May 3, 1960 T. GROB ET AL 2,934,980

METAL ROLLING MACHINE

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FIG. 1.

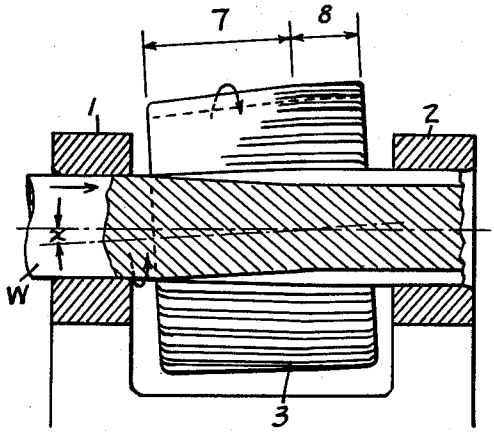


FIG. 2.

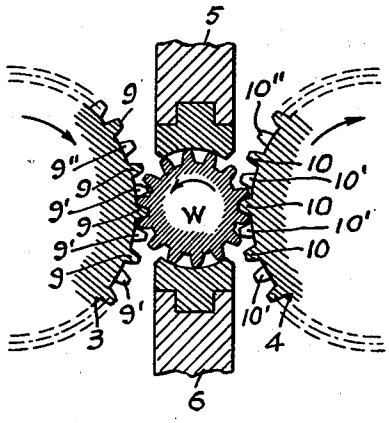


FIG. 3.

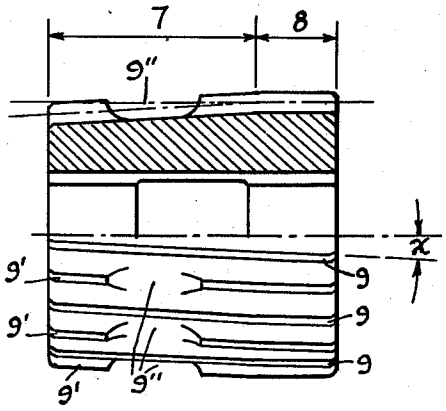
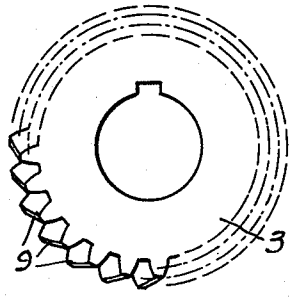


FIG. 4.



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FIG. 5.

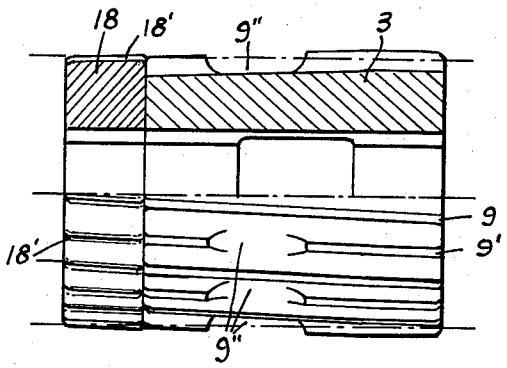


FIG. 6.

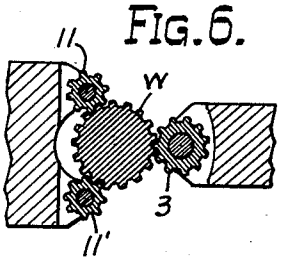


FIG. 7.

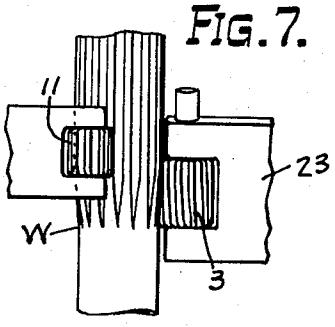


FIG. 9.

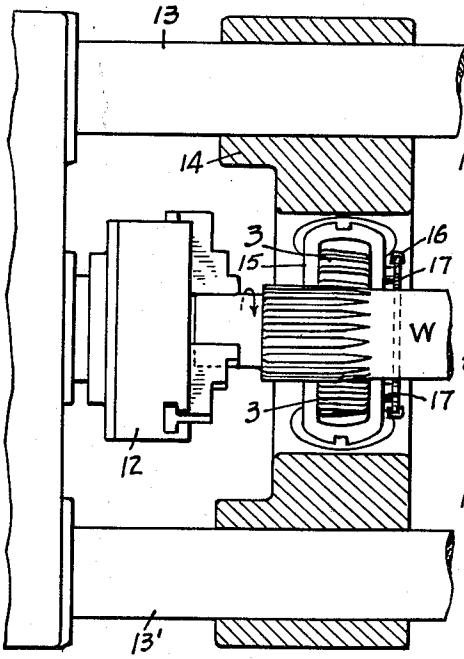
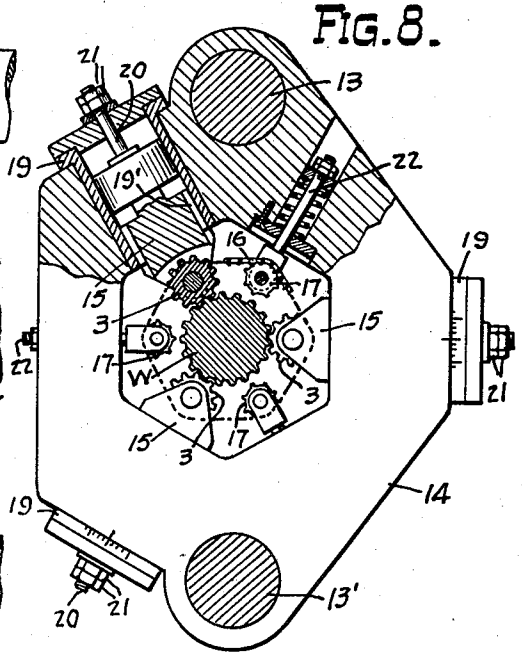


FIG. 8.



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METAL ROLLING MACHINE

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2 Claims. (Cl. 80—23)

This invention relates to the art of metal rolling and particularly to a rolling method and apparatus for the chipless production of spur and helical gears, multiple splines and the like.

Prompted by the success had in the chipless production of screw threads by rolling methods heretofore used, various attempts have been made to utilize such methods in the production of articles of the type above named, but without success. It would appear that the higher lead angles of the teeth or ribs, characteristic of such articles, introduce problems heretofore unsolved and render inapplicable those thread rolling methods heretofore known.

One object of the present invention is to provide a rolling method and apparatus specially adapted for the accurate production of multiple ribs and grooves of high lead angle on cylindrical blanks. This we have accomplished by passing the blank lengthwise between and in rolling engagement with a set of spaced forming rollers whose axes of rotation are slightly tilted relative to the blank axis so that the desired lengthwise advance of the blank is induced by the rolling engagement of the rollers with the blank, and whose transverse contours vary progressively at successive points in the length of the rollers in a manner to determine the progress of the shaping action.

It has been found particularly favorable for the material structure of each tooth being formed if it is not laterally confined by and between the sides of adjacent forming ribs whose action causes the tooth to expand or rise outwardly as it is being formed. As a result of such confinement, undesirable folds develop in the tips of the teeth, as in some thread rolling operations.

Another object of the present invention is to avoid such folds. It has been found that this objectionable condition may be avoided entirely or for the most part by a forming action which causes each instant tooth section under treatment to be pressed up from the right and from the left alternately so that the material thereof may deviate slightly about a tilt point located in the vicinity of the root of the tooth. In the apparatus hereinafter described this is accomplished by providing recesses or interruptions in alternate forming ribs, particularly in the zone of maximum deforming action.

Other more specific objects and advantages will appear, expressed or implied, from the following description of an exemplary method and apparatus wherein the principles of the present invention are advantageously utilized.

For purposes of explanation the invention will be described as applied to the chipless production of spur gears whereby teeth of finished form are first developed, as ribs on cylindrical blanks of considerable length, and which are later divided to provide gear units of desired face width; although, as above noted, the invention may be advantageously employed in the production of various other articles, particularly those having multiple ribs and grooves whose lead angles are high.

In the accompanying drawings:

Figure 1 is a fragmentary longitudinal sectional view illustrating the relative positions of blank and forming roller in a metal rolling machine embodying the present invention.

Fig. 2 is a fragmentary transverse sectional view including an alternative form of blank guide.

Fig. 3 is a side view, partly in section, of a forming roller such as shown in Figs. 1 and 2, but equipped with interrupted alternate forming ribs.

Fig. 4 is a front end view of a forming roller.

Fig. 5 is a view similar to Fig. 3 illustrating a forming roller equipped with a preliminary blank-gripping roller.

Fig. 6 is a transverse section and Fig. 7 a plan view of modified form of apparatus involving the use of a single roller of the form shown in the preceding figures.

Fig. 8 is a transverse section and Fig. 9 a longitudinal section of a further modified form of apparatus embodying the invention.

The apparatus shown in Figs. 1 and 2 comprises a pair of laterally spaced rotary forming rollers 3 and 4 supported and driven in the same direction and at the same peripheral speed by means and in a manner well known in the thread rolling art.

The space between the rollers constitutes a working zone through which a cylindrical blank W under treatment is continuously advanced lengthwise while in rolling engagement with both rollers. The blank W is centered and guided in its advance by suitable guides, such as the aligned bushings 1 and 2 disposed fore and aft of the working zone, as indicated in Fig. 1, or such as the spaced guide bars 5 and 6 shown in Fig. 2. The opening in the rear bushing 2 is larger than that of the forward bushing 1 to accommodate the increased diameter of the finished blank as it leaves the working zone, and the guide faces of the bars 5 and 6 of Fig. 2 are slightly inclined relative to each other for the same purpose.

The blank W is continuously rotated during its passage through the working zone as a result of the continuous rolling engagement thereof with the driven rollers; and the lengthwise advance of the blank through the working zone also results from the same rolling engagement, the axes of the rollers being oppositely tilted out of coplanar relation with the axis of the blank for that purpose. The angle of tilt between the axis of roller 3 and the blank axis is indicated at X in Fig. 1, and the angle of tilt between the axis of roller 4 and the blank axis is of equal value but in an opposite direction. The degree of tilt determines the rate of advance of the blank relative to the rotative speed thereof, and it has been found that in most instances the best results are obtained with a small tilt angle, in the neighborhood of two degrees for instance.

To insure that the blank W is rotating and advancing at the proper speed at the time of entry into the working zone, each forming roller may be equipped at its front or leading end with an auxiliary feed roller, such as shown at 18 in Fig. 5, adapted to initially seize the blank and advance it into the working zone. Each of these rollers may be equipped with shallow ribs 18' respectively aligned with the forming ribs on the forming rollers, or the peripheral surface thereof may be knurled or otherwise fashioned to insure gripping engagement with the blank.

Both forming rollers 3 and 4 are substantially identical so that a description of one will suffice for both. Each includes a tapered forming zone 7 and a cylindrical finishing zone 8. Each has formed thereon a circular series of helical forming ribs 9—10 each extending across the peripheral face of the roller and through both zones 7 and 8 thereof, and having a uniform predetermined lead angle, the degree of lead angle used and the shape of the ribs being dependent upon the article to be formed.

For the production of straight spur gears, for instance, the forming ribs are disposed with a lead angle X, as indicated in Fig. 3 equal to angle of tilt of the roller but of opposite hand, so that at each point of engagement of a rib with the blank the rib extends parallel to the blank axis. For the production of helical gears, the forming ribs are disposed with a lead angle greater or less than the lead angle of the teeth of the gear in an amount equal to the angle of tilt of the roller, dependent upon whether the gear to be produced is a helical gear of left or right hand.

For the production of either straight or helical gears those portions of the forming ribs contained in the working zone 8 of a roller are shaped to mesh with those of the finished blank, just as though the roller and finished blank were regular mating gears. The forming rollers are preferably of greater diameter than the finished blank and are equipped with forming ribs in greater number than the teeth in the finished blank, but the rollers may be of the same size or smaller than the finished blank and with ribs in equal or lesser number than the teeth of the finished blank.

The purpose and function of those portions of the ribs 9—10 contained in the finishing zone 8 of the rollers is to calibrate the teeth in the formed blank and to finish the flanks thereof. The purpose and function of those portions of the ribs contained in the forming zone 7 of the rollers is to progressively develop teeth of desired form on the blank by a pure rolling action continuously applied as the blank advances lengthwise through the working zone.

Those portions of the ribs in the forming zone 7 are shaped to merge smoothly with those portions in the finishing zone 8, and they extend forwardly therefrom to the leading end of the roller with their outer edges slightly inclined inwardly, hence the tapered form of roller within zone 7. This may be a straight taper or may be longitudinally curved, either convexly or concavely, in order to properly distribute the forming load under various forming conditions. The taper is such that the external diameter of the leading end of each roller is approximately equal to or slightly less than the pitch circle diameter of the gear-like formation of zone 8; and the axial extent of zone 7 may be varied to best satisfy the requirements of any particular forming operation.

It will be noted that, with the outer edges or crests of the ribs in zone 7 inclined in the manner above described, each is inclined with respect to the blank axis during forming engagement thereof with the blank and in a direction to penetrate deeper into the blank as the forming engagement proceeds lengthwise of the engaged rib. In this connection it will be further noted that by reason of the helical form of each forming rib, no rib ever makes full length pressure contact with the blank at any instant, such contact being limited to a zone of limited length which travels or progresses lengthwise of the rib during each forming engagement of each rib with the blank. By reason of these conditions the shaping pressures are highly concentrated, effective and efficiently applied, and the action is smooth and noiseless.

It will of course be understood that, as the rotating blank advances from left to right (Fig. 1) to and between the forming rollers, it is initially engaged by the inclined portions of the helical forming ribs of both rollers which act successively thereon to initially form therein a succession of recesses circumferentially spaced about the blank. As the advance continues, these recesses are extended and deepened by repeated re-entry of the successive forming ribs thereinto and by the repeated shaping action of the ribs, this process continuing until grooves and intermediate ribs of desired shape are formed.

The inclined portions of the ribs in forming zone 7 of each roller may be variously shaped in a manner best suited for any particular forming operation. They may be shaped like the teeth of a slow tapered spiral bevel gear, as indicated particularly in Fig. 4, or the spaces or grooves between the ribs may be parallel sided in which case the ribs would be longitudinally tapered. Or they might have a shape such as obtained by forming them on a roller initially of cylindrical form but ultimately machined into tapered form by a simple turning operation.

In order to avoid or reduce to insignificance the objectionable fold which commonly develops in the crests of ribs formed by rolling processes of the kind herein involved, suitable recesses, gaps, or interruptions, such as shown at 9'' and 10'', are provided in alternate forming ribs 9' and 10'' of both forming rollers 3 and 4. These recesses are disposed within the forming zone 7 of each roller and particularly in regions of maximum forming action. The use of such recesses of course requires that each roller be equipped with an even number of forming ribs, and it is also important that a rotative phase relation be maintained between the rollers such that an unrecessed rib 9 or 10 of one roller always engages the same groove or tooth space on the blank which was last engaged by a recessed rib 10' or 9' of the other roller. The arrangement is such that throughout the shaping operation, each rib or tooth being formed on the blank is engaged on one side or the other alternately by an unrecessed forming rib 9 or 10 on one or the other roller and that, during each such engagement, each is also engaged on its opposite side by one of the recessed forming ribs 9' or 10' on the same roller. A limited section of each rib or tooth being formed on the blank is thus capable of yielding slightly toward a recessed forming rib throughout the forming action.

In the apparatus thus far described two forming rollers 3 and 4 are employed, although three or more may be used equally spaced about the center of the working zone. When such additional forming rollers are used, the blank is centered and guided thereby, thus eliminating the need for guides such as shown in Figs 1 and 2.

The apparatus shown in Figs. 8 and 9 involves a three roller arrangement in which the forming rollers 3 have all of the structural and functional characteristics of those included in the two roller arrangement of Fig. 1. In this instance, however, the non-travelling blank W is directly rotated by suitable means, such as a chuck 12, the rollers 3 being rotated by the blank as a result of the rolling engagement therewith, and the rollers being carried by a suitable slide 14 for travel lengthwise of the blank. The slide is shown mounted for travel along a pair of rigidly supported spaced guide bars 13—13' extending parallel to the blank.

Each of the forming rollers 3 is shown suitably journalled on the projecting end of a ram 15 guided for axial movement in a circular cage 18 seated for rotary adjustment in the carriage 14. The longitudinal axis of the ram 15 and cage 18 is disposed radially of the working zone between the rollers, and the ram is held against relative rotation with respect to the cage 18 by splines 19 or the like. The desired angular tilt between each roller 3 and the blank is obtainable by rotative adjustment of the cage 18, and each roller is held in proper working relation with respect to the blank by hydraulic pressure supplied to the outer end of the cage. A tail rod 20, extending through the outer end of the cage 18 and having nuts 21 threaded thereon, provides an adjustable limiting stop for determining the proper working position of each roller with respect to the blank.

The arrangement is such that upon relieving the hydraulic pressure from the outer ends of the cages 18 the several rollers 3 may be radially withdrawn sufficiently to admit entry of a blank therebetween and into the driving chuck 12, and that by re-application of the hydraulic pressure the rollers may be advanced in proper working position. After each forming operation, the rollers may be again withdrawn to permit withdrawal of the blank.

At the start at least of each forming operation it is

desirable to synchronize the rotation of the three rollers, so as to insure that the recesses initially formed in the blank be accurately spaced about the blank, and to insure re-entry of the forming ribs into the recesses thus formed. This is accomplished in this instance by an endless chain **16** trained about a series of sprockets **17**. Some of these sprockets are connected to and rotatable with the rollers **3** while others are idler sprockets yieldably supported to maintain tension in the chain. These other sprockets are shown supported on spring loaded rods **22** mounted and guided for lengthwise movement in the slide **14**.

An arrangement is shown in Figs. 6 and 7 in which a single forming roller **3** is used having all of the structural and functional characteristics of that shown in Fig. 1. It is shown journalled in a suitable support **23** and engaged with a blank W held in proper working relation therewith by a pair of laterally spaced guide rollers **11—11'** which cooperate with the forming roller **3** to guide and center the blank. The guide rollers have teeth shaped to mesh with the tooth-like ribs formed by the forming roller. In this apparatus the blank is preferably mechanically rotated and all three rollers are rotated by the blank and mounted for travel, as a unit, along the blank, in much the same manner as in the apparatus shown in Figs. 8 and 9.

Various changes may be made in any of the embodiments of the invention hereinabove specifically described without departing from or sacrificing the advantages of the invention as defined in the appended claims.

We claim:

1. In a metal rolling machine the combination of a pair of forming rollers disposed in spaced relationship to receive the cylindrical blank lengthwise therebetween and in rolling engagement therewith, the axis of rotation of said rollers being tilted relative to the axis of the engaged blank to effect a relative axial advance between said blank and rollers by the rolling engagement therebetween, each of said rollers having an even numbered series of circumferentially spaced parallel forming ribs thereon successively engageable with the blank during rotation of the roller, each of said ribs having a blank penetrating portion longitudinally inclined toward the axis of the blank during engagement thereof with the blank to effect a progressively deeper penetration thereof in the blank during the engagement thereof with the blank, the sides of alternate ribs of each forming roller having interrupted portions whereby the material of the blank engaged by the adjacent uninterrupted rib is permitted unimpaired lateral displacement within the range of the interrupted side portions of the adjacent ribs, and the pair of forming rollers being arranged in phase relationship such that the uninterrupted ribs of one roller successively engage the sides of the teeth formed in the blank which were disposed adjacent the interrupted ribs of the preceding roller to thereby overcome the formation of folds at the tip of the teeth which normally result when movement of the material of the blank is confined between uninterrupted adjacent ribs.

2. In a metal rolling machine the combination of a pair of forming rollers disposed in spaced relationship to receive a cylindrical blank lengthwise therebetween and in rolling engagement therewith, each of said rollers having a longitudinal tapered forming portion and a cylindrical finishing portion coaxial therewith, the axis of rotation of said rollers being oppositely tilted relative to the axis of the engaged blank to effect relative axial advance between said blank and rollers by the rolling engagement therebetween, each of said rollers having an even numbered series of circumferentially spaced parallel forming ribs thereon successively engageable with the blank during rotation of the rollers, each of said ribs having a blank penetrating portion longitudinally inclined toward the axis of the blank during engagement thereof with the blank to effect a progressively deeper penetration thereof in the blank during its engagement therewith, the sides of alternate ribs of each forming roller having interrupted portions whereby the material of the blank engaged by the adjacent uninterrupted rib is permitted unimpaired lateral displacement within the range of the interrupted side portions of the adjacent ribs, and the forming pair of forming rollers being arranged in phase relationship such that uninterrupted ribs of one roller successively engage the sides of the teeth formed in the blank which were disposed adjacent the interrupted ribs of the preceding roller to thereby overcome the formation of folds at the tip of the teeth which normally result when movement of the material of the blank is confined between uninterrupted adjacent ribs in the forming portion of the roller, said finishing portion of the roller serving to complete the formation of the teeth.

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