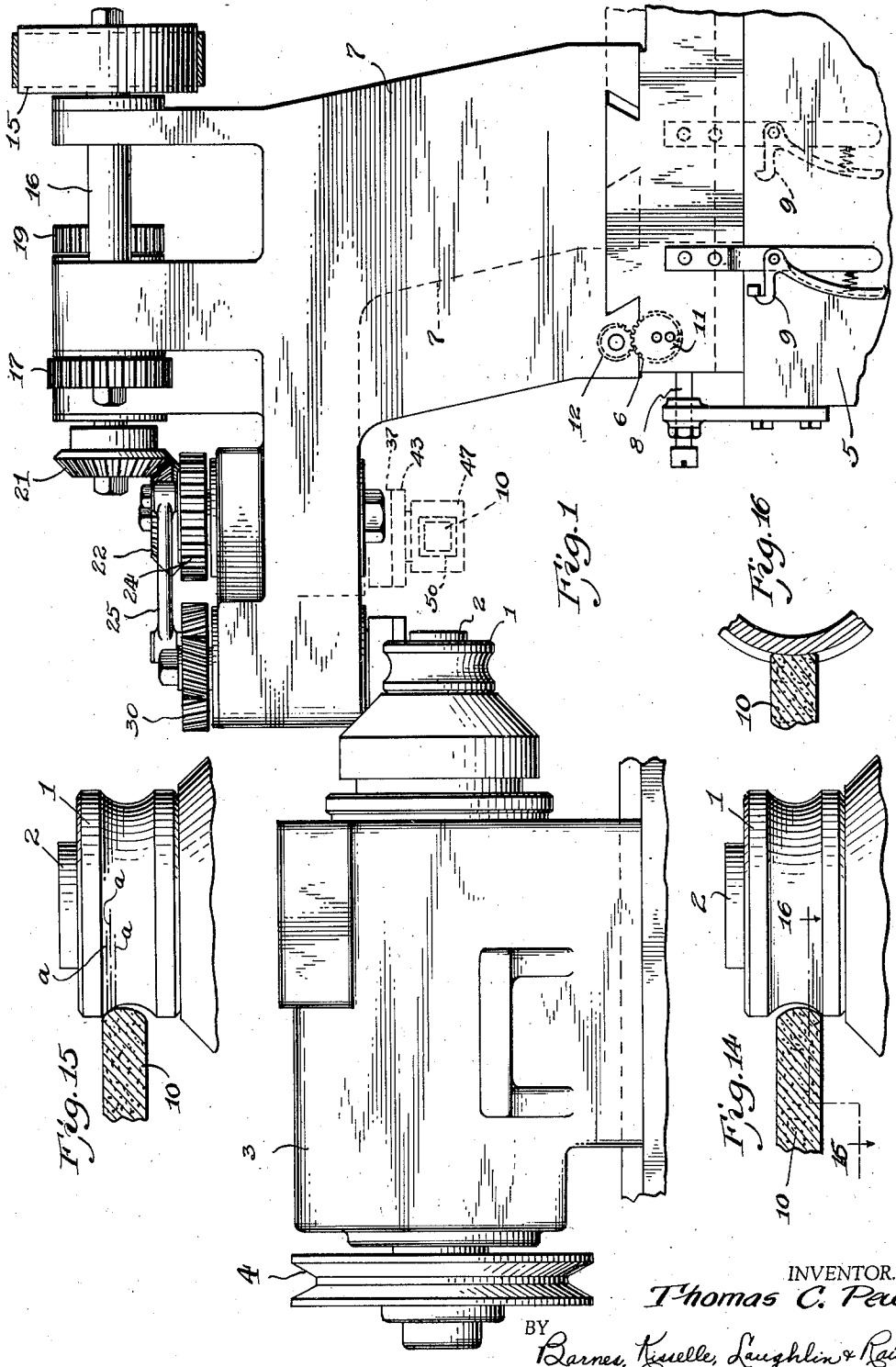
Aug. 12, 1941. T. C. PEW 2,252,096

METHOD AND APPARATUS FOR FINISHING BALL RACEWAYS OR THE LIKE

Filed June 26, 1939 4 Sheets-Sheet 1



INVENTOR.
Thomas C. Pew
BY
Barnes, Kisselle, Laughlin & Raisch
ATTORNEYS

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METHOD AND APPARATUS FOR FINISHING BALL RACEWAYS OR THE LIKE

Filed June 26, 1939 4 Sheets-Sheet 2

Fig. 2

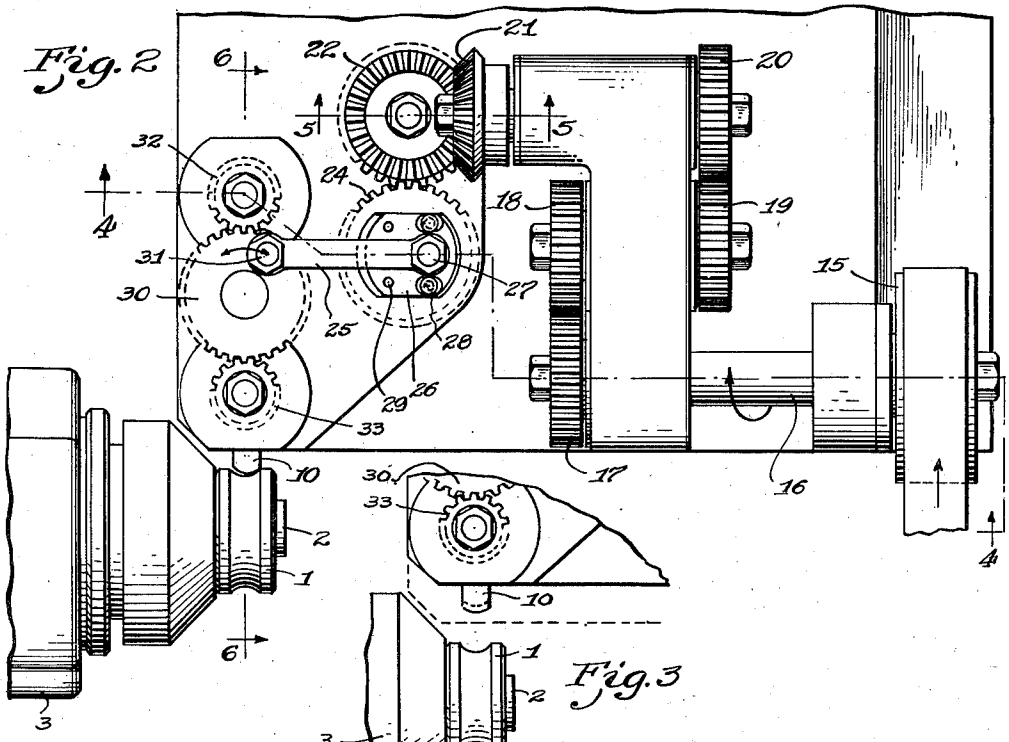
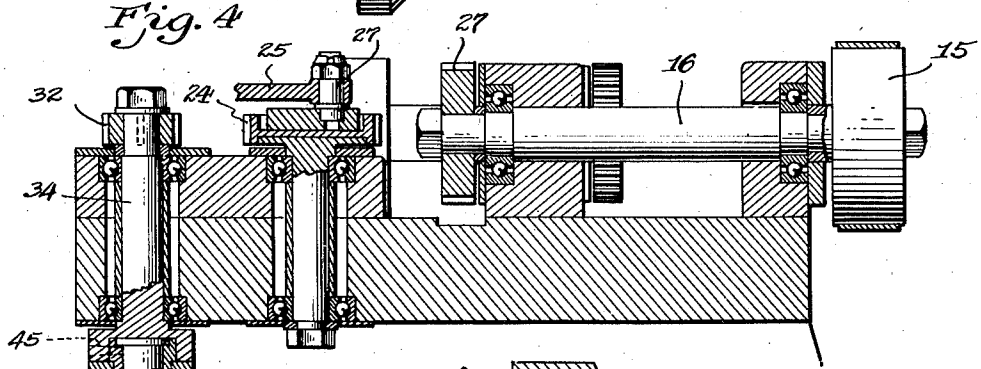


Fig. 3

Fig. 4



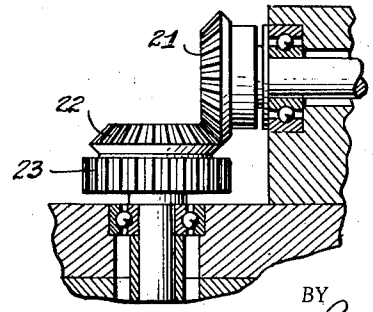


Fig. 5

INVENTOR.
Thomas C. Pew

BY
Barnes, Kisselle, Laughlin & Raisch
ATTORNEYS

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Filed June 26, 1939 4 Sheets-Sheet 3

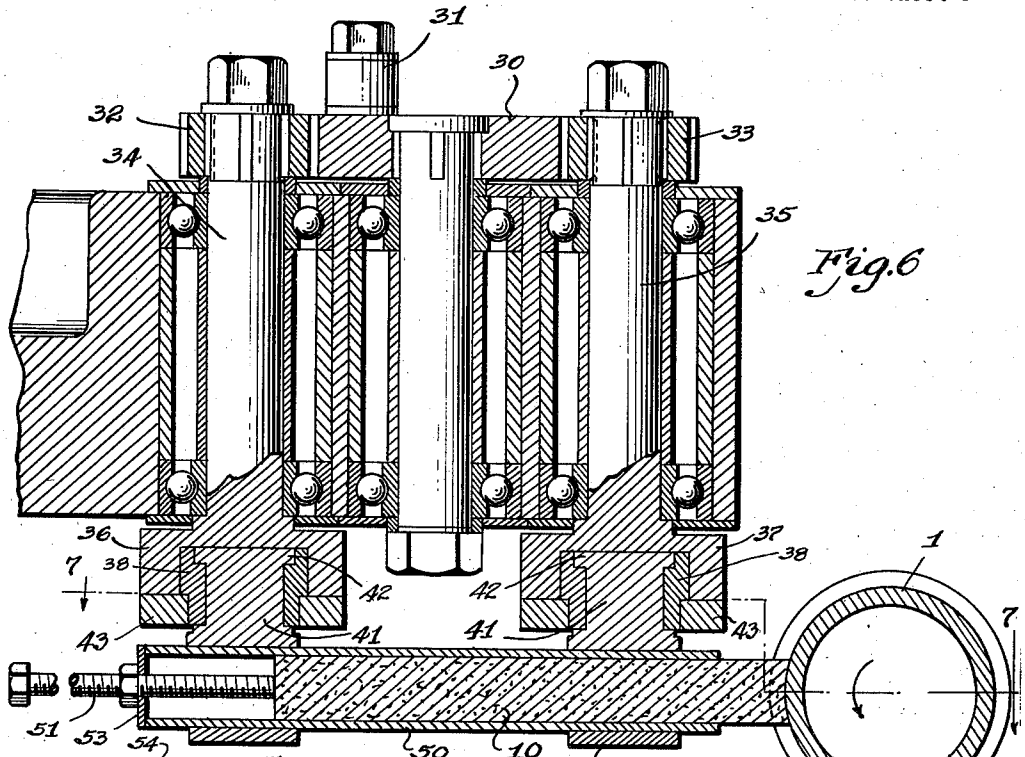


Fig. 6

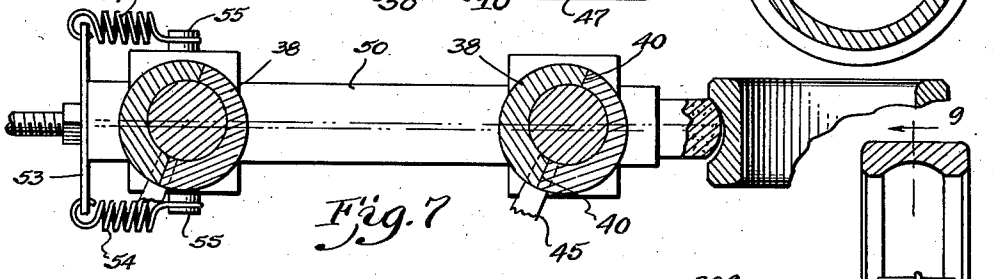


Fig. 7

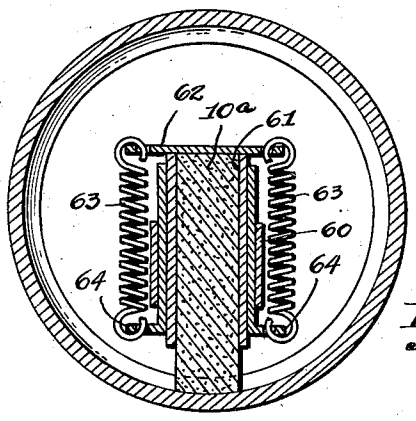


Fig. 9

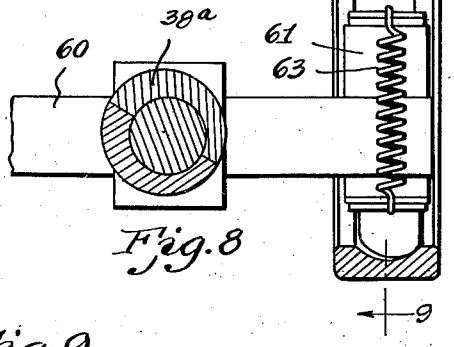


Fig. 8

INVENTOR.
Thomas C. Pew

BY
Barnes, Kisselle, Laughlin & Raisch
ATTORNEYS

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METHOD AND APPARATUS FOR FINISHING BALL RACEWAYS OR THE LIKE

Filed June 26, 1939 4 Sheets-Sheet 4

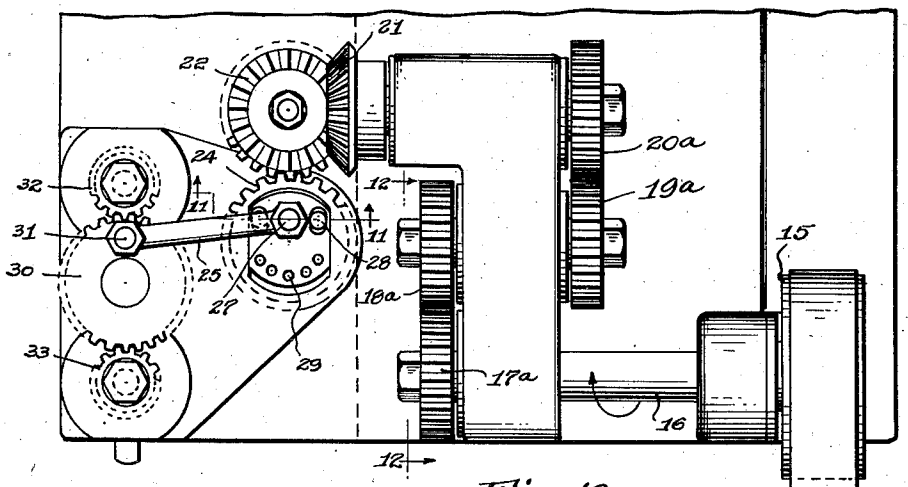


Fig. 10

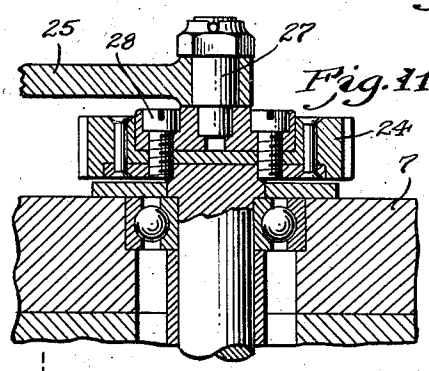
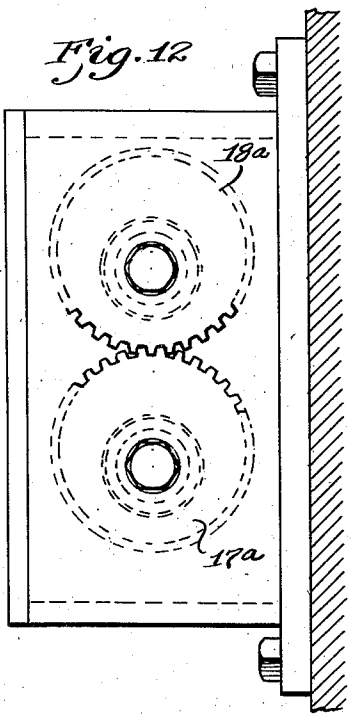


Fig. 11

Fig. 12



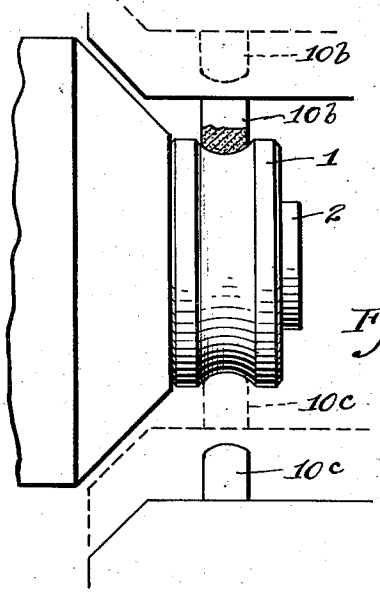


Fig. 13

INVENTOR.
Thomas C. Pew

BY
Barnes, Kisselle, Laughlin & Raisch
ATTORNEYS

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UNITED STATES PATENT OFFICE

2,252,096

METHOD AND APPARATUS FOR FINISHING BALL RACEWAYS OR THE LIKE

Thomas C. Pew, Ann Arbor, Mich., assignor to Hoover Ball & Bearing Company, Ann Arbor, Mich., a corporation of Michigan

Application June 26, 1939, Serial No. 281,072

14 Claims. (Cl. 51—58)

This invention relates to an apparatus for and method of finishing the surface of a machine element which is of curved formation both transversely and longitudinally such as raceways for ball bearings.

The raceway for a ball bearing is, of course, circular in form, and the surface as viewed in cross section is rounded to conform to the shape of the ball, and much difficulty has been encountered in providing a highly finished surface on such a contour. One of the principal objects of the invention is to provide an arrangement where a hone has a surface contact with the raceway circumferentially; that is the hone has an elongated circumferential contact with the surface of the raceway, and more or less wraps around the raceway for a short distance while at the same time the arrangement provides for movement of the hone in the finishing process transversely of the raceway groove. The difficulties of the past have largely been that where the hone is partially wrapped around the race, it could not be moved crosswise. Movement of the hone relative to the race is desirable, for otherwise there is a tendency to cut grooves in the finished surface. The movement permits of changing the location of particles and permits escape of particles which might otherwise scratch the surface if retained in the same location. A hone of cylindrical form which engages in a circumferential groove can be moved transversely of the race in the honing action but a cylindrical form only provides for a line contact, whereas a surface contact is desired.

In accordance with this invention the hone can have a wrapping surface contact with the race and at the same time be shifted or oscillated transversely of the race member in the honing action. The invention is applicable to the honing of both interior and exterior races, and the above remarks are to be considered in this light. The term "hone" is used in a broad sense, it being understood that rough finishes may be obtained by the use of an abrasive member having a considerable abrasive action, and finer finishes can be obtained by an abrasive member having a finer action and not such a great cutting action. Both of these items are intended to be covered by the use of the term "hone."

An arrangement for carrying out the invention is shown in the accompanying drawings.

Fig. 1 is a general view of a machine showing a race with an exterior groove in position on a spindle and illustrating the general features of a machine.

Fig. 2 is a top plan view of the apparatus.

Fig. 3 is a view illustrating the position of the work and hone before the hone is applied to the work.

Fig. 4 is a cross sectional view taken substantially on line 4—4 of Fig. 2.

Fig. 5 is a cross sectional view taken substantially on line 5—5 of Fig. 2.

Fig. 6 is an enlarged cross sectional view taken substantially on line 6—6 of Fig. 2 showing the hone mounting and manipulating device.

Fig. 7 is a cross sectional view taken substantially on line 7—7 of Fig. 6 showing the arrangement for oscillating the hone.

Fig. 8 is a sectional view similar to Fig. 7 showing the device applied to a race with an interior groove.

Fig. 9 is a sectional view taken substantially on line 9—9 of Fig. 8.

Fig. 10 is a plan view of a modified form.

Fig. 11 is a cross sectional view taken substantially on line 11—11 of Fig. 10.

Fig. 12 is a view looking in the direction of line 12—12 of Fig. 10 showing eccentric gears.

Fig. 13 is a view illustrating how two operations may be performed on a race with one setting of the race.

Fig. 14 is a view showing the relative positions of the hone and race in one extreme position of the hone.

Fig. 15 is a view similar to Fig. 14 showing the relative positions of the hone and race in another extreme position of the hone.

Fig. 16 is a view taken substantially on line 16—16 of Fig. 14, showing how the hone wraps the race to obtain a surface contact.

The mechanism for the mounting of the race and for the mounting and movement of the hone may take various forms, but as shown in Fig. 1 the work shown in the form of a race 1 with an exterior groove is mounted upon a spindle 2 journaled in a housing 3 and which may be rotated through the means of a pulley 4. The machine may include a bed 5 upon which is mounted slidably a sub-bed 6 for shifting from right to left as Fig. 1 is viewed and upon which is mounted a head 7 for shift toward and away from the observer. Thus the head 7 may be shifted laterally relative to the spindle axis to bring the hone into and out of position in the raceway. The head and sub-bed 6 may be shifted axially to remove the hone from the raceway, that is, to a position similar to the dotted line position shown in Fig. 1.

The hone is illustrated at 10 and is carried by the head 7. When the hone is in the dotted line position shown in Fig. 1 the head 7 has been shifted rearwardly and the sub-bed 6 with the head shifted to the right. To bring the hone into position, the sub-bed is shifted to the left against the stop 8 where it is latched by latch device 9, and then the head 7 may be shifted forwardly to cause the hone to engage the work. The head 7 may be shifted by means of gear 11 operating a screw 12 or other similar device. The structure thus far described is exemplary of means for mounting the work and the hone.

Referring now to Fig. 2, the drive for the hone may be through a pulley 15, shaft 16, and a gear 17 meshing with gear 18, and then through meshing gears 19 and 20. The provision of these several gears makes it feasible for changing the gears, particularly for reasons as will later appear, although in the arrangement shown in Fig. 2 they are merely for transmitting the driving action. The rotary power is transmitted to a bevel gear 21 which meshes with bevel gear 22. In fact, the beveled gear 22 is a combined bevel gear and spur gear having teeth 23 which mesh with a gear 24. A crank arm 25 is mounted on the gear 24 preferably in an adjustable manner. To this end a plate 26 is slidably mounted on the gear 24 and the plate carries a stud 27 which amounts to a crank (Figs. 2 and 11). Plate 26 has elongated apertures by means of which it may be adjusted and held to the gear 24 by screws 28 passing therethrough. Once the plate has been properly adjusted, such adjustment may be maintained by drilling a hole through the plate and into the gear and by the insertion of a pin through the aligned holes. Such holes for receiving locking pins are illustrated at 29. The adjustment of the plate 26 determines the throw of the crank stud 27.

A gear 30 is connected to the other end of the arm 25 as at 31, and it will be seen that rotation of the gear 24 oscillates the gear 30. The throw of the pin 27, that is the distance of the center of the pin from the center of the gear 24 determines the angularity of the oscillation of the gear 30.

In making reference to Fig. 6 it will be seen that the gear 30 meshes with the two smaller gears 32 and 33, and the reduction is advantageously two to one so that if the gear 30 is oscillated through 55°, for example, the gears 32 and 33 oscillate through 110°. This assembly has been found to be an expedient arrangement. The gears 30 and 33 are keyed to shafts 34 and 35, which are mounted in bearings as illustrated, and the ends of these shafts have enlarged hollow heads 36 and 37. Within these hollow heads are positioned eccentric bushings 38. As shown in Fig. 7 these bushings may be made of two matched pieces with the dividing lines therebetween illustrated at 40.

A stud is located within each bushing, the studs being illustrated at 41 and they have heads 42 so that the studs are held in position by the bushings, and this is the reason for making the bushings in two matched halves so that they can be placed around the journaled portions of the studs. After the bushings and studs are located, they may be held in position by rings 43 secured to the ends of the shafts 34 and 35, and the bushings are shouldered to receive the rings as illustrated. The bushings are keyed or pinned to the shafts 34 and 35 to oscillate therewith. To this end a pin 45 may pass through the recessed head of each shaft and into the bushing, the pin advantageously being disposed on the line separation between the two halves of the bushing. These pins are shown in Fig. 7 and one is illustrated in Fig. 4.

The exposed ends of the studs 41 are of enlarged formation, this formation being illustrated at 46 (Fig. 4) and are of U-shape and arranged to be crossed by closure plates 47. A holder for a hone which may take the form of a tube of square formation is slidably mounted in the two enlarged portions of the studs. Such a holder is illustrated at 50 and it may have an adjustable screw backing member 51 which bears against the body of the hone 10 slidably mounted in the tubular holder. The holder may be spring pressed toward the work, to which end one end of the holder is closed by a plate 53, and coil springs 54 connect the plate and projections 55 on the oscillating stud 41 adjacent this rear end of the holder.

Before proceeding with the modified forms the operation of the structure may be considered. With the race in position on the spindle 2 and the hone in the dotted line position shown in Fig. 1, in which position the hone is retracted from the spindle, the sub-bed 6 may be shifted to the left to align the hone with the work. The parts are now in a position as illustrated in Fig. 3. Then by turning the wheel 11 the head 7 is advanced toward the work and the hone is brought up against the work as illustrated in Figs. 6, 7 and 14 to 16, inclusive. The bushings are so arranged as to oscillate the hone to and from the extreme positions substantially shown in Figs. 14 and 15. The cross dimensions of the hone are preferably somewhat less than the cross dimensions of the raceway. With a 55° throw of the gear 24, the gears 32 and 33, and likewise the eccentric bushings, are given a 110° throw. It has been found that an eccentricity of the bushings of about .012 of an inch is satisfactory for use with raceways for balls ranging from $\frac{7}{16}$ to $\frac{5}{8}$ of an inch in diameter. By this I mean that the centers are .012 of an inch off from each other, which would give, on a complete rotation, a movement of .024 of an inch. The springs 54 urge the hone with light pressure against the work, say from 8 ounces to about a pound and a half, although this is variable. It would probably be desirable to increase the pressure in cases where a rough finish is desired.

Assuming that the hone has the shape illustrated in Figs. 14; 15 and 16, it oscillates to and from the positions shown in Figs. 14 and 15, while the springs urge the holder forward so that there is a slight reciprocating movement of the holder and its hone. As the hone wears away the springs take up the loss, but from time to time the hone may be advanced by the screw 51. Thus the hone constantly moves back and forth across the raceway together with a movement in and out radially while maintaining a surface contact by the slight wrapping action illustrated in Fig. 16. When the hone is in the position shown in Fig. 14, the raceway is engaged along a narrow surface having the circumferential extent shown in Fig. 16, and as it moves across to the Fig. 15 position, the surface engaged progressively moves across the surface of the groove. Theoretically, it may be considered that there is only a line contact, but as a matter of fact there is a slight surface contact. To illustrate what is meant, lines are shown in Figs. 14 and 15 more or less dividing the surface into areas a, representing the surface

contact between the hone and the raceway at different positions of the hone.

It will be found that the hone keeps itself dressed to the true shape of the raceway. The radius on the hone will be generated thereon to the radius of the raceway less the amount of the eccentricity. The end of the hone will shape itself to the circumferential contour of the raceway so that the hone has a wrapping action as shown in Fig. 16. The contour of the end of the hone, when viewed after the manner of Fig. 16, will be such that the hone fits that portion of the race with which it contacts, and this shape will be generated on the hone. In other words, when the hone is in the Fig. 15 position, it contacts throughout its circumferential extent with the upper area *a*; as the hone moves across the race its surface will make contact with the next area *a* and so on across the entire surface of the raceway. Thus it will be seen that there is a surface contact between the hone and the raceway, with a constant shift of the hone across the raceway, which prevents the cutting of grooves or the marring of the surface, and permits of the escape of abrasive particles. By way of example it might be stated that good results have been obtained where the work was given 1100 R. P. M. with about 1300 oscillations per minute of the hone; that is, 1300 complete cycles of the hone from the Fig. 14 position to the Fig. 15 position and back. However, at the commencement of the operation, it may be desirable to rotate the work at a low R. P. M., say about 600, and to have a high hone oscillation, say about 1500 per minute; while at the finish of an operation, the work may be speeded up to 1500 R. P. M. and the oscillations of the hone diminished to about 600 R. P. M. These figures are given for exemplary purposes only and are not to be construed as limiting the invention.

This manner of honing the race does not destroy the contour, and provides a highly finished surface which materially increases the life of the bearing and makes the bearing function much more quietly.

For honing a race which has an interior groove, an arrangement shown in Figs. 8 and 9 may be employed. In this case a support **60** is carried by the studs **41** and this support slidably carries the hone holder **61** positioned at right angles thereto. The hone holder has a back plate **62** acted upon by coil springs **63** and connected to the support as at **64** for holding the hone **10***a* against the race. With this arrangement, since the hone has been turned through 90°, it is only necessary to shift the bushings **38***a* through 90° to thus get the same movement as that previously described. As a matter of fact, the hone may be disposed at most any angle and the same hone movement may be imparted thereto by relatively adjusting the bushings to correspond to the angle of the hone.

As shown in Fig. 13 two operations may be given to a race with one mounting of the race. The spindle and race shown in this view bear the same characters as those previously used, and two hones may be mounted after the manner illustrated in Figs. 1 and 2 to approach the work from different sides. The hone **10***b*, as shown, may give the work a rough finish, and then it may be retracted to the dotted line position where it is inoperative and the hone **10***c* moved into engagement with the work to give the final finish. As a matter of fact several hones may be thus grouped around the work to perform as many rough and final finishing operations.

The arrangement thus far described is such that the hone moves with uniform action; that is to say, its oscillations and speed of movement is uniform with a constant R. P. M. of the driving mechanism. In Figs. 10, 11 and 12 an arrangement is shown for giving to the hone recurring variations in its speed of movement and also to break up the regularity of the recurring variations. The arrangement shown in Fig. 10 and in Fig. 11 is substantially the same as that shown in Fig. 2, and the corresponding parts are given the same reference characters. However, the gears **17***a* and **18***a* are eccentric gears, as shown in Fig. 12. Thus with the shaft **16** operating at a uniform R. P. M., the speed of the gear **18***a* varies. Accordingly, the speed of movement of gear **22** similarly varies, and this varies the speed of movement of the hone in its oscillations. That is to say, in some positions of the hone in its cycle of movement, the hone will move faster than in other positions. Now in order to break up the regular recurring manner of such variation in the speed of the hone, gears **19***a* and **20***a*, instead of having a direct or uniform ratio relative to each other, are arranged to have some odd ratio. For example, these two gears may have an odd arrangement of teeth, such, for example, as 63 to 33, or vice versa, and 47 to 49, or vice versa, or some other arrangement of this character. These figures are only given as examples. With this arrangement, the regular recurring variation in the R. P. M. of the gear **24** is broken up so that the variation in movements of the hone takes place at various places in its cycle of movement. This is one reason for providing the gear arrangement shown, since different arrangements may be obtained by merely changing the gears **17***a* and **18***a*, as well also as the gears **19***a* and **20***a*. The eccentric gears may be used with or without the odd ratio gears **19***a* and **20***a*, but in this case the movements of the hone varies in a regular recurring manner. The structure shown in Fig. 11 is no different than the corresponding structure of these parts in the apparatus shown in Fig. 2, but Fig. 11 may be employed for the purpose of showing the parts in Fig. 2 in a different position.

In some of the claims appended hereto, use is made of the term "hone." It is advantageous to use such a term for the sake of brevity, and the word is to be construed to mean any suitable abrasive or polishing element. Some of the claims make use of the term "wrap" or "wrapping" in describing the contact between the hone and the race. This means that the hone contacts with the race measured circumferentially for a distance as distinguished from a line contact. Some of the claims, particularly the apparatus claim, call for an apparatus for acting upon a ball bearing race or the like. This language is to be construed to cover any device, regardless of whether or not it is a ball bearing race, and so long as it has a surface which is of curved formation transversely and longitudinally.

I claim:

1. The method of finishing the surface of a ball bearing race which comprises applying to the race under pressure a hone having a cross dimension less than the cross dimension of the race and having a dimension measured circumferentially of the race such that the hone has a wrapping fit with the race, causing relative ro-

tation between the race and the hone and oscillating the hone crosswise of the race.

2. The method of finishing the surface of a ball bearing race which comprises applying to the race under yielding pressure a hone having a cross dimension slightly less than that of the cross dimension of the race and having a dimension measured circumferentially of the race such that the hone has a wrapping fit with the race, causing relative rotation between the race and the hone and oscillating the hone crosswise of the race whereby the hone follows the contour of the transverse curve of the race incident to the yielding pressure.

3. The method of finishing a surface of a machine element, which surface is of curved formation transversely and longitudinally, applying to the race yieldably and under pressure a hone having a dimension measured longitudinally of the surface such that the hone has a wrapping fit on the longitudinally curved surface, causing relative movement between the surface and the hone for the presentation of successive longitudinally related portions of the surface to the hone, oscillating the hone transversely of the surface whereby the hone follows the transverse curvature of the surface, the hone having dimensions measured transversely of the surface whereby it is adapted to present different surfaces for contact with successive transversely related portions of the surface as the hone oscillates.

4. The method of finishing a surface of a machine element, which surface is of curved formation transversely and longitudinally, applying to the race yieldably and under pressure a hone having a dimension measured longitudinally of the surface such that the hone has a wrapping fit on the longitudinally curved surface, causing relative movement between the surface and the hone for the presentation of successive longitudinally related portions of the surface to the hone, oscillating the hone transversely of the surface whereby the hone follows the transverse curvature of the surface, the hone having dimensions measured transversely of the surface whereby it is adapted to present different surfaces for contact with successive transversely related portions of the surface as the hone oscillates and varying the speed of movement of the hone in its oscillation.

5. The method of finishing a surface of a machine element, which surface is of curved formation transversely and longitudinally, applying to the race yieldably and under pressure a hone having a dimension measured longitudinally of the surface such that the hone has a wrapping fit on the longitudinally curved surface, causing relative movement between the surface and the hone for the presentation of successive longitudinally related portions of the surface to the hone, oscillating the hone transversely of the surface whereby the hone follows the transverse curvature of the surface, the hone having dimensions measured transversely of the surface whereby it is adapted to present different surfaces for contact with successive transversely related portions of the surface as the hone oscillates, and varying the speed of movement of the hone in its oscillations in an irregularly recurring manner.

6. The method of finishing the surface of a ball bearing race which comprises applying to the race yieldingly and under pressure a hone having dimensions measured longitudinally of the race such that the hone has a wrapping fit longitudinally on the surface, causing relative rotation between the race and the hone for the presentation of successive longitudinally related portions of the surface to the hone, said hone having dimensions measured transversely of the surface such that it is adapted to present different surfaces for contact with successive transversely related portions of the surface, and oscillating the hone transversely of the surface whereby the hone follows the transverse curvature and presents such different surfaces to the successive transversely related portions of the race surface.

7. The method of finishing the surface of a ball bearing race which comprises applying to the race yieldingly and under pressure a hone having dimensions measured longitudinally of the race such that the hone has a wrapping fit longitudinally on the surface, causing relative rotation between the race and the hone for the presentation of successive longitudinally related portions of the surface to the hone, said hone having dimensions measured transversely of the surface such that it is adapted to present different surfaces for contact with successive transversely related portions of the surface, and oscillating the hone transversely of the surface whereby the hone follows the transverse curvature and presents such different surfaces to the successive transversely related portions of the race surface and varying the speed of movement of the hone in its oscillatory motion.

8. The method of finishing the surface of a ball bearing race which comprises applying to the race yieldingly and under pressure a hone having dimensions measured longitudinally of the race such that the hone has a wrapping fit longitudinally on the surface, causing relative rotation between the race and the hone for the presentation of successive longitudinally related portions of the surface to the hone, said hone having dimensions measured transversely of the surface such that it is adapted to present different surfaces for contact with successive transversely related portions of the surface, and oscillating the hone transversely of the surface whereby the hone follows the transverse curvature and presents such different surfaces to the successive transversely related portions of the race surface and varying speed of movement of the hone in its oscillatory motion in an irregularly recurring manner.

9. The method of finishing the surface of a ball bearing race which comprises applying to the race yieldingly and under pressure a hone having dimensions measured longitudinally of the surface such that the hone has a wrapping fit on the longitudinally curved surface and having dimensions measured transversely of the race surface substantially equal to the transverse dimension of the race surface less the amount of the below mentioned oscillation to be given to the hone, causing relative rotation between the race and the hone for the presentation of successive longitudinally related portions of the surface to the hone, and oscillating the hone transversely of the race surface whereby the hone follows the transverse curvature and presents different parts of its surfaces for contact with successive transversely related portions of the race surface.

10. An apparatus for finishing the surface of a member such as a ball bearing race or the like which comprises, means for holding and rotating the race, a hone for application to the

race surface having a dimension in one direction for a wrapping fit with the race surface and a dimension in a direction perpendicular to the first dimension for the presentation of different parts of its own surface to successive transversely related portions of the race surface, a holder for the hone, means for yieldingly applying the hone to the race surface, means for oscillating the hone transversely of the race surface including an eccentric bushing, and means for oscillating the bushing.

11. An apparatus for finishing the surface of a member such as a ball bearing race or the like which comprises, means for holding and rotating the race, a hone for application to the race surface having a dimension in one direction for a wrapping fit with the race surface and a dimension in a direction perpendicular to the first dimension for the presentation of different parts of its own surface to successive transversely related portions of the race surface, a holder for the hone including means for yieldingly applying the hone to the race surface, eccentric bushings supporting the holder, and means for oscillating the bushings to oscillate the hone transversely across the race surface.

12. An apparatus for finishing the surface of a member such as a ball bearing race or the like which comprises, means for holding and rotating the race, a hone for application to the race surface having a dimension in one direction for a wrapping fit with the race surface and a dimension in a direction perpendicular to the first dimension for the presentation of different parts of its own surface to successive transversely related portions of the race surface, a holder for the hone including means for yieldingly applying the hone to the race surface, rockable means for supporting the holder and for oscillating the hone transversely across the race surface, means for operating the rockable means including eccentric gears for varying the speed of movement of the hone in its oscillatory action.

13. An apparatus for finishing the surface of a member such as a ball bearing race or the like which comprises, means for holding and rotating the race, a hone for application to the race surface having a dimension in one direction for a wrapping fit with the race surface and a dimension in a direction perpendicular to the first dimension for the presentation of different parts of its own surface to successive transversely related portions of the race surface, a holder for the hone including means for yieldingly applying the hone to the race surface, rockable means for supporting the holder and for oscillating the hone transversely across the race surface, means for operating the rockable means including eccentric gears for varying the speed of movement of the hone in its oscillatory action, and also including related gears with an odd ratio for causing an irregular recurrence of the variation in the speed of movement of the hone.

14. An apparatus for finishing the surface of a member such as a ball bearing race or the like which comprises, means for holding and rotating the race, a hone for application to the race surface having a dimension in one direction for a wrapping fit with the race surface and a dimension in a direction perpendicular to the first dimension for the presentation of different parts of its own surface to successive transversely related portions of the race surface, a holder for the hone including means for yieldingly applying the hone to the race surface, rockable means for supporting the holder and for oscillating the hone transversely across the race surface, means for operating the rockable means including eccentric gears for varying the speed of movement of the hone in its oscillatory action, and also including means for causing an irregular recurrence of the variation in the speed of movement of the hone.

THOMAS C. PEW.