Oct. 22, 1940. R. H. CRAMER 2,218,982

PRECISION GRINDING OF CONTOURED ARTICLES

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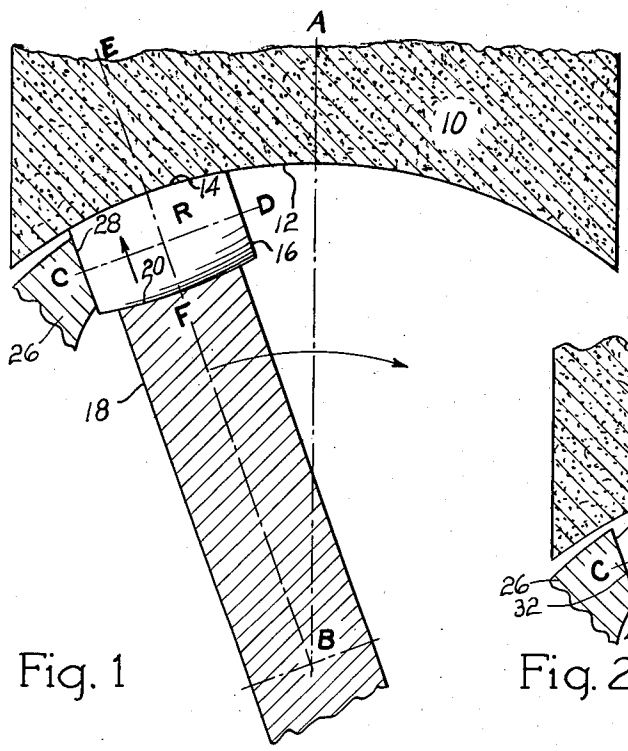


Fig. 1

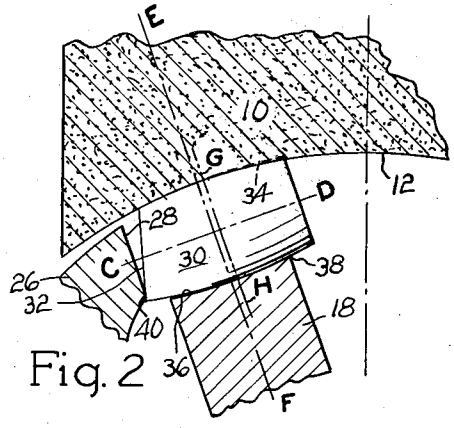


Fig. 2

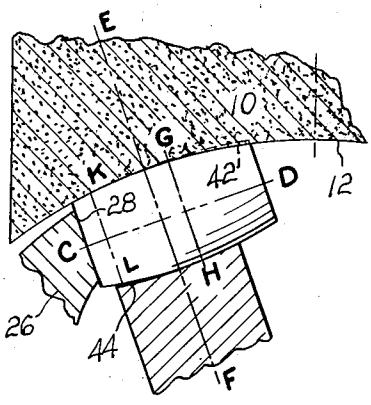


Fig. 3

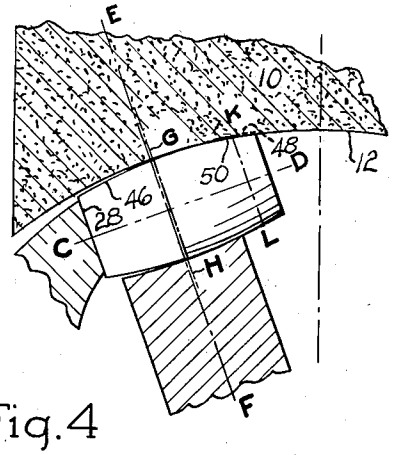


Fig. 4

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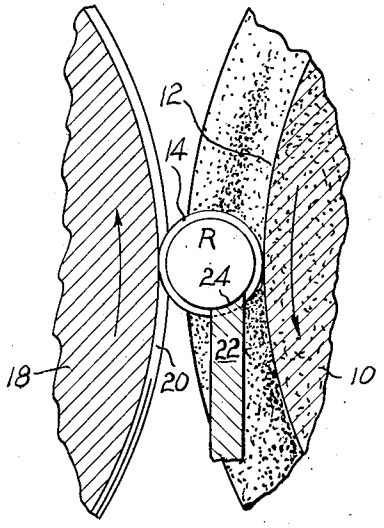


Fig. 5

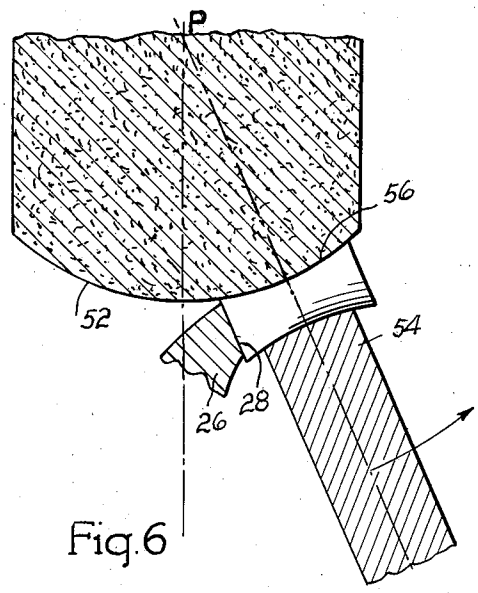


Fig. 6

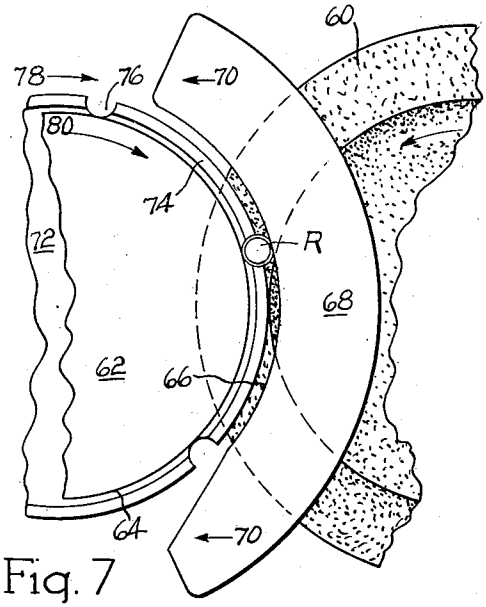


Fig. 7

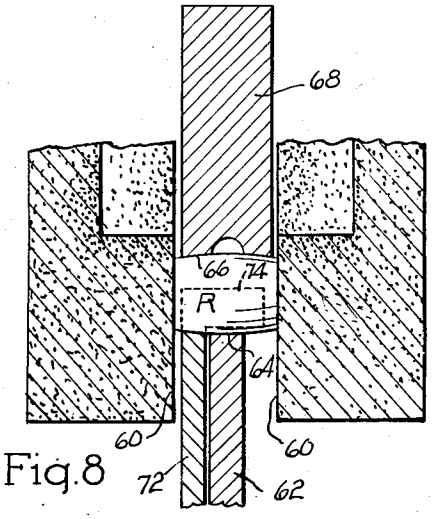


Fig. 8

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2,218,982

PRECISION GRINDING OF CONTOURED ARTICLES

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Application November 16, 1936, Serial No. 111,056

4 Claims. (Cl. 51—289)

This invention relates to precision grinding of contoured articles and comprises all of the feature and aspects of novelty herein disclosed. An object of the invention is to provide an improved method of generating surfaces of revolution of great accuracy. Another object is to provide an improved method for the precision grinding of contoured surfaces on articles such as barrel-shaped rollers for bearings.

To these ends and also to improve generally upon methods of this character, the invention consists in the various matters hereinafter described and claimed. In its broader aspects, the invention is not necessarily limited to the specific steps selected for disclosure in the accompanying drawings in which

Fig. 1 is a horizontal sectional view of a portion of a grinding machine for operating on barrel-shaped rollers.

Fig. 2 is a similar view illustrating the effect produced when one of the ends of the roller is out of square.

Fig. 3 is a similar view illustrating the effect produced when a roller has excess length, as at one end.

Fig. 4 is a similar view illustrating the effect produced when a roller which is ground as in Fig. 3 is reversed end for end.

Fig. 5 is a vertical section through a portion of the grinding machine of Fig. 1.

Fig. 6 is a horizontal sectional view of a portion of a grinding machine adapted to produce waisted rollers.

Fig. 7 is a side elevation of a portion of an end grinding machine to prepare the rollers of Figs. 1 and 5 for surface grinding.

Fig. 8 is a sectional view of a portion of the machine of Fig. 7.

In Fig. 1, the numeral **10** indicates a wide grinding wheel rotating about an axis perpendicular to its central plane A—B and having a concave face **12** struck on a radius whose center is at B. The radius is the same as that desired for the radius of the longitudinal surface **14** of a barrel shaped roller R. Such roller has an axis C—D and is symmetrical about a plane E—F through its geometric center, its end faces **16** being flat and exactly perpendicular to the axis C—D. A narrow regulating wheel **18** has a concave surface **20** which has the same curvature as the grinding wheel and the roller. Its central plane is indicated by the line F—B and it rotates on an axis perpendicular to this central plane. The regulating wheel rotates upwardly at the work and the grinding wheel rotates downwardly at the work, the work being supported by a work blade **22** whose upper surface **24** is preferably angled downwardly away from the grinding wheel but contoured to fit the surface of the work. The blade is also preferably wholly under that half of the work nearest to the grinding wheel. It is apparent that the foregoing apparatus would grind the work surface but that the work would quickly wear a groove in the grinding wheel.

To generate the desired contour on the surface of the work and to have the grinding wheel maintain its form as long as possible without dressing, the work is traversed across the face of the grinding wheel by oscillation of the regulating wheel and the work blade as a unit around a vertical axis through the point B. In order that there may be no tendency of the work to cock or tilt, a locating plate or pusher **26** is also mounted to oscillate as a unit with the regulating wheel and the blade. The plate **26** has a work locating and pushing surface **28** which is flat and exactly parallel to the plane E—F which extends through the geometric center of the roller at its plane of maximum diameter. The surface **28** is also located from this plane E—F at a distance equal to exactly one-half the roller length. The rollers may be placed one at a time on the work blade in front of the pusher when such parts are swung clear beyond one end of the grinding wheel and the rollers may be removed at the opposite extremity of oscillation. Any suitable feeding and ejecting mechanism may be used. One machine for carrying out certain steps of the process is disclosed in detail in the applicant's copending application, Serial No. 81,498, filed May 23, 1936. Ordinarily the amount of material to be removed and the high degree of precision dimensions and finish demanded in rollers for roller bearings require several passes of the roller through the machine and, during these several passes, it will make no difference which end of the roller is in advance so long as the end faces are flat and perpendicular to the axis and at the proper distance from the plane of maximum diameter. Such ideal rollers are not obtainable for this contour grinding operation by the usual cold-heading method of producing rough roller blanks, such method having certain practical limitations for accuracy which are accepted by the trade. The errors produced in the cold-heading manifest themselves in the form of length variation, asymmetry, and ends not parallel or normal to the axis. Accordingly, I insure the proper initial length, symmetry and end

squareness by end grinding the rollers as hereinafter described before running them through the contour generating apparatus. To emphasize the necessity and importance of this end grinding to precede the contour grinding, the effect of asymmetry, errors in length, and lack of end squareness will next be referred to.

In Fig. 2 there is shown a roller 30 whose end faces are the correct distance apart at the axis CD but not perpendicular to the axis, the defect being exaggerated and the roller being inserted between wheels arranged as in Fig. 1. Obviously, the inclined face 32 of the roller will not engage the locating face 28 except at one point and will shift the roller lengthwise so that its geometric center and plane of maximum diameter G—H will incorrectly lie to one side of the plane E—F where there is maximum space between the wheels. In other words, the leading end of the roller is pushed towards and into a converging space which is too small for it and the rear end is pushed into a diverging space which is too large for it. Thus the roller tends to receive too much grinding in the region 34 and does not fit against the regulating wheel in the region 36. It contacts at the points 38 and 40, the location of the contact point 40 on the roller continually changing its relation to the locating face 28 and the other supporting parts as the roller rotates, and a condition of instability is produced such that the roller wabbles as it rotates and causes an irregular or wavy surface to be generated instead of a true surface of revolution. The condition is also complicated because pushing of the roller along the work blade, due to excess material in the region 40, tends to tip the axis of the roller out of the horizontal. The excess grinding towards the leading end also produces an asymmetrical roller. This condition would be aggravated, if on subsequent passes through the machine, the roller were reversed end for end and it obviously would be very difficult and expensive to construct a mechanical feeder which would insure that the same end would always be in advance, especially when the variations are small.

Fig. 3 shows the effect produced when a roller has its end faces normal to the axis C—D but has excess length at one end as represented in exaggerated degree by the distance between the locating face 28 and the plane K—L. The locating face 28 would shift the roller endwise so that the plane G—H through the desired maximum diameter of the roller would lie to the right of the plane E—F where there is maximum space between the wheels. The roller would receive excess grinding in the region 42 and would not fit against the regulating wheel in the region 44.

It would also be tilted somewhat in a vertical plane by the contoured work blade. These displacements, even though small, greatly diminish the frictional grip of the regulating wheel against the roller which is so very important to uniform rotation. The condition is somewhat similar to that shown in Fig. 2 except the flat surface contact at 28 would provide greater stability. More material would be removed from the roller at the leading end and the roller would be asymmetrical. The usual length variations met with in practice may not be great enough to make this condition of asymmetry in itself serious or detrimental to good bearing performance but, if the roller should become turned around after one pass and presented for a subsequent pass in a reversed position, a very serious defect will develop as indicated in Fig. 4.

In Fig. 4, the asymmetrical roller, after being produced by grinding as in Fig. 3, is turned end for end so that the portion 46 of the surface which received excessive grinding in Fig. 3 lies adjacent to the locating surface 28. This roller then has the planes G—H and K—L located as shown and there is no contact of the excessively ground surface portion 46 with the grinding wheel. Thus, the second or other subsequent pass will not effect the desired finish grinding on the portion 46. When the remainder of the roller is ground in the region 48, it has a surface at 50 produced by the grinding surface 12. Hence the completed roller will not have a longitudinal surface in a continuous arc but there will be two arcs 46 and 50 with a distinct line of intersection near the plane G—H of maximum diameter of the finished roller. Such defect would of course be aggravated if the roller had excess length at both ends. Inasmuch as it is impracticable to feed rollers with the same end in advance at every pass, this serious defect is bound to exist unless the rollers are corrected by precise end grinding prior to form grinding. Rollers which are less than the specified length produce the same effect as over-length rollers. Occasionally rollers are rough formed asymmetrically in which case the final result may be the same as obtained by a long or a short roller, the result depending on the initial degree of asymmetry. A condition of improper length plus ends not normal to the axis results in the same condition with the added defect of a wavy or irregular contour due to unstable support of the roller as it rotates as indicated in Fig. 2.

As indicated in Fig. 6, rollers of the waisted or hour-glass type may be contoured by using a convex grinding wheel 52 and a convex regulating wheel 54, the latter and the locating plate or pusher 26 oscillating about a center at point P which is the center of curvature of the roller surface 56. The invention is also applicable to generate asymmetrical rollers of half-length or any other specified length either in barrel rollers or waisted rollers, the principal requirement being that the locating face 28 be at the correct distance from the central plane of the regulating wheel and that the roller ends have sufficient difference in size or character that the proper end may always be selected to go in advance.

Precision end grinding necessary to prepare the work for form grinding may be performed by the apparatus disclosed in Figs. 7 and 8. Two co-axial grinding wheels have annular grinding faces 60 spaced apart a distance equal to the desired length of the roller R. The faces are exactly parallel and perpendicular to the axis of rotation. The rollers are guided between the wheels by a series of members which control location, rotation and traverse. One member is a rotating regulating wheel or disc 62 having a narrow peripheral surface 64 contoured to fit the middle portion of the roller. Opposed to this surface is a concave surface 66 on a non-rotary pressure shoe 68 which is urged and guided in the direction of the arrows 70. The surface 66 is preferably recessed or interrupted centrally and its end portions are contoured to fit the roller. The shoe is so located and of such radius that the work will traverse the annular grinding faces 60 twice, first inwardly across the faces and then outwardly so that the grinding faces are kept dressed. Another rotary disc 72 has a flange 74 projecting laterally over the surface 64 and provided with a series of notches 76 curved

to fit the rollers and breaking through the flange so the roller will roll on the surface **64**. The notches are so spaced angularly that no more than two rollers can be between the shoe and the regulating disc and also between the grinding faces at one time. The rollers are fed successively into the notches at the top and are discharged at the lower end of the shoe. The discs **62** and **72** are positively driven, the disc **72** at one-half the speed of the disc **62** as indicated by the arrows **78** and **80**.

The pressure upon the roller exerted by the opposed and similarly contoured surfaces **64** and **66** causes the roller to turn on its own axis in exactly the same manner as it will travel between the races of a roller bearing. The applied pressure between the contoured surface **64** fitting the middle portion of the roller and the interrupted surface **66** fitting the end portions of the roller (the surface **64** being convex as viewed from the side and the surface **66** being concave) naturally causes the roller to settle down and find its own center endwise with its plane of maximum diameter in the center of curvature of the surfaces **64** and **66** and with the roller axis perpendicular to the grinding faces **60**. The axes of discs **62** and **72** are of course parallel to the axes of the grinding wheels. The pocketed flange **74** prevents the grinding wheels from taking control when the first heavy cut occurs and insures constant speed of traverse and rotation. The pocketed flange functions in a manner similar to the cage of a roller bearing.

Since the notches **76** are so spaced that a maximum of two rollers can be pressed between the shoe and the regulating disc at one time, the pressure must be shared by such two rollers and controlled rotation during grinding is thereby assured whereas, if three rollers could be in the grinding zone at one time and if one were the least bit smaller in diameter than the others, such smaller roller would be loose and fail to rotate with consequent inaccurate grinding. If any asymmetry exists in the rough roller, the tendency of the roller to locate itself with its plane of maximum diameter in the center of curvature of the surfaces **64** and **66** will cause the grinding wheels to correct the defect. This insures the production of parallel faces equidistant from the plane of maximum diameter even if the rough roller is initially asymmetrical. Rotating freely upon its own axis and restrained axially by its own contour fitting the guiding surfaces, the roller is presented to the abrading action of the wheels and its ends are ground exactly square with the axis and at equal distances from the plane of maximum diameter and geometrical center. The space between the grinding wheels is accurately adjustable to control the finished length of the roller.

The accurately end ground roller is then supported on the work blade in contact with the regulating wheel **18** and pusher **26** when such members are swung to one side of the grinding wheel **10**. The regulating wheel, work blade, pusher and roller then swing as a unit about the center B to traverse the roller along the countered grinding face **12**, the roller being ejected at the end of the swing. The return stroke to receive the next roller is idle. The surface ground rollers are given subsequent passes through the machine as needed and it is immaterial which end is in advance because both ends are square and equidistant from the plane of maximum diameter. These subsequent passes can of course occur on the same machine or on other machines of the same kind.

I claim:

1. The method of precision production of longitudinally contoured rollers which have end-ground flat faces which are parellel to and equidistant from a central plane through the geometric center of the roller, which comprises centerless grinding the roller periphery between a grinding wheel and a regulating wheel which have contours corresponding to the roller contour, the roller being located endwise by only one of its end-ground faces and thereby stabilized for rotation with its central plane in the central plane of the regulating wheel; substantially as described.

2. The method of precision production of barrel rollers which have flat faces which are parallel to and equidistant from the plane of maximum diameter of the roller, which consists in utilizing only one of said flat faces to locate the roller endwise and hold it for rotation with its plane of maximum diameter in the plane of minimum diameter of a similarly contoured regulating wheel, and centerless grinding the roller periphery by swinging the regulating wheel and roller as a unit around an axis to traverse the roller along the surface of a correspondingly contoured grinding wheel; substantially as described.

3. The method of precision production of longitudinally contoured bearing rollers which have parallel end faces normal to the roller axis and at predetermined distances from the cross section where the roller diameter reaches a limit of size, which consists in supporting the roller for uniform rotation with its contoured periphery conforming to a correspondingly contoured regulating wheel, swinging the regulating wheel and roller as a unit around an axis to traverse the roller periphery across the periphery of a correspondingly contoured grinding wheel while leaving one end face of the roller free and utilizing the other end face to prevent endwise movement of the roller with respect to the regulating wheel and to thereby maintain the geometric center of the roller where the roller reaches a limit of size in the central plane of the regulating wheel; substantially as described.

4. The method of precision production of longitudinally contoured rollers which have end ground flat faces which are parallel to and equidistant from a central plane through the geometric center of the roller, which comprises centerless grinding the roller periphery between a grinding wheel and a regulating wheel which have contours corresponding to the roller contour, the roller being located endwise by only one of its end-ground faces and thereby stabilized for rotation with its central plane in the central plane of the regulating wheel, swinging the regulating wheel and located roller around a common axis to traverse the roller periphery across the periphery of the correspondingly curved grinding wheel, removing the roller, and giving it a second grinding traverse while the roller is again located endwise by either end ground face; substantially as described.

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