Dec. 1, 1936. J. M. CHRISTMAN 2,062,699

BURNISHING APPARATUS

Filed May 4, 1934 2 Sheets-Sheet 1

FIG. 1.

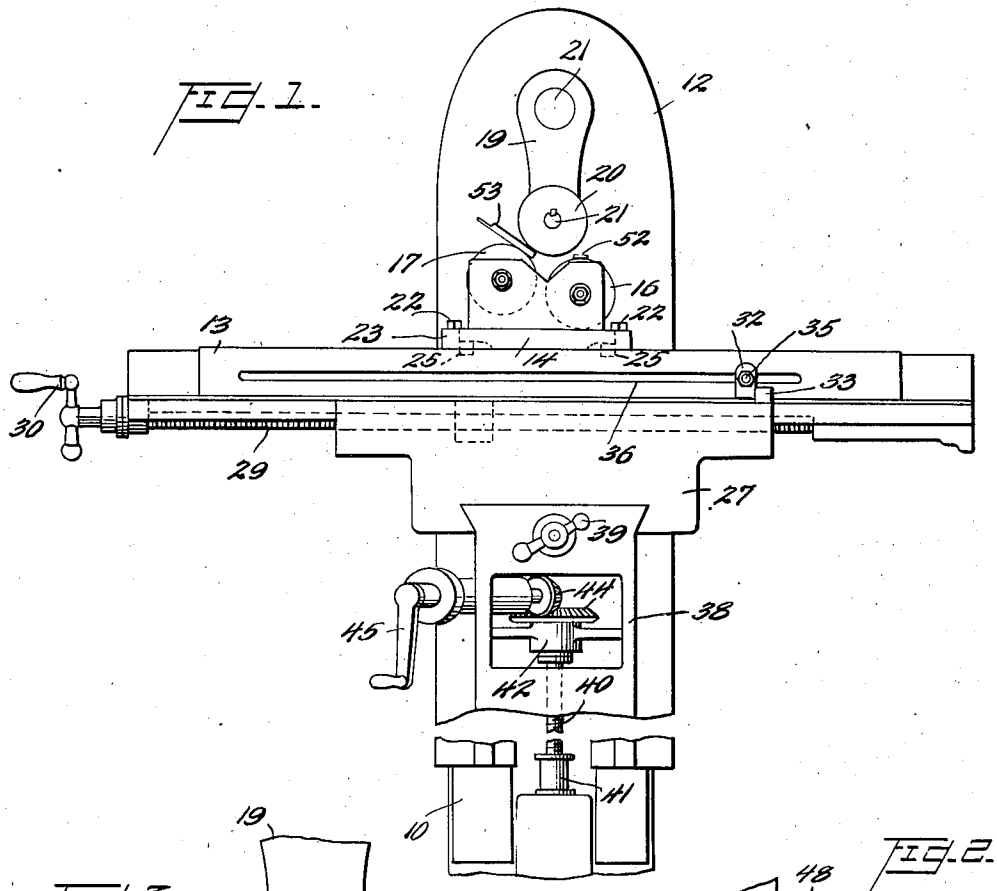


FIG. 3.

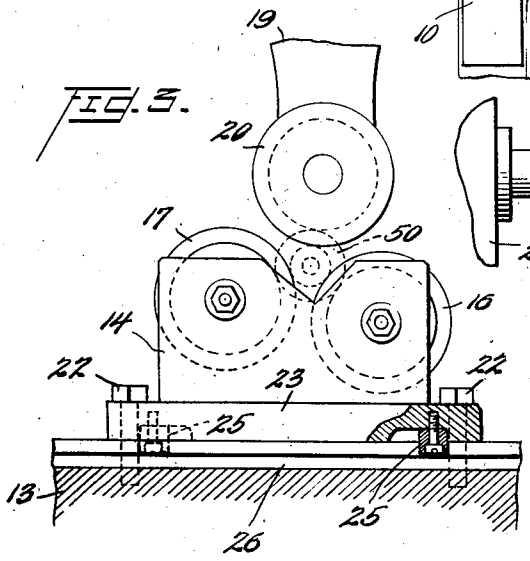
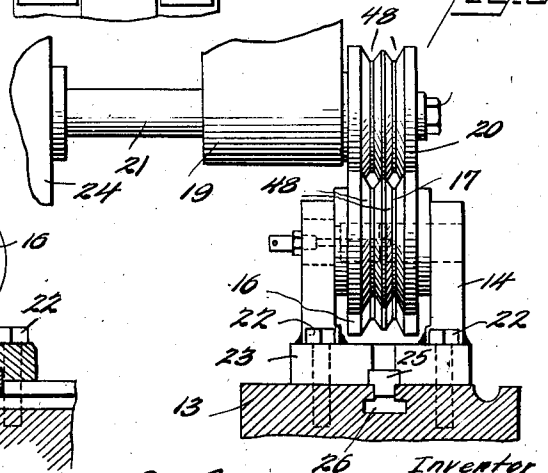


FIG. 2.



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BURNISHING APPARATUS

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FIG. 4.

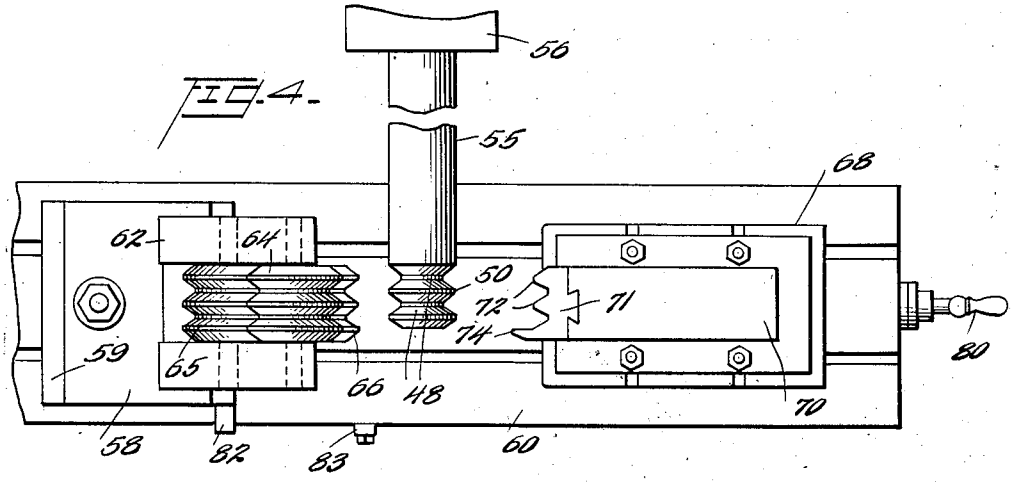


FIG. 5.

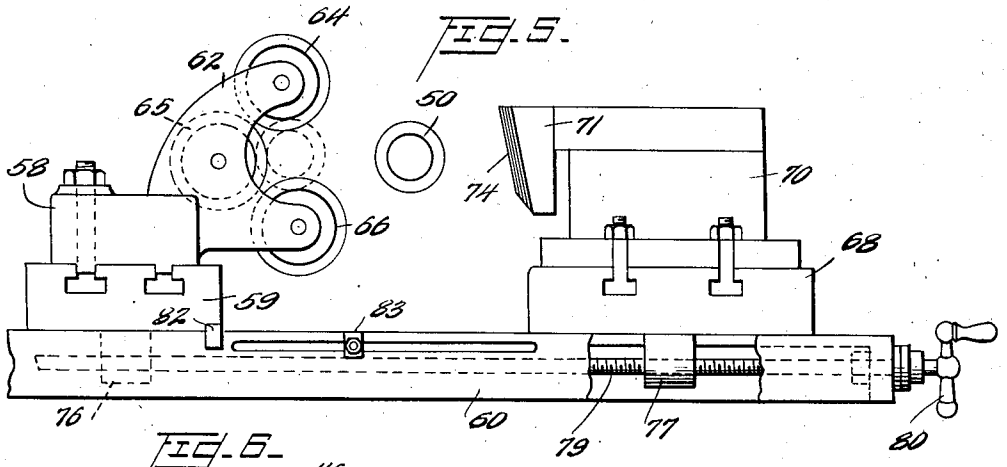


FIG. 6.

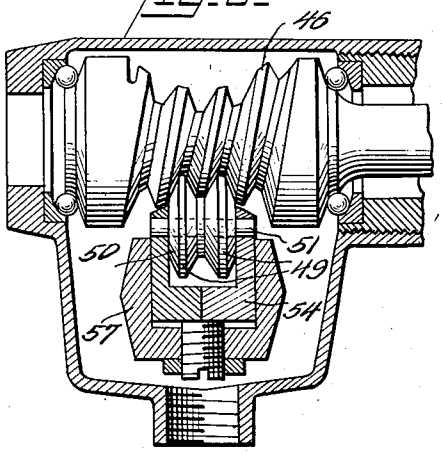
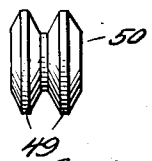


FIG. 7.



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Patented Dec. 1, 1936

2,062,699

UNITED STATES PATENT OFFICE

2,062,699

BURNISHING APPARATUS

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17 Claims. (Cl. 29—27)

This invention relates to a method of and apparatus for burnishing machine elements, and is more particularly concerned with the burnishing of the circumferentially toothed rollers commonly employed in automobile steering gear for engagement with and operation by the usual worm at the lower end of the steering column. These rollers are employed in lieu of the more conventional worm gear or sector for the purpose of reducing friction in the steering gear.

It is of course essential that proper meshing of the roller with the worm be effected and accurate and smooth finishing of both the roller and the worm is important. By the present invention it is possible to produce true and extremely smooth working surfaces on the teeth of the roller and at the same time to harden and toughen these surfaces, the result of the burnishing operation being much more satisfactory in these respects than if grinding of the roller is resorted to. The invention contemplates the employment of two or more master rollers which are grooved to receive the teeth of the roller to be burnished and which are suitably hardened, the roller to be burnished being received between these master rollers and being rotated with the simultaneous application of pressure thereto.

It is a more specific object of the invention to provide a plurality of master burnishing rollers which are so supported and positioned that the roller to be burnished can be readily located therebetween and the requisite degree of pressure applied, means being provided whereby this degree of pressure may be predetermined.

In one embodiment of the invention a machine capable of automatic operation is contemplated, the stock from which the rollers are formed being periodically advanced and the rollers being successively completed by grooving the stock, burnishing the grooved stock, and severing the burnished roller. Preferably the grooving and severing operations are combined, one roller being severed simultaneously with the grooving of the stock to form the succeeding roller by a single tool.

Further objects and features of the invention will be apparent from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a side elevation of a machine illustrating the invention and disclosing one embodiment thereof;

Figure 2 is an end elevation partly in section of a portion of the construction shown in Figure 1;

Figure 3 is a side elevation corresponding to Figure 2;

Figure 4 is a plan view of a modified type of machine capable of both forming and burnishing the rollers;

Figure 5 is an end elevation of the structure shown in Figure 4;

Figure 6 is a sectional view of one type of steering gear illustrating the manner in which the product of the machine disclosed herein may be employed; and

Figure 7 is a view in elevation of the product.

In order to facilitate an understanding of the invention the embodiments thereof shown in the drawings are described herein specifically. It will nevertheless be understood that by the employment of detailed descriptive language no limitation of the scope of the invention is intended, various alterations of the structure and modifications of the method being contemplated.

In the form of the invention shown in Figure 1 of the drawings, a conventional machine of the adjustable bed type is disclosed, this machine comprising a base 10 having a standard 12 rigid therewith and extending vertically therefrom, and a bed or table 13 supported on the base 10 for movement in several directions with respect thereto. Secured rigidly to the table 13 is a carrier 14 on which are journalled for rotation a plurality of master rollers 16 and 17, preferably two in number as illustrated in the drawings. An arm 19 rigid with and dependent from the standard 12 carries a third master roller 20 which is journalled for rotation on the arm 19, for instance by means of a shaft 21 extending through the arm and rotatable by a pulley 24, the pulley and roller 20 being secured to the shaft. The axes of the master rollers 16, 17, and 20 are parallel and preferably horizontal, the axis of the roller 20 being shown as located above the axes of the rollers 16 and 17. It will nevertheless be understood that this arrangement is by no means essential and that the relative positions of these rollers may be altered as desired so long as the axes thereof remain substantially parallel. It is convenient, however, in describing and defining the invention to refer to the rollers 16 and 17 as located beneath the roller 20.

The carrier 14 for the rollers 16 and 17 may be secured to the bed 13 by bolts 22 passing through the base 23 of the carrier and threaded in the bed, locating keys 25 secured to the carrier and engaging corresponding grooves 26 in the bed being provided to ensure that the carrier will not

be twisted on the bed during operation of the machine.

The carrier 14 and the bed 13 are displaceable in a plane substantially perpendicular to the axes of the rollers 16, 17, and 20, and for this purpose are supported for sliding movement on a member 27, displacement of the bed and carrier and retention thereof in any desired position of adjustment being effected by the threaded rod 29 operable by the handle 30 in the conventional manner. It will be observed that the axis of the roller 16 is spaced to a sufficient extent from the axis of the roller 20 to permit the roller 16 to move under the roller 20 from one side thereof to the other, movement of the carrier and bed to the right being limited by the engagement of abutments 32 and 33 on the bed and the member 27 respectively. One of these abutments is adjustable in the direction of displacement of the bed. Thus the abutment 32 may be supported on the bed 13 by means of a bolt 35 extending through a slot 36 in the bed so that the abutment may be displaced along the slot 36 and may be clamped in any desired position.

The member 27 is preferably, although not necessarily, supported for sliding movement in the axial direction of the rollers 16, 17, and 20, for instance on a member 38, suitable screw and nut gearing actuable by the handle 39 being provided to adjust the position of the member 27. The member 38, and the elements of the machine supported thereby, including the table 13, are adjustable vertically, being preferably guided in this vertical movement on the standard 12 in the conventional manner. This vertical movement may be effected by means of a threaded shaft 40 engaging a nut 41 carried in the base 10, the shaft 40 being journalled in the member 38 as indicated at 42 and being rotatable by bevel gearing 44 which is in turn actuated by the handle 45.

The structure thus far described for effecting relative adjustment of the axes of the roller 20 and of the rollers 16 and 17 is conventional and the details thereof form no essential part of the present invention. Such arrangements are commonly found in milling machines and the like which ordinarily provide for vertical adjustment as well as horizontal adjustment in two directions of a work table or other support.

The master rollers 16, 17, and 20 are preferably similar so far as the configuration of their circumferentially toothed portions is concerned although they may differ in diameter. It will be observed that each roller is grooved as indicated at 48, two grooves being provided to accommodate and to receive in interlocking relation the teeth 49 on the roller 50 to be burnished which are shown more particularly in Figures 3, 6, and 7 of the drawings, it being apparent that the number of grooves provided in the master rollers will equal the number of teeth formed on the roller 50. While in the preferred form of the invention a roller having two circumferential teeth is formed, rollers having a less or greater number of teeth can obviously be burnished by the same operation.

The machine thus far described is initially adjusted so as to permit the burnishing of rollers in rapid succession with the least possible delay. Thus the handle 39 is operated to align the rollers 16, 17, and 20 in an axial direction, the correct relative position being indicated in Figure 2 of the drawings. The handle 45 is then operated to raise or lower the table 13 and the carrier 14 to the proper vertical position, this position being determined by displacing the carrier 14 laterally until the roller 16 is directly beneath the roller 20 and inserting a gauge or feeler 52 between these rollers to determine the correct spacing thereof. The carrier 14 is then displaced to the right by operation of the handle 30 to a position in which the rollers 17 and 20 are spaced by the thickness of the gauge or feeler 53 as shown in Figure 1 of the drawings. The abutment 32 is then engaged with the abutment 33 and secured in position on the table, it being observed that displacement of the table and carrier 14 to the right on each operation is thereby limited.

The handle 30 is then manipulated to displace the table 13 and carrier 14 to the left, a roller 50 to be burnished is placed in position between the master rollers 16 and 17, and the table and carrier are then displaced to the right to bring the roller 50 into engagement with the master roller 20 and apply the necessary pressure between all of the rollers, the shaft 21 being simultaneously rotated and the master rollers and the roller 50 being rotated thereby. If desired the rollers may be cooled during the burnishing operation by causing flow of liquid such as oil over the same. On completion of the operation, the table and carrier are moved once more to the left and the burnished roller 50 replaced by the succeeding roller, the foregoing operations being then repeated.

Obviously a machine of this character can be made entirely automatic, the lateral displacement of the table and carrier from the operative to the inoperative position and vice versa being effected by suitably designed cams, and the rollers 50 being successively delivered and removed from the carrier by conventional automatic feeding mechanism, it being only necessary to make slight adjustments from time to time to compensate for wear of the master rollers or to replace these rollers.

When formed in this way, the rollers 50 will mesh accurately with hour-glass worms such as shown at 46 in Figure 6 of the drawings, the roller being preferably supported for rotation on an axis 51 parallel to the worm in a carrier 54, the latter being in turn rotatable about an axis perpendicular to the axis of the roller in an arm 57, this second rotational axis being provided to accommodate the roller to the varying helix angle of the worm. The arm 57 constitutes in effect the equivalent of the usual worm gear and is connected in the conventional manner to the steerable road wheels of the vehicle. The structure shown in Figure 6 forms no part of the present invention and is included to facilitate an understanding of the nature of the rollers 50 and their function.

Referring now more particularly to the form of the invention shown in Figures 4 and 5, it will be observed that the rollers 50 are illustrated as formed on stock 55, the latter being secured in and rotated by a suitable work holder 56. While the work holder 56 is shown diagrammatically in the drawings to simplify the description and illustration of the invention, I may use for this purpose a conventional type of screw machine which is automatically operable in known manner to periodically advance the stock axially and to rotate the stock, the periodical advance being effected by suitably designed cams or the like.

At one side of the stock a carrier 58 is provided, this carrier being secured to a table 59 which is in turn supported on a base 60 for sliding movement laterally of the axis of the rotating stock 55. The carrier 58 is provided with a bracket 62

in which are supported for rotation two or more master rollers, of which three are preferably provided, these rollers being designated 64, 65, and 66. The axes of the rollers are parallel to the axis of the stock and may be so relatively positioned that as a roller 50 to be burnished passes between the rollers 64 and 66 and into engagement with the roller 65 with the desired pressure, substantially equal pressure will be applied thereto by the rollers 64 and 66.

At the other side of the stock a device for forming and preferably for cutting off the rollers is disposed, this device consisting of a table 58 which is mounted for sliding movement on the support 60 transverse of the axis of the stock 55 and which has rigidly secured thereto a tool supporting bracket 70, the latter carrying a tool 71 formed as shown more particularly in Figure 4 of the drawings with two cutting edges 72, adapted to form corresponding grooves in the stock, and a severing edge 74 adapted to remove a formed and burnished roller from the stock.

The burnishing device and the cutter or grooving device are alternately brought into engagement with the stock 55 by lateral displacement with respect thereto, a common operating means being preferably provided. Thus nuts 76 and 77 may depend from the burnishing device and the grooving device respectively, these nuts being engaged by a threaded rod 79 supported in any suitable manner for rotation and against lengthwise displacement in the base 60, a handle 80 being provided to effect rotation of the rod and simultaneous displacement of the two devices in the same direction.

With the parts in the position shown in Figure 4, the stock 55 is advanced axially through a distance corresponding to the length of the element 50 which may be assumed to have been formed and burnished. The cutting device is then displaced to the left to engage the stock, the grooves being formed in the rotating stock by the cutting edges 72 and the formed and burnished roller 50 being severed by the cutting edge 74. The cutting device and the burnishing device are then simultaneously displaced to the right so that the master rollers may be engaged with the roller 50 in the manner suggested by the dotted line showing in Figure 5. The continued rotation of the stock then effects corresponding rotation of the master rollers to complete the burnishing operation, the burnishing device and the cutting device being thereupon displaced to the left and the stock 55 again advanced while disengaged from both devices as hereinbefore explained.

In order that the pressure applied by the master rollers to the roller to be burnished may be determined in advance, an arrangement similar to that shown in Figure 1 may be provided; thus abutments 82 and 83 located on the table 59 and the base 60 respectively may be employed, one of these abutments being adjustable.

The entire operation of the machine shown in Figures 4 and 5 may be automatic, displacement of the burnishing device and the cutting device being effected by suitable mechanism serving to periodically rotate the threaded rod 79 in timed relation with the axial advance of the stock 55. In this connection it may be pointed out that the displacement of the burnishing rollers with respect to the stock is relative, that is to say, the stock may be displaced laterally while the burnishing rollers and the cutting device are maintained in a stationary position. Similarly, in the first described form of the invention, the master roller 20 may be displaced laterally of the axis thereof while the rollers 16 and 17 are retained against movement. Various other changes in the structure herein described will occur to one skilled in the art to which the invention relates and all modifications are contemplated such as fall within the scope of the appended claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a circumferentially toothed master element rotatably mounted on said support, at least two master elements carried by said support for rotation about spaced axes parallel to the axis of said first named element and for lateral displacement with respect to said first named element, said master elements receiving therebetween a circumferentially toothed element to be burnished, means for imparting relative lateral displacement to said second named master elements and said first named master element to apply pressure in a generally radial direction to the element to be burnished, and means for rotating said elements.

2. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a circumferentially toothed master element rotatably mounted on said support, at least two master elements carried by said support for rotation about spaced axes parallel to the axis of said first named element and for lateral rectilinear displacement as a unit with respect to said first named element, said master elements receiving therebetween a circumferentially toothed element to be burnished, means for imparting relative lateral displacement to said second named master elements and said first named master element to apply pressure in a generally radial direction to the element to be burnished, and means for rotating said elements.

3. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a circumferentially toothed master element rotatably mounted on said support, two master elements carried by said support for rotation about spaced axes parallel to the axis of said first named element and for lateral rectilinear displacement as a unit with respect to said first named element, said master elements receiving therebetween a circumferentially toothed element to be burnished, means for imparting relative lateral displacement to said second named master elements and said first named master element to apply pressure in a generally radial direction to the element to be burnished, and means for rotating said elements, one only of said two second named master elements being so positioned as to permit displacement thereof to a position adjacent either side of said first named master element to facilitate the positioning of the element to be burnished between the three master elements.

4. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a circumferentially toothed master element rotatably mounted on said support, a carrier laterally displaceable on said support with respect to said master element, two circumferentially toothed master elements supported for rotation on said carrier about axes parallel to the axis of said first named master element, the plane

defined by one of said carrier supported master elements on lateral displacement of said carrier being spaced to a greater extent from the axis of said first master element than the plane defined by the other of said carrier supported master elements, and to an extent sufficient to permit movement thereof past said first named master element, whereby an element to be burnished may be located on said two carrier supported elements and positioned between the three master elements by lateral displacement of said carrier, and means for rotating said elements.

5. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a plurality of circumferentially toothed master elements carried by said support for rotation about parallel axes and receiving the toothed element to be burnished therebetween, means for rotating said elements, and means for effecting relative lateral displacement of said master elements in two directions to apply generally radial pressure to the element to be burnished.

6. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a plurality of circumferentially toothed master elements carried by said support for rotation about parallel axes and receiving the toothed element to be burnished therebetween, means for rotating said elements, means for effecting relative lateral displacement of said master elements in two directions to apply generally radial pressure to the element to be burnished, and means for effecting relative axial displacement of said master elements in one direction to align the teeth thereof.

7. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a circumferentially toothed master element rotatably mounted on said support, at least two master elements carried by said support for rotation about spaced axes parallel to the axis of said first named element and for lateral displacement with respect to said first named element, said master elements receiving therebetween a circumferentially toothed element to be burnished, means for imparting relative lateral displacement to said second named master elements and said first named master element to apply pressure in a generally radial direction to the element to be burnished, means for rotating said elements, and an adjustable abutment acting between said support and said carrier to limit relative lateral displacement of said master elements toward pressure applying position.

8. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a plurality of circumferentially toothed master elements carried by said support for rotation about parallel axes and receiving the toothed element to be burnished therebetween, means for applying pressure between said master elements and the element to be burnished in directions generally radial of the latter, means for limiting the degree of pressure applied by said last named means, and means for rotating said elements.

9. A process of burnishing circumferentially toothed rollers for use in steering gears which comprises rotating the roller to be burnished between and in interlocking toothed relation with a plurality of master rollers circumferentially disposed about the periphery of the roller to be burnished, and simultaneously applying pressure in a generally radial direction between the master rollers and the roller to be burnished.

10. In apparatus for forming and burnishing circumferentially toothed elements, the combination with means for supporting and rotating substantially cylindrical stock, of means positioned at one side of said stock for grooving the latter circumferentially, means disposed at the other side of said stock for engaging the grooved stock to burnish the same, and mechanism for effecting relative lateral displacement of said stock, and said grooving and burnishing means to engage the latter successively with said stock.

11. In apparatus for forming and burnishing circumferentially toothed elements, the combination with means for supporting and rotating substantially cylindrical stock, of means positioned at one side of said stock for grooving the latter circumferentially, means disposed at the other side of said stock for engaging the grooved stock to burnish the same, and mechanism for effecting relative lateral displacement of said stock and said grooving and burnishing means to engage the latter successively with said stock, said burnishing means comprising a plurality of circumferentially toothed elements supported for rotative engagement with the grooved stock at points spaced about the periphery of the latter.

12. In apparatus for forming and burnishing circumferentially toothed elements, the combination with means for supporting and rotating substantially cylindrical stock, of means positioned at one side of said stock for grooving the latter circumferentially, means disposed at the other side of said stock for engaging the grooved stock to burnish the same, mechanism for effecting relative lateral displacement of said stock and said grooving and burnishing means to engage the latter successively with said stock, and a cutter associated with said stock grooving means for severing a grooved and burnished element from the stock as the succeeding element is grooved.

13. In apparatus for forming and burnishing circumferentially toothed elements, the combination with means for supporting and rotating substantially cylindrical stock, of means positioned at one side of said stock for grooving the latter circumferentially, means disposed at the other side of said stock for engaging the grooved stock to burnish the same, and mechanism for effecting simultaneous lateral displacement of said grooving and burnishing means with respect to said stock in alternately opposite directions to successively engage the stock with the grooving and burnishing means.

14. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a plurality of circumferentially toothed master elements carried by said support for rotation about parallel axes and receiving the toothed element to be burnished therebetween, means for applying pressure between said master elements and the element to be burnished in directions generally radial of the latter, and means for supporting and rotating the element to be burnished, whereby said master elements are rotated therefrom.

15. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a plurality of circumferentially toothed master elements carried by said support for rotation about parallel axes and receiving the toothed element to be burnished therebetween, means for applying pressure between said master

elements and the element to be burnished in directions generally radial of the latter, and means for supporting and rotating the element to be burnished, whereby said master elements are rotated therefrom, said last named means comprising a rotatable stock holder for supporting and rotating the stock on which the element to be burnished is formed, and means for engaging and simultaneously forming an element on said stock and severing the preceding burnished element from the stock.

16. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a plurality of circumferentially toothed master elements carried by said support for rotation about parallel axes and receiving the toothed element to be burnished therebetween, means for applying pressure between said master elements and the element to be burnished in directions generally radial of the latter, said means comprising a relatively laterally displaceable support for the element to be burnished, and an adjustable stop means for limiting the relative displacement of said said supports to limit the pressure applied to said elements.

17. In apparatus for burnishing circumferentially toothed elements, the combination with a support, of a plurality of circumferentially toothed master elements carried by said support for rotation about parallel axes and receiving the toothed element to be burnished therebetween, means for applying pressure between said master elements and the element to be burnished in directions generally radial of the latter, said means comprising a relatively laterally displaceable support for the element to be burnished, and an adjustable stop means for limiting the relative displacement of said supports to limit the pressure applied to said elements, said support for the element to be burnished being rotatable, whereby said master elements may be rotated therefrom.

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