By forming the ribbon slightly thinner on the inside edge than on the outside edge the resulting ring will be of uniform thickness across its entire width. This is due to the thickening of the metal on the inside of the neutral axis of the ring due to the compression which takes place during the forming operation and the reduction in thickness at the outside due to the tensile force exerted thereon. By supplying a properly shaped ribbon the finished rings will be of substantially uniform thickness and, due to my improved forming method, each ring will be of uniform diameter within very close limits regardless of variations in the characteristics of the ribbon, etc.

Although I have described in considerable detail the illustrated embodiment of a machine for carrying out my improved method it will be understood by those skilled in the art that many variations and modifications may be made in the specific apparatus illustrated and described. Other types of devices might be provided for bending and cutting off the ribbon in accordance with my improved method. I do not therefore wish to be limited to the specific form herein described and illustrated but claim as my invention all embodiments thereof coming within the scope of the appended claims.

I claim:

1. The method of forming a ring from a metal wire or the like which includes the steps of moving the ribbon in the direction of its length, imposing a primary bending force on the moving ribbon whereby the moving ribbon will be bent to form a ring, imposing a second bending force on said moving ribbon opposite to said primary force whereby the ribbon will assume a ring form of diameter different from that of the primary bend.

2. The method of forming a ring of wire or the like which includes the steps of moving the wire in the direction of its length, bending the moving wire to form a ring, and then while continuing said bending of the moving wire, re-bending the moving wire to form a ring of different diameter, said re-bending taking place before a complete ring is formed.

3. The method of forming a ring of wire or the like which includes the steps of moving the wire in the direction of its length, bending the moving wire to form a ring, and then, while continuing said bending of the moving wire, re-bending the moving wire to form a ring of different diameter, said re-bending being in a direction opposite to the first bending.

4. The method of forming a metal ribbon or the like into ring form which includes the steps of first bending the ribbon to form a ring of one diameter and then re-bending the ribbon to form a ring of another diameter, said re-bending being effected on one part of the ribbon while the first bending is being effected on another part of the ribbon and before a complete ring has been formed by said first bending.

5. The method of forming rings of metal ribbon, wire or the like which includes the steps of moving the ribbon in the direction of its length, bending the moving ribbon to form a ring of a predetermined diameter, and re-bending the moving ribbon, at a point adjacent said first bending while continuing said first bending, to

form a ring of a diameter between 5% and 15% different from the diameter first formed.

6. The method of forming rings of metal ribbon, wire or the like which includes the steps of moving the ribbon in the direction of its length, bending the moving ribbon to form a ring of a predetermined diameter, re-bending the moving ribbon to form a ring of a diameter between 5% and 15% different from the diameter first formed, stopping the movement of and severing the ribbon as each ring is formed and continuing said forming and severing operations in a repeating cycle.

7. The method of forming rings of metal ribbon, wire or the like which includes the steps of moving the ribbon in the direction of its length, bending the moving ribbon to form a ring of one diameter, re-bending the moving ribbon to form a ring of another diameter, and stopping the movement of and severing the ribbon as each ring is formed.

8. The method of forming rings of metal ribbon, wire or the like which includes the steps of moving the ribbon in the direction of its length, bending the moving ribbon to form a ring of one diameter, re-bending the moving ribbon to form a ring of another diameter, stopping the movement of and severing the ribbon as each ring is formed, and continuing said forming and severing operations in a repeating cycle.

9. The method of forming rings of metal ribbon or the like, of greater cross-sectional width than depth, which includes the steps of moving the ribbon in the direction of its length, bending the moving ribbon to form a ring while maintaining the cross-sectional width substantially in a plane extending radially of the ring being formed, re-bending the moving ribbon to form a ring of different diameter than that first formed and severing the ribbon into completed rings.

10. The method of forming rings of metal ribbon or the like which includes the steps of moving a ribbon of greater cross-sectional width than depth and greater cross-sectional depth at one edge than at the other in the direction of its length, bending the moving ribbon to form a ring while maintaining the cross-sectional width substantially in a plane extending radially of the ring being formed, the edge of the ribbon of least depth being disposed to the inside of the ring being formed, and re-bending the moving ribbon to form a ring of different diameter than that first formed.

11. In a machine for forming rings or the like, the combination of a pair of driven feed rolls, means for guiding a wire or the like to said feed rolls, primary wire bending means interposed in the path of the wire leaving the feed rolls, secondary wire bending means positioned to bend said wire after said primary bending means, cut-off mechanism adapted to sever the wire after it has been bent by said secondary bending means, means for causing said feed rolls to have intermittent rotation and means for operating said cut-off mechanism to sever the wire when the feed rolls are stationary.

12. In apparatus for forming rings from wire or the like, a pair of feed rolls adapted to feed the wire in the direction of its length, primary wire bending means interposed in the path of the wire after leaving said feed rolls and adapted to deflect the wire sufficiently to cause it to take a permanent set and be bent into ring form, and secondary wire bending means interposed in the path of the wire leaving said primary bending means, said secondary bending means being adapted to re-bend the wire into a ring of different diameter than that formed by said primary bending means.

13. In apparatus for forming rings from wire or the like, a pair of feed rolls adapted to feed the wire in the direction of its length, primary wire bending means interposed in the path of the wire after leaving said feed rolls and adapted to deflect the wire sufficiently to cause it to take a permanent set and be bent into ring form, secondary wire bending means interposed in the path of the wire leaving said primary bending means, said secondary bending means being adapted to re-bend the wire into a ring of different diameter than that formed by said primary bending means, and independent adjusting means for adjusting said primary and secondary bending means to vary the diameter of the rings formed thereby.

14. In apparatus for forming rings from wire or the like, a pair of feed rolls adapted to feed the wire in the direction of its length, primary wire bending means interposed in the path of the wire after leaving said feed rolls and adapted to deflect the wire sufficiently to cause it to take a permanent set and be bent into ring form, secondary wire bending means interposed in the path of the wire leaving said primary bending means, said secondary bending means being adapted to re-bend the wire into a ring of different diameter than that formed by said primary bending means, and independent adjusting means for adjusting said primary and secondary bending means to vary the diameter of the rings formed thereby, said secondary bending means being positioned to re-bend said ribbon before a complete ring is formed due to the action of said primary bending means.

15. In apparatus for bending wire ribbon or the like into ring form, a pair of feed rolls, resilient means for maintaining said feed rolls in feeding engagement with the ribbon, driving means for rotating said rolls together, said driving means including means for intermittently stopping the rotation of said rolls for a predetermined period, means for bending the ribbon into ring form, means for severing the ribbon to separate the completed rings, and cam means for controlling said roll stopping means and said ribbon severing means whereby said ribbon will be severed when said rolls and ribbon are stationary.

16. In apparatus for bending wire ribbon or the like into ring form, a pair of feed rolls, adjustable resilient means for maintaining said feed rolls in feeding engagement with the ribbon, driving means for rotating said rolls together, said driving means including means for intermittently stopping the rotation of said rolls for a predetermined period, means for bending the ribbon into ring form, means for severing the ribbon to separate the completed rings, and cam means for controlling said roll stopping means and said ribbon severing means whereby said ribbon will be severed when said rolls and ribbon are stationary, said cam means being adapted to be actuated by said roll driving means.

17. In apparatus of the class described, a pair of rotatable feed rolls adapted to feed a wire ribbon in the direction of its length, means for varying the pressure of said rolls on the ribbon, means for adjusting the roll shafts toward or away from each other whereby rolls of different

diameters may be used, and a bending bar having a slotted end and a pin extending across the slot, said slot and pin being adapted to guide and bend the ribbon into ring form as it is fed by said rolls.

18. In apparatus of the class described, a pair of rotatable feed rolls adapted to feed a wire ribbon in the direction of its length, means for varying the pressure of said rolls on the ribbon, means for adjusting the roll shafts toward or away from each other whereby rolls of different diameters may be used, a bending bar having a slotted end and a pin extending across the slot, said slot and pin being adapted to guide and bend the ribbon into ring form as it is fed by said rolls, and a second bending bar having a slotted end and a pin extending across the slot, said second slot and pin being adapted to guide and re-bend the ribbon into a ring of different size than that formed by said first bending bar.

19. In apparatus of the class described, a pair of rotatable feed rolls adapted to feed a wire ribbon in the direction of its length, means for varying the pressure of said rolls on the ribbon, means for adjusting the roll shafts toward or away from each other whereby rolls of different diameters may be used, a bending bar having a slotted end and a pin extending across the slot, said slot and pin being adapted to guide and bend the ribbon into ring form as it is fed by said rolls, a second bending bar having a slotted end and a pin extending across the slot, said second slot and pin being adapted to guide and rebend the ribbon into a ring of different size than that formed by said first bending bar, and means for adjusting the positions of said bending bars to vary the size of the rings formed thereby.

20. The method of forming a metal ribbon or the like into ring form which includes the steps of moving the ribbon in the direction of its length, bending said moving ribbon into arcuate form and simultaneously re-bending said moving ribbon in the opposite direction to said first bending into a ring having a greater radius than said arcuate form.

21. The method of forming a metal ribbon or the like into ring form which includes the steps of moving the ribbon in the direction of its length, bending said moving ribbon into arcuate form, re-bending said ribbon into a ring having a greater radius than said arcuate form, stopping the movement of said ribbon and severing the completed ring.

22. In apparatus for bending wire ribbon or the like into ring form, a feed roll, means for maintaining said feed roll in feeding engagement with the ribbon, means for driving said feed roll, said driving means including means for intermittently stopping the rotation of said roll for a predetermined period, means for bending the ribbon into ring form, means for severing the ribbon, and means for controlling said roll stopping means and said ribbon severing means whereby said ribbon will be severed while said roll and ribbon are stopped.

23. In apparatus of the class described, a feed roll for feeding a wire or the like in the direction of its length, primary bending means adapted to give the wire while moving an arcuate form and secondary bending means adapted to re-bend said moving wire into an arcuate form of different radius from that imparted by said primary bending means, said secondary bending means being adapted to operate upon said wire simultaneously with said primary bending means.

24. In a ring forming machine, a rotatable feed roll adapted to feed a wire ribbon in the direction of its length, a primary bending bar interposed in the path of the ribbon, means carried by said primary bending bar for guiding and bending the ribbon into arcuate form, a secondary bending bar interposed in the path of the ribbon adjacent said primary bending bar, means carried by said secondary bending bar for guiding said ribbon and bending said ribbon in a direction opposite to that of said first bending means whereby rings of accurate and uniform diameter will be formed.

25. In a ring forming machine, a rotatable feed roll adapted to feed a wire ribbon in the direction of its length, a primary bending bar, means carried by said primary bending bar for guiding and bending the ribbon into arcuate form, a secondary bending bar adapted to act upon said ribbon simultaneously with said primary bending bar, means carried by said secondary bending bar for guiding said ribbon and bending said ribbon in a direction opposite to that of said first bending means whereby rings of accurate and uniform diameter will be formed, and means for adjusting the position of said primary and secondary bending means.

26. In a ribbon bending device of the type described, a feed roll, a bending device, and adjustable ribbon guiding means disposed between said feed roll and said bending device, said guide means including a member having an aperture through which the ribbon may pass, cylindrical trunnion means for supporting said member, a bracket for said trunnion and means for adjusting the vertical and horizontal positions of said bracket whereby said apertured member may be adjusted to direct the ribbon from said feed roll to said bending device.

27. In apparatus of the type described, a feed roll, a shaft supporting said feed roll, a clutch disc having a friction face mounted on said shaft and secured thereto for rotation therewith, a cooperating clutch disc and friction face rotatably supported on said shaft, means for holding said friction faces in engagement, means for driving said cooperating clutch disc whereby said shaft and feed roll may be driven and means for locking from rotation the clutch disc which is secured to said shaft.

28. In apparatus of the type described, a feed roll, a shaft supporting said feed roll, a clutch disc having a friction face mounted on said shaft and secured thereto for rotation therewith, a cooperating clutch disc and friction face rotatably supported on said shaft, means for holding said friction faces in engagement, means for driving said cooperating clutch disc whereby said shaft and feed roll may be driven, means for locking from rotation the clutch disc which is secured to said shaft, and means associated with the means for driving said cooperating clutch disc for intermittently causing said first named clutch disc to be locked from rotation.

29. In apparatus of the type described, a feed roll, a shaft supporting said feed roll, a drive shaft, means for continuously rotating said drive shaft, friction clutch means for effecting driving engagement between said roll shaft and said drive shaft, spring means for maintaining said clutch in constant engagement, a latch pin adapted when in one position to lock said roll

shaft from rotation, and means operated by said drive shaft for moving said latch pin out of locking position to permit rotation of said roll shaft and roll.

30. In apparatus for forming rings from metallic ribbon or the like, means for feeding the ribbon in the direction of its length, primary bending means interposed in the path of the ribbon and adapted to deflect the ribbon sufficiently to cause it to take a permanent set and be bent into ring form, and secondary ribbon bending means interposed in the path of the ribbon as it leaves said primary bending means, said secondary bending means being adapted to re-bend said ribbon into a ring of different diameter than that formed by said primary bending means.

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