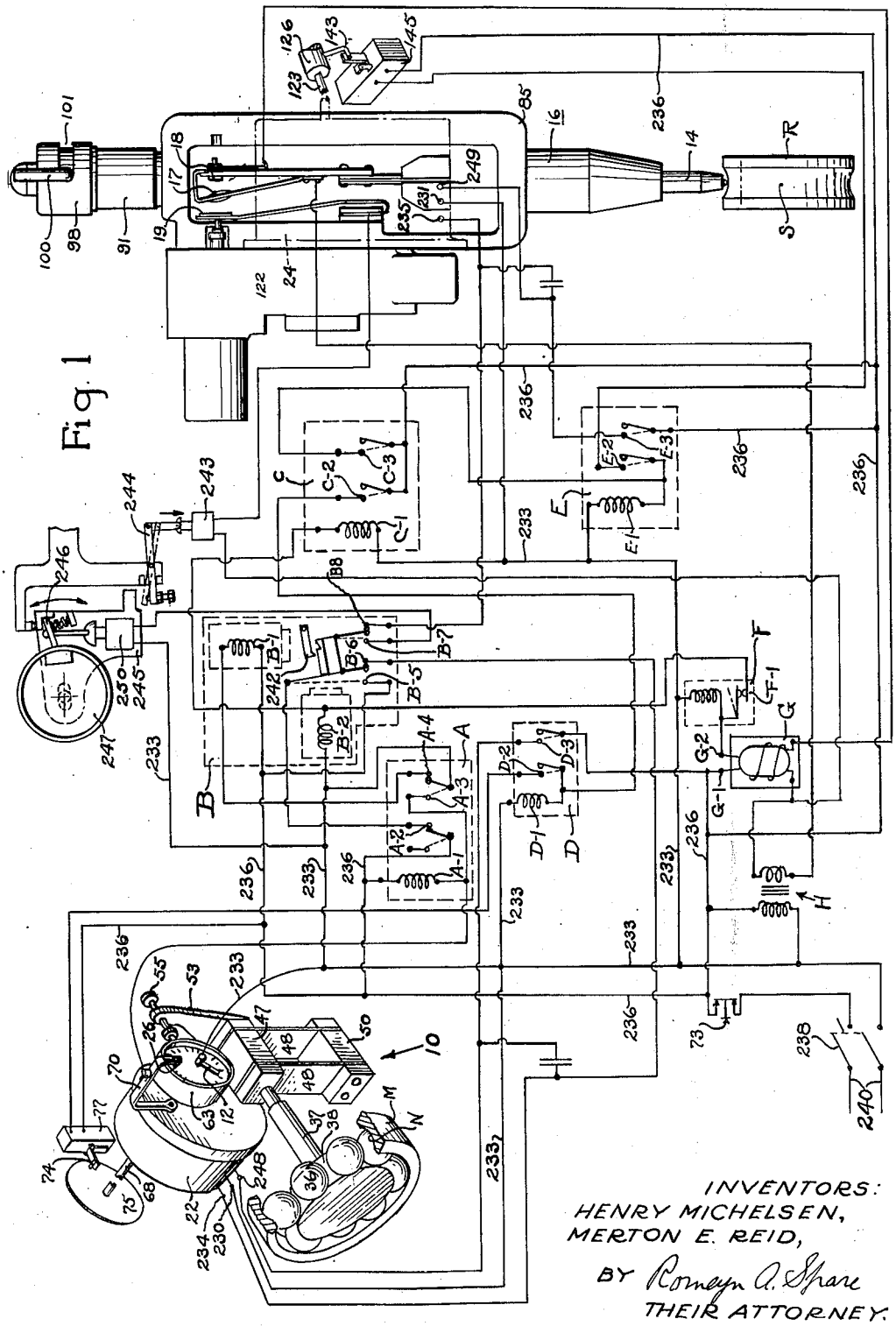
Jan. 25, 1949. H. MICHELSEN ET AL 2,460,232

GAUGING APPARATUS FOR CONTROLLING A GRINDING OPERATION

Filed Aug. 16, 1944 4 Sheets-Sheet 1

Fig. 1



Jan. 25, 1949. H. MICHELSEN ET AL 2,460,232

GAUGING APPARATUS FOR CONTROLLING A GRINDING OPERATION

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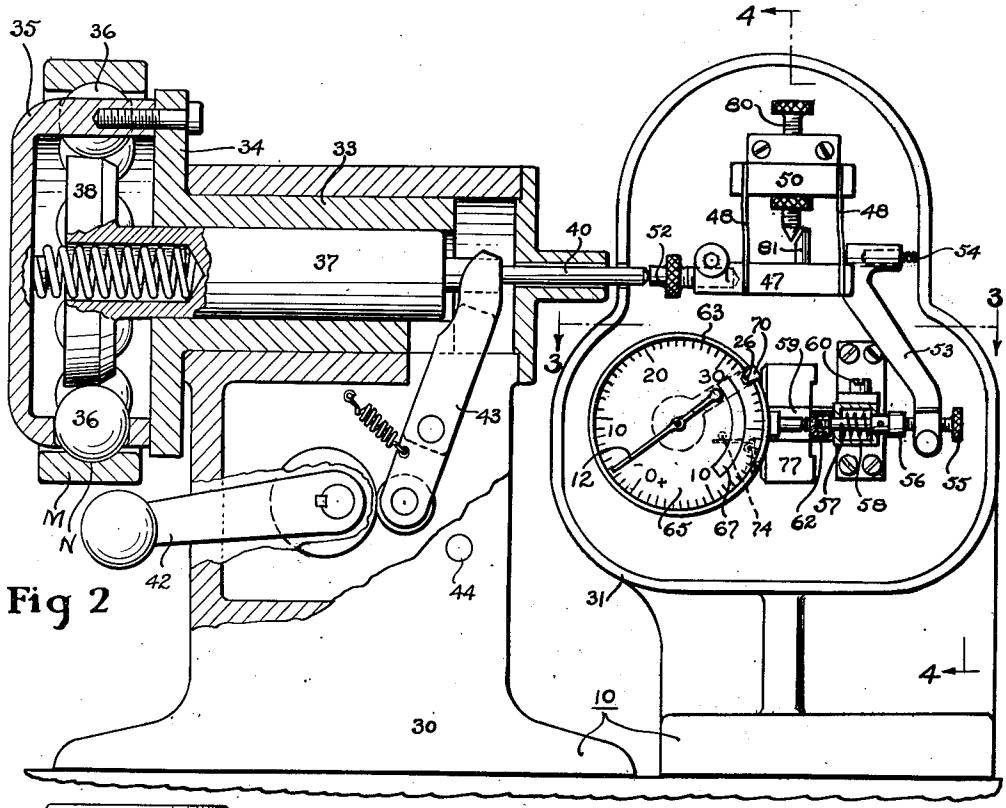


Fig 2

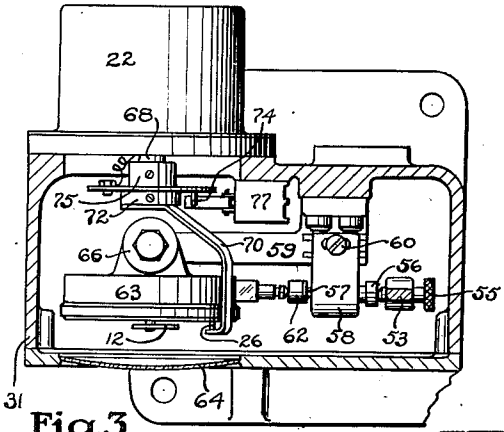


Fig.3

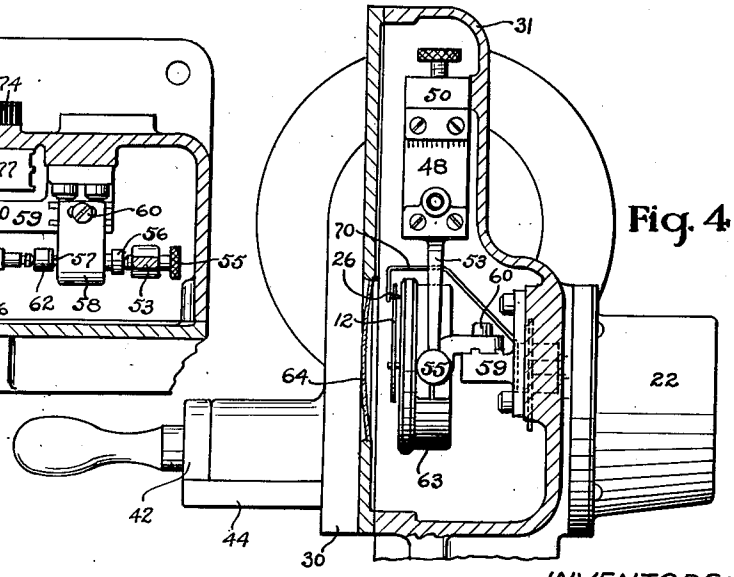


Fig. 4

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GAUGING APPARATUS FOR CONTROLLING A GRINDING OPERATION

Filed Aug. 16, 1944 4 Sheets-Sheet 3

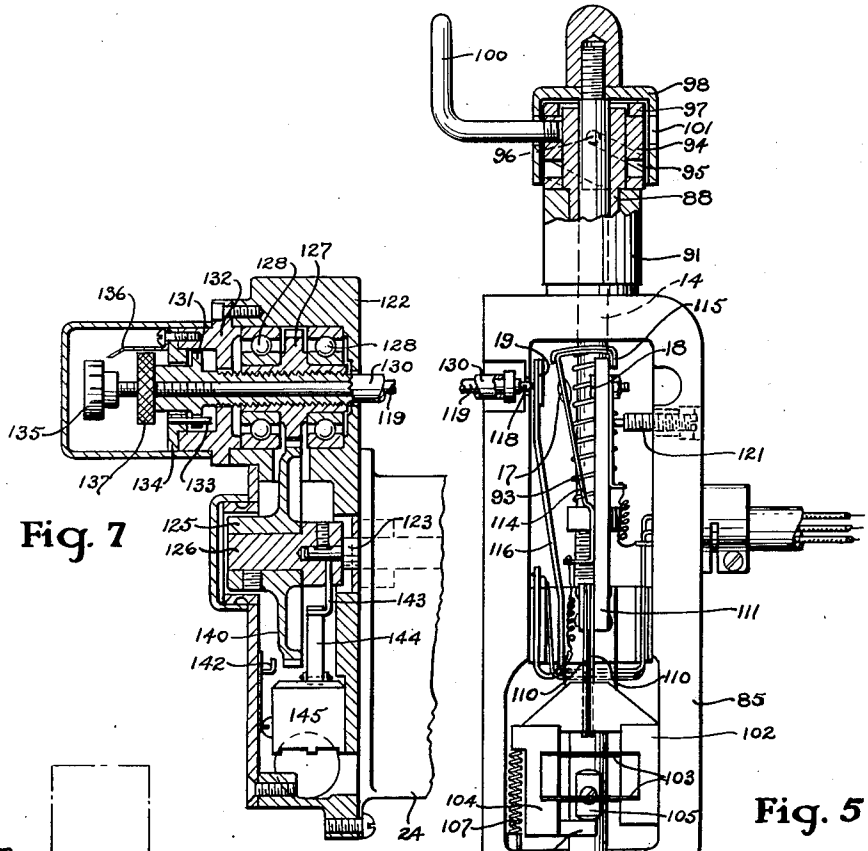


Fig. 7

Fig. 5

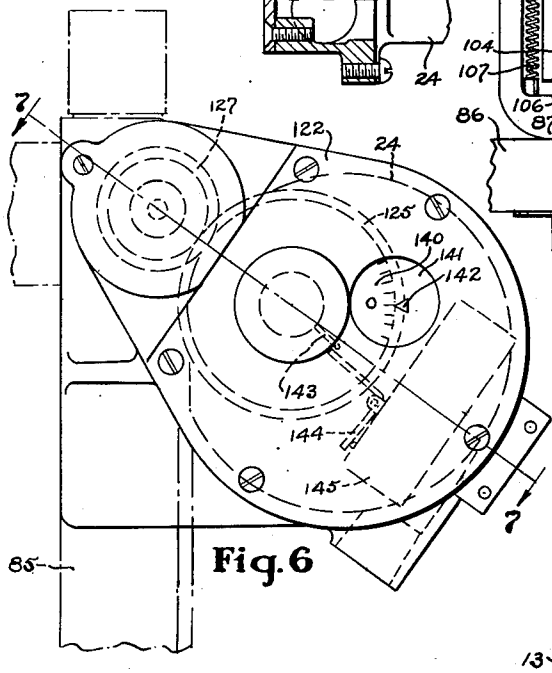


Fig. 6

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GAUGING APPARATUS FOR CONTROLLING A GRINDING OPERATION

Filed Aug. 16, 1944 4 Sheets-Sheet 4

Fig. 8

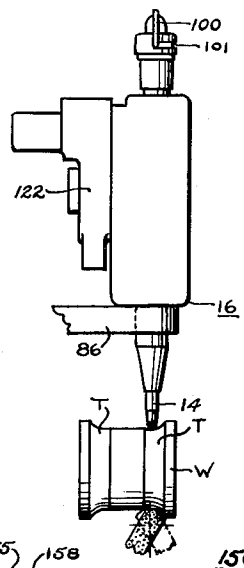


Fig. 9

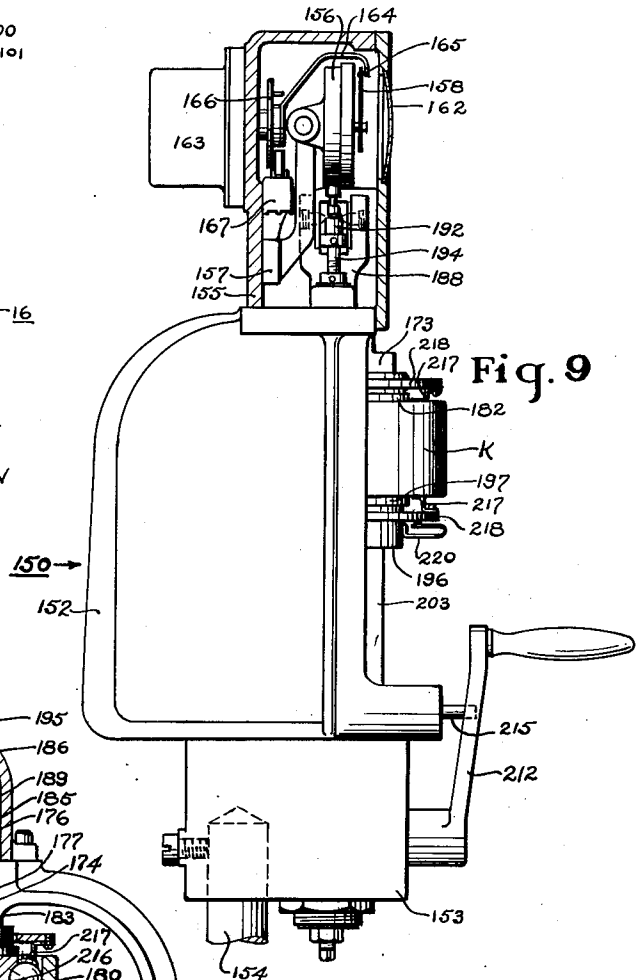
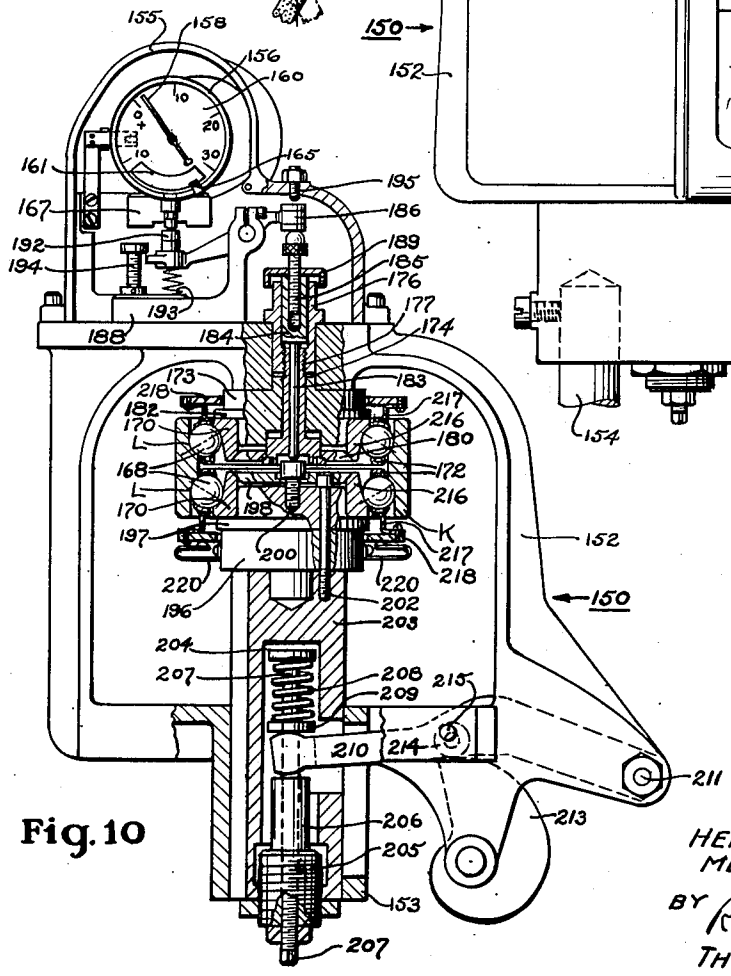


Fig. 10



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Patented Jan. 25, 1949 2,460,232

UNITED STATES PATENT OFFICE

2,460,232

GAUGING APPARATUS FOR CONTROLLING A GRINDING OPERATION

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Application August 16, 1944, Serial No. 549,666

21 Claims. (Cl. 51—165)

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This invention relates to gauging apparatus and particularly to gauging apparatus which controls a sizing operation on a work piece.

An object of the invention is to provide an improved gauging apparatus for controlling the grinding of a work piece to size.

Another object is to provide an improved gauging apparatus for controlling a grinding operation on an article in response to the finished size of another article.

Another object is to provide an improved gauging mechanism for controlling a grinding operation on one of a pair of articles remotely positioned from each other and intended for mating relation and wherein the finished size of one of these articles controls the size to which the other article is ground.

To these ends and also to improve generally upon devices of the character indicated, the invention consists in the various matters hereinafter described and claimed. In its broader aspects, the invention is not necessarily limited to the specific constructions selected for illustrative purposes in the accompanying drawings wherein;

Figure 1 is a diagrammatic view including a showing of the electrical circuits and illustrating the operation of the invention;

Figure 2 is a fragmentary side elevation of the remote control gauging mechanism;

Figure 3 is a view in cross section taken substantially along the line 3—3 of Figure 2;

Figure 4 is a vertical section taken substantially along the line 4—4 of Figure 2;

Figure 5 is a partially broken away side elevation of the work piece gauging head;

Figure 6 is a front elevation of the regulating mechanism for the gauging head;

Figure 7 is a cross section through the regulating mechanism and taken along the line 7—7 of Figure 6;

Figures 8, 9 and 10 relate to a modification;

Figure 8 shows the work piece gauging head engaging one of the raceways on a race ring for a double row antifriction bearing;

Figure 9 is a partially broken away side elevation of a remote control gauging mechanism for measuring the raceways of a double row race ring; and

Figure 10 is a fragmentary front elevation of the remote control gauging mechanism of Figure 9.

This invention, which controls a machining operation for reducing an article to a size determined by the size of another article, is especially adapted for controlling the grinding to size of

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an antifriction bearing race ring by mechanism which measures the finished size of another race ring. Heretofore, it has been common practice to employ oscillating grinding machines for separately grinding the mating inner and outer raceway grooves in ball bearing race rings to predetermined sizes within as close limits of accuracy as the grinding machines were capable. Grinding errors may be present in one or in both raceways that are to be used in mating relation, and frequently these errors may be cumulative. Attempts to reduce these cumulative errors have been made by gauging and matching the raceway sizes of the inner and outer race rings for mating relation so that one error would tend to offset or minimize the other error. In some instances, these errors have also been reduced by selecting the size of the balls which roll within these mating raceways. However, the additional operations of carefully gauging and sorting race rings and bearing balls into matching relation seriously retards production and frequently results in bearings with balls that do not correctly fit their raceways. In accordance with this invention, either the outer or the inner race rings are initially ground in a suitably simple manner and as closely as possible to the desired raceway size. Thereafter, each of these ground race rings, irrespective of its raceway size, is employed in conjunction with the gauging mechanism to control the grinding to a corresponding size of the raceway in a race ring to be used therewith in mating relation. By way of illustration, this invention is described by reference to the grinding of the raceway of a ball bearing inner race ring under control of gauging mechanism which precisely measures the finished raceway size of the outer race ring that is to be assembled in mating relation with this inner ring as a part of the final bearing.

Generally considered, an outer race ring as M, has a finished raceway N measured by a remote-control gauging mechanism 10 having an indicator hand 12 movable over a dial to indicate the raceway size. An inner race ring, as R, provided with a raceway S to be ground by a grinding wheel 13 to a size for assembly in mating relation through standard sized bearing balls with the raceway N, is rotatably mounted in the usual manner for grinding, as on an oscillating grinding machine. The details of this mounting and of the grinding machine are not herein illustrated since they can be variously constituted and are well understood in the art. During grinding, a vertically movable stem 14 in a gauging head

16 responds to the size of the raceway S and acts through amplifying leverage to shift a pair of contactors 17 and 18 towards an adjustable contactor 19 which is prelocated in accordance with the size of the raceway N. Similar slow-speed synchronous motors 22 and 24, respectively secured on the gauging mechanism 10 and on the gauging head 16, are simultaneously started from predetermined individually controlled starting positions after the indicator hand 12 has reached a measuring position. The motor 24 advances the contactor 19 towards the contactors 17 and 18 until a contactor 26, moved by the motor 22, engages the indicator hand 12 to close a relay circuit which stops both motors. When the raceway S is nearly down to final size, the advancing contactor 17 engages the prelocated contactor 19 to electrically control a change in grinding feed from a coarse feed to a fine feed, and when the raceway is completely ground except for sparking out, the contactor 18 engages the contactor 17 to electrically control the stopping of the grinding feed. At the completion of the grinding feed, the motors 22 and 24 are reversed to return the contactors 26 and 19 to their predetermined starting positions.

In the illustrated embodiment, the remote control gauging mechanism 10, which may be suitably supported remotely from the gauging head 16, has a body portion 30 and a housing 31 mounted in adjacently fixed relation on a suitable support. A horizontally disposed sleeve 33 fastened in the body portion 30, has an end flange 34 to which is secured a dished ball retainer 35 that has a cylindrical wall provided with a series of circumferentially spaced apertures through which balls 36 project for gauging contact with the raceway N. These balls preferably have the same size as and are spaced correspondingly to the balls which will later be assembled with this race ring M in a ball bearing, and the apertures which loosely receive these balls 36 are preferably restricted sufficiently at their outer ends to prevent the balls from falling out of the ball retainer when there is no race ring being gauged. A plunger 37, journalled in the sleeve 33 for longitudinal and rotatable movement, has at one end a frusto-conical ball-engaging head 38, and has at its other end a stem 40 that freely extends into the housing 31. A coiled spring, projecting from a recessed end of the plunger 37 and compressed against the ball retainer 35, yieldably urges the plunger towards the housing 31 and into a gauging position which is determined by that axial position of the conical head 38 which locates the balls 36 seated against the raceway N. To assure that these balls will locate in correctly seated raceway engagement, the race ring M may be turned manually causing the balls to roll on the raceway N and on the conical head 38. A hand lever 42, mounted on a shaft carried by the body portion 30, operates a cam against a roller on the lower end of a pivoted lever 43 to swing the upper end of this lever against the plunger 37 and shift the conical head 38 towards the ball retainer 35 so that the balls 36 may move radially inwardly of the ball retainer to allow the race ring M to be moved over the balls into and out of gauging positions. A spring urges the lever 43 away from plunger engagement, and the hand lever 42 may be swung to rest against a supporting stud 44 to hold the plunger 37 in non-gauging position.

A horizontally movable block 47, supported by a pair of reed springs 48 that depend from a bracket 50 in the housing 31, has threaded into one end an adjusting screw 52 fastened in adjusted position to be engaged by the stem 40. A depending arm 53 is secured to the other end of this block. A coiled spring 54, compressed between the arm 53 and the housing, co-operates with the reed springs 48 to urge the block 47 and the depending arm towards the left to a gauging position determined by the engagement of the screw 52 with the stem 40. A screw 55, secured in adjusted position in the lower end of the arm 53, is engaged by a head 56 on a horizontally disposed spring pressed plunger 57 longitudinally slidable in a bracket 58 that is fastened in horizontally adjusted position on a housing arm 59 by a screw 60. A cap 62, insulated from and secured to the plunger 57, is engaged by the spring pressed stem of a dial indicator 63 visible through a housing window 64. This indicator has a graduated dial 65 over which the indicator hand 12 moves to show the variation from standard size of the raceway N. A screw clamps the dial indicator in position on the arm 59 and insulating washers 66 prevent grounded electrical connection between the dial indicator and the arm 59. The screw 52 is preferably so adjusted that the lower ends of the reed springs 48 are deflected slightly towards the arm 53 during a gauging operation, and the screw 55 is adjusted to position the indicator hand 12 at a zero index when the balls 36 are in gauging position against a raceway of standard size. In the present instance, the dial 65 is shown graduated at each side of the zero index so that the indicator hand 12 will indicate the extent of oversize or undersize of the diameter of the raceway N in ten thousandths of an inch. For convenience, the dial 65 is also marked with an arcuate zone 67 that is located beyond the range of acceptable raceway diameter. Hence, whenever the operator sees the indicator hand 12 at a measuring position within this zone 67, he discards the race ring being gauged since its raceway lies outside of an acceptable size range.

The reversible slow-speed synchronous motor 22 is fastened to the housing 31 and has a reduction gearing provided with a shaft 68 coaxial of the indicator hand 12. An arm 70, overlying the dial indicator 63 is secured at its inner end to a collar 72 of insulating material fastened in adjusted position on the shaft 68 as by a set screw, and the other end of this arm 70 carries the contactor 26 which is swung into and out of engagement with the indicator hand and in a path adjacent to the dial graduations. After the indicator hand has reached a measuring position, the operator presses a starting button 73 which energizes circuits to be later described and simultaneously starts both motors 22 and 24 operating in synchronism, and these motors advance the contactors 26 and 19 from their initial preset positions shown in Figures 2 and 5. The contactor 26 is moved counterclockwise as viewed in Figure 2 until it engages the indicator hand 12 and closes electrical circuits which cause both motors to simultaneously stop with the contactor 19 located in a position determined by the measuring position of the indicator hand 12. At the end of the grinding wheel feed these motors are reversed to return the contactors 19 and 26 to their initial starting positions. During this motor reversal, the contactor 26 swings clockwise away from the indicator hand 12 until a pin 74, projecting from a flange on a collar 75 adjustably fastened to the

shaft 68, as by a set screw, shifts a bell crank to operate a switch 77 which stops the motor 22. This initial preset position to which the contactor 26 is returned may be preadjusted by rotatably positioning the collars 72 and 75 relative to each other.

The indicator hand 12 cannot be swung into electrical contact with the contactor 26 while this contactor is located at its preset starting position of Figure 2 because movement of the indicator stem is limited in both directions. The cap 62 will engage the adjusted bracket 58 and limit outward movement of the stem, and this stem cannot be urged inwardly by the plunger 57 beyond a point determined by the engagement of a stud 81 with the lower end of an adjusting screw in the bracket 50.

The gauging head 16 has a casing 85 that is supported in a fixed position by a bracket 86, and the stem 14 is vertically slidable in a bushing 87 in the bottom of the casing and in a bushing 88 having a lower reduced portion fitted within a boss 91 on top of the casing. A wear-resistant gauging point 92, on the lower end of the stem 14, is arranged to ride upon the raceway S for vertically positioning the stem 14 during grinding, and a coiled spring 93, interposed between the top of the casing 85 and an adjusting nut on this stem, urges the stem downwardly into a gauging position. A collar 94, journalled on the enlarged upper end of the bushing 88 and seated on top of the boss 91, has a generally spiral slot 95 open at its lower end and slidably engaging a fixed pin 96 that laterally projects from the enlarged upper end of the non-rotatable bushing 88. A washer 97, fitted over the upper end of the bushing 88, is normally loosely interposed between the top of the collar 94 and the underside of a cap member 98 that is fastened by a nut against a shoulder on the upper end of the stem 14. A hand lever 100, threaded into the collar 94, laterally extends through a slot 101 in the cap member 98. When the hand lever 100 is turned to the position of Figure 5 where the pin 96 is at the top of the spiral slot 95, the stem 14 is lowered into supported relation on the raceway S, and there is sufficient clearance between the cap member 98 and the washer 97 so that the stem 14 is free to move downwardly and remain in raceway engagement during the grinding of this raceway to size. When the hand lever 100 is swung in an opposite direction, the collar 94 moves upwardly on the pin 96 and acts through the washer 97 to lift the cap member 98 causing the stem 14 to be lifted out of gauging position so that race rings R may be mounted in and demounted from grinding position. If desired, the hand lever 100 may be turned sufficiently to remove the pin 96 from the bottom of the slot with the bottom of the collar 94 resting on this pin to hold the stem 14 in raised position.

A block 102, fastened to a lower portion of the casing 85, holds an end of each of a pair of spaced horizontally extending thin reed springs 103 whose opposite ends cooperatively support a block 104 for vertical floating movement. A block 105, secured to and laterally projecting from the stem 14, has a hardened contact point on its lower end engaged by a laterally projecting arm 106 on the floating block 104 which is urged upwardly by a coiled spring 107 causing this floating block 104 to take a vertical position corresponding to the vertical position of the stem 14. A pair of upwardly extending flat springs 110, whose spaced lower ends are secured respectively to the upper

ends of the blocks 102 and 104, are spaced at their upper ends by a plate, and an upwardly extending amplifying finger 111 of insulating material has its lower end tightly secured as by rivets to the spaced upper ends of both springs 110 and to the plate therebetween. A spring finger 114, provided with the contactor 17 and secured at its lower end to the amplifying finger 111, tends to spring outwardly from the amplifying finger to a position determined by the engagement of a depending lug 115 on the arcuate upper end of the spring finger 114 against the finger 111 to initially position the contactor 17 at a predetermined spaced distance from the contactor 18 which is adjustably threaded through the upper end of the amplifying finger 111. A spring finger 116, secured at its lower end to an insulating block on the casing 85, carries the contactor 19 at its upper end and urges this contactor 19 away from the contactors 17 and 18 to a position determined by the engagement of the upper end of the spring finger 116 against the rounded end of a stud 118 of insulating material extending into the casing 85 and mounted on the inner end of a horizontal adjusting rod 119.

The downward movement of the stem 14 and of the floating block 104, in response to a reduction in diameter of the raceway S, produces a corresponding downward movement of the spring 110 secured to the floating block 104 while the fixed block 102 prevents a bodily downward movement of its spring 110. The relative movement of these springs 110 causes a greatly amplified swinging movement of the amplifying finger 111 towards the contactor 19 so that the contactor 17 will make circuit with the contactor 19 and cause the initial rough grinding feed to change to a finish grinding feed when the raceway S has been reduced to a size dependent on the preset position of the contactor 19. Thereafter, further reduction of the raceway S causes the springs 110 to swing the contactor 18 into engagement with the contactor 17 to close an electrical circuit which causes a termination of the finish grinding feed when the raceway S is further reduced to size that is dependent upon the gauged size of the finished raceway N. The extent of finish grinding feed may be predetermined by adjusting the contactor 18 in the amplifying finger 111 towards and from the contactor 17. When the hand lever 100 is swung to lift the stem 14 out of raceway engagement, the upward movement of the floating block 104 acts through the springs 110 and causes the amplifying lever 111 to swing away from the contactor 19 until it engages a stop screw 121 adjustably threaded in the casing 85.

The reversible slow speed synchronous motor 24, which is secured to a gear housing 122 fastened on the side of the casing 85, is provided with a reduction gearing having a driving shaft 123 that extends into the gear housing. A gear 125 fastened to a stub shaft 126 which is secured to the shaft 123 as by a set screw, meshes with a pinion 127 that is axially fixed and supported for rotation by bearings 128 mounted in a counter-bore of the housing 122. A horizontal sleeve 130, threaded through and axially adjusted by the pinion 127, has a flanged portion 131 movable within a closure member 132 secured to the housing at the end of the counterbore. The sleeve 130 is held from rotation by a pin 133 received by a slot in the flanged portion 131 and mounted in an annular plate 134 surrounding the outer end of the sleeve 130 and fastened to the closure

member 132. The rod 118 is threaded in the sleeve 130 for longitudinal adjustment of the stud 116 relative to the sleeve 130 under control of a graduated knob 135 that may be turned with reference to a fixed index finger 136. A thumb nut 137, threaded on the rod 118, secures this rod in adjusted position. The knob 135 is preferably so calibrated that turning the knob to the extent of one graduation effects a difference of one ten thousandth of an inch in the diameter to which the raceway S is ground. A dial 140 on the gear 125, graduated similarly to the dial 65 and visible through a housing window 141, rotates with respect to a fixed index finger 142 on the housing to indicate the extent of adjusting movement imparted to the stud 116 prior to each grinding operation and under control of the measuring position of the indicator hand 12. To aid the operator in determining that the contactor 19 is correctly positioned each time that a cup raceway N is measured, the gear 125 is adjustably secured to the stub shaft 126 in such a position that the indicated readings on the dials 140 and 65 will be identical while the contactor 26 engages the indicator hand 12.

At the end of the finsh grinding feed when the contactor 18 makes circuit with the contactor 17, electrical mechanism to be later described reverses both motors 22 and 24. The motor 24 continues its reversed rotation until an arm 143, laterally projecting from the stub shaft 126 operates a bell crank 144 to open a normally closed switch 145 to stop this motor and locate the contactor 19 at its initial starting position. Since the stopping positions for the reversed rotation of both motors are individually controlled by the switches respectively operated by these motors, the contactors 19 and 26 will be returned to their preadjusted starting positions after each grinding operation and there can be no occasion for accumulated error of contact settings relative to each other. The electrical circuits, which also apply to the modification, will be described later.

Figures 8, 9 and 10 show another embodiment of this invention which operates in generally the same manner for controlling the grinding to size of both raceways on one of the race rings of a double row angular contact antifriction bearing under control of a gauging mechanism which responds to the sizes and to the axial spacing of both raceways on the other race ring. In the usual grinding of the companion race rings of a double row antifriction bearing, slight inaccuracies may occur in the diameters of all four raceways and slight inaccuracies may also occur in the spacings of both sets of raceways. These inaccuracies are frequently cumulative. Hence, it has been usual to gauge these race rings and sort them as to raceway spacing and as to raceway diameters so that these inaccuracies would tend to offset each other. Also, to further compensate for these errors, it has often been necessary to select the sizes of the rolling elements for those raceways. This embodiment is described by reference to the grinding of each of the angular contact raceways T on an inner race ring W to the same size which is controlled by a remote control gauging mechanism 150 that precisely measures the accumulated slight differences from standard size and from standard spacing of both angular contact raceways L on an outer race ring K to be assembled with standard size balls and in mating relation with this race ring W.

A rotatable chuck on a grinding machine (not shown) reversibly receives the inner race ring W to successively place each raceway T in grinding position, and the gauging head 16 is fixedly supported through the bracket 86 so that the stem 14 may be lowered into correct engagement with the raceway T being ground. A forwardly open housing 152, having a depending boss 153 demountably secured on a post 154, has a flat top portion on which is mounted a casing 155. A dial indicator 156, firmly fastened to and electrically insulated from a casing bracket 157, has a measuring pointer or indicator hand 158 movable over a graduated dial 160 that may be observed through a casing window 162. A synchronous motor 163, corresponding to the motor 22 and mounted on the casing, swings an arm 164 coaxially of the pointer 158 to bring a contactor 165 from its present starting position of Figure 10 into electrical contact with the pointer 158 to present the gauging position of the gauging head contactor 19 in the same manner as described with reference to the gauging mechanism 10. The dial 160, which may be graduated similarly to the dial 65, is marked with an arcuate zone 161 corresponding to the zone 67 on the dial 65 for aiding the operator in determining when the raceway measurements of the race ring K lie outside of an acceptable range. At the end of each grinding operation, the motors 163 and 24 are shifted into reverse by the engagement of the contactor 18 with the contactor 17. The reversed rotation of the motor 163 continues until a pin, laterally projecting from a disc 166 adjustably secured to the motor shaft, acts through a bell crank to operate a switch 167 which stops the motor when the contactor 165 is returned to its starting position.

The finished double row outer race ring K is demountably held within the housing 152 in an axially vertical position by two similar rows of spaced balls 168 that are respectively engageable with the upper and lower angular contact raceways L in this outer race ring and with corresponding angular contact raceways on a pair of spaced inner race rings 170 one of which is arranged for coaxial movement relative to the other. The balls 168 of each row, which are loosely mounted in peripherally spaced relation within a retainer 172, are preferably of the same size, number and spacing as the balls which will be used in the finished bearing between the race rings K and W. When the rows of balls 168 are correctly seated against both sets of raceways, the axial spacing of the inner race rings 170 will be affected by the slight differences from standard size and from standard spacing of the raceways L, and the pointer 158 will respond to this axial spacing to precisely measure the aggregate of these slight differences and determine the presetting of the contactor 19 so that both of the raceways T will be ground to a size which compensates for these slight variations from standard in the race ring K. After one of these raceways T is ground and the contactors 165 and 19 have returned to their starting positions, the stem 14 is lifted from the ground raceway, the inner race ring W is reversed on the chuck and the other raceway T is ground in the same manner and to the same size while the race ring K remains in gauging position.

An upper supporting member 173 that locates against a housing shoulder at the lower end of a vertical bore 174 through the top of the housing

182, is piloted in this bore and has a depending cylindrical portion over which the upper race ring 170 demountably fits. A flanged bushing 176, seated on top of the housing and piloted in the bore 174, has a lower internally threaded end in which is adjustably threaded the upper end of a vertical sleeve 177 that extends through an axial bore in the supporting member 173. A head on the lower end of the sleeve 177 and received in a counterbore in the supporting member 173, holds a plate 180 in conically seated engagement against a bevelled lower edge of the upper race ring 170 to demountably clamp this upper race ring against an annular locating shoulder on a supporting member flange 182 and to also demountably hold the supporting member 173 against the housing shoulder. A vertical plunger 183, longitudinally slidable in the sleeve 177, has a rounded lower end projecting into a counterbore in the head on the sleeve 177, and has at its upper end a head 184 slidable in the bushing 176. An adjusting screw 185, threaded in and extending upwardly from the plunger head 184, has a rounded upper end engageable with a flat face on a boss depending from the short arm of an amplifying lever 186 which is pivotally supported intermediate of its ends by horizontally disposed cross pins carried by a bracket 188 mounted in the casing 155. The screw 185 is secured in adjusted position by a lock nut 189 having a skirt that overlies the top of the bushing 176 to prevent the entrance of dirt between the plunger head 184 and the bushing. The dial indicator stem, which is spring-urged downwardly from the dial indicator in the usual manner, is engaged by a stud 192 electrically insulated from and projecting upwardly from the long arm of the amplifying lever 186. A coiled spring 193 urges the amplifying lever clockwise towards the indicator stem and towards the screw 185. Adjustable stop screws 194 and 195 limit the amplifying lever movement to prevent swinging of the pointer 158 into electrical contact with the contactor 165 when this contactor is located at its starting position shown in Figure 10.

The lower race ring 170 is demountably fitted over the reduced cylindrical upper end of a lower supporting member 196 and held against an annular shoulder on a supporting member flange 197 by a clamping plate 198 that is clamped in conically seated engagement against a bevelled race ring face by a cap screw 200 threaded into the supporting member 196. The flat top face of the cap screw 200 vertically positions the plunger 183 causing the pointer 158 to locate at a measuring position during a gauging operation. Screws 202, freely extending through the clamping plate 198, demountably secure the supporting member 196 on top of a ram 203 which is keyed against rotation and is vertically slidable through the boss 153. A depending pilot on the supporting member 196 fits within a bore in the top of the ram to locate the supporting member 196 coaxial with the supporting member 173 so that the inner race rings 170 will be coaxial. The ram 203 has a vertical bore 204 extending upwardly from a counterbore in which a plug 205 is threaded and held in adjusted position by a locknut, and a reduced sleeve portion 206 of this plug extends upwardly into the bore 204. A bolt 207, provided with a head in the upper end of the bore 204, extends downwardly through and is threaded in the plug 205 for longitudinal adjustment. The bottom of the bolt has a wrench-receiving shank and a locknut secures this bolt in adjusted position. A coiled spring 208 loosely surrounds the bolt between its head and a washer 209 slidable on the bolt.

A generally horizontal lever 210, pivotally supported at its outer end by a bolt 211 in the housing, extends laterally through slots into the bore 204 and has a forked inner end which straddles the bolt 207 and has rounded upper and lower surfaces that are respectively engageable with the washer 209 and with the top of the sleeve portion 206. A hand lever 212 acts through a housing-supported shaft to rotatably position a cam 213 against a roller 214 on the lever 210 for raising and lowering the forked lever end which acts through the bolt 207, ram 203 and associated parts to vertically shift the bottom race ring 170 into and out of gauging position. The hand lever may be swung in one direction to lower the ram to its bottom position so that the operator may easily laterally move a race ring K between the race rings 170 to mount this race ring K upon and remove it from the bottom row of balls 168. The hand lever is swung in an opposite direction to rest against a stop pin 215 for locating the race ring K, ram and associated parts in gauging position.

The plug 205 is adjusted in the ram to locate the ram relative to the lever 210 dependent upon the spacing of the raceways L. The bolt 207 is adjusted in the plug 205 to so regulate the compression of the spring 208 during gauging that the balls 168 will correctly seat against the raceways under substantially identical conditions during successive gauging operations and without causing injury or distortion to the balls or raceways. The minute difference in spacing of the race rings 170 resulting from the slight variations in size and/or spacing of the raceways L of similar race rings K is insufficient to noticeably change the pressure imparted by the spring 208. After the race ring K is located in gauging position, the operator may turn this race ring on the balls 168 to assure that the balls correctly seat against the raceways. The gauging mechanism is initially adjusted by turning the adjusting screw 185 to position the pointer 158 at a zero index on the dial 160 whenever the race ring K being gauged has raceways of standard size and standard spacing.

To avoid binding of the balls 168 against the raceways L during mounting and demounting of the race ring K, both rows of balls 168 may be moved out of raceway engagement with the race rings 170 and radially inwardly towards similar conical race ring portions 216 which taper inwardly and towards each other. Stepped annular members 217, respectively secured to the retainers 172, extend axially out of the race ring K during gauging. Similar rings 218, detachably fastened to the annular members 217, loosely fit respectively about the supporting member 173 above the flange 182, and about the supporting member 196 below the flange 197, these rings being spaced from these flanges when the balls 168 are seated against the raceways as shown. When there is no race ring K in gauging position, spaced springs 220 on the supporting member 196 yieldably lift the bottom ring 218 against the flange 197 causing the lower retainer 172 to locate in a raised position so that the bottom row of balls 168 may move radially inwardly of the race rings and against the lower conical portion 216. At this time, the upper ring 218 has dropped into

engagement with the flange 182 and the upper row of balls 168 may move radially inwardly of the race rings and against the conical portion 216 of the upper race ring 170. Hence, whenever the race ring K is removed from gauging position, the balls 168 may move inwardly out of contact with the raceways L, and when a race ring K is placed in gauging position, these balls are brought back into correct raceway engagement by the movement of the inner race rings 170 towards each other.

The operation and electrical controls shown in Figure 1 will be described with respect to the matched grinding of a single row race ring R under control of the finished size of the companion single row race ring M. The same or similar electrical controls are operated in the same manner to regulate the size-grinding operation on each of the raceways of the double row race ring W under control of the measured sizes and spacing of the raceways in the companion double row race ring K.

A finished race ring, as M, is mounted on the remote control gauging mechanism 10 causing the indicator hand 12 to swing to a measuring position. The cone race ring R to be ground is mounted in grinding position, and the grinding machine is started with a coarse feed of the grinding wheel into the raceway S. The reed gauge stem 14 is lowered onto the raceway S. Motor terminals 230 and 231 of the synchronous motors 22 and 24 are connected to a power line 233, and motor terminals 234 and 235 are connected to a power line 236 through a contact A—2 of a relay A and through contacts B—6 and B—8 of a relay B. A main switch 238 is manually closed to connect the power lines 233 and 236 in circuit with power wires 240 through the normally closed push-button starting switch 73 and causing both motors 22 and 24 to simultaneously start rotating in synchronism and in the same direction to advance the contactors 26 and 19. A relay coil B—1 is thus energized from the power lines through a switch contact A—4 of the relay A thereby lifting and holding a latch 242 out of latching engagement with a notch in the switch of relay B.

When the motor 22 swings the contactor 26 into engagement with the indicator hand 12, a relay coil A—1 is energized and shifts the switching arms of the relay A to their dot-indicated positions. Contact A—2 is then in open circuit causing both motors to stop with the contactor 19 located by the motor 24 in a position determined by the measuring position of the indicator hand 12. Contact A—4 is then in open circuit position causing the relay coil B—1 to de-energize and drop the latch 242, and contact A—3 is in closed circuit with the power lines to provide a holding circuit through the relay coil A—1 which remains energized and holds the switching arms of the relay A in their dot-indicated positions during the subsequent reversal of the motor 22 while the contactor 26 is being withdrawn from the indicator hand 12.

When the cone raceway S is reduced to an initial size determined by the preset position of the contactor 19, the contactor 17 engages the contactor 19 to close a circuit from the secondary of a transformer H through a solenoid 243 which now shifts a lever 244 from its full line position to its dot-indicated position for restricting the stroke of an oscillating carriage 245 to reduce the coarse grinding feed to a finish grinding feed. The oscillating carriage 245 pivotally supports a spring-pressed pawl 246 which imparts a feeding movement to a wheel 247 that forms a part of a grinding wheel feeding mechanism. When the raceway S has been further reduced to a size determined by the measuring position of the indicator hand 12, contactor 18 engages contactor 17 which results in stopping the finish grinding feed and sparking out of the grinding wheel with this raceway ground to the required size. This engagement of the contactors 18 and 17 energizes a relay G from the secondary of the transformer H causing electrical connection between terminals G—1 and G—2 to energize the coil of a delay relay F from the power lines 233 and 236. After a short delay, which may be approximately one second, a normally closed switch F—1 will be shifted to open circuit position by the energized coil of the relay F. The temporarily closed circuit made through the switch F—1 causes current from the power lines to simultaneously energize the relay coils B—2 and C—1 which now shift the switching arms of re'ays B and C to their dot-indicated positions. While the relay coil B—2 is temporarily energized, the latch 242 drops into latched position to lock the switching arms of the relay B in engagement with contacts B—5 and B—7 which are thus connected to energize a solenoid 250 that pulls the spring pressed pawl 246 from engagement with the feeding wheel 247 to stop the grinding wheel feed. The grinding wheel sparks out with the diameter of the cone raceway S in matching relation with the measured size of the cup raceway N.

While the relay coil C—1 remains temporarily energized, current flows through contacts C—2 and C—3 to respectively energize relay coils D—1 and E—1 which then shift the switching arms of the reversing relays D and E from their normally open circuit to their dot-indicated closed circuit positions. Contacts D—3 and E—3 of the relays D and E now respectively connect the motor terminals 248 and 249 with the power line 236 causing the motors 22 and 24 to start reversing and to withdraw the contactors 26 and 19 towards their starting positions, the contactor 26 disengaging from the indicator hand 12 and the retracting contactor 19 causing the contactor 17 to first spring away from the contactor 18 followed by the retreat of the contactor 19 from the contactor 17. The disengagement of the contactor 17 from the contactor 18 deenergizes the relay G which in turn deenergizes the coil of the relay F causing the switch F—1 to again close. The deenergizing of the temporarily closed relay C does not cause the motor reversing relays D and E to shift back to open circuit positions since their switching arms which engage contacts D—2 and E—2 are respectively in series connection with the normally closed motor operated switches 77 and 145, to provide holding circuits which maintain the relay coils D—1 and E—1 energized to hold the switching arms of the relays D and E in their closed circuit positions.

The pin 74, moved by the motor 22, opens the switch 77 at a predetermined position of this motor's reversal to deenergize the relay coil D—1 resulting in the return of the switching arms of the relay D to their open circuit positions which causes the motor 22 to stop with the contactor 26 located at its predetermined starting position. Similarly the arm 143, moved by the motor 24, opens the switch 145 to deenergize the relay E and stop the motor 24 with the contactor 19 located at its predetermined starting position. The individual control of the stopping

positions of these motors during reversal prevents accumulative error of the resetting positions of the contactors 26 and 19 in the event that these motors might not stop uniformly.

The relay F could be eliminated in which event the connections to the switch F—1 would be permanently joined and the relay coils B—2 and C—1 would remain energized as long as the contactors 17 and 18 were in engagement. Normally, these contactors disengage in response to the withdrawal of the contactor 19 and prior to the opening of the switches 77 and 145. However, the delay relay F is preferably included to insure that the contactors 17, 18 will be taken out of circuit at the start of the motor reversal so that the resetting of the contactors 26 and 19 will be controlled only by the opening of the switches 77 and 145. Hence, a conceivable delayed disengagement of the contactors 17 and 18 cannot make the opening of the switches 77 and 145 ineffective by maintaining the relay C in closed circuit position which in turn would maintain the relay coils D—1 and E—1 energized and cause an incorrect resetting of the contactors 26 and 19.

When the grinding of raceway S is completed, the gauge stem 14 is lifted. The finished cone race ring R is replaced by another cone race ring to be ground, and the cup race ring M is replaced by the next cup race ring which is to control the following size-grinding operation. At the start of the next grinding operation, the push button switch 73 is temporarily pressed to break the circuit to the relay coil A—1 causing the switching arms of the relay A to return to their full line positions. Contact A—3 is thus disconnected and contact A—4 is again placed in circuit to energize the relay coil B—1 which lifts the latch 242 causing a shifting of the switching arms of the relay B back to their full line positions. Current then flows through the contact A—2 and the contacts B—6 and B—8 to simultaneously start both motors rotating forwardly, and the cycle of operation continues as before.

From the foregoing it will be noted that the gauging mechanism 16, which responds to the size of the article R being ground for mating relation with the article M, has a member 111 movable in accordance with the changing size of the raceway S; and gauging means 10, which measures the article M, has the element 12 movable to a position determined by the size of the raceway N. Electrically operated mechanism, including the simultaneously moved motor driven contactors 26 and 19 that are adjustably preset by the engagement of contactor 26 with the element 12, locates the adjustable member or contactor 19 in a position to limit the movement of contactor 17 thereby predetermining the circuit controlling positions of the contactors 17, 18 and 19 which act as switches for adjusting the operative relations between the grinding controlling means 243—247 and the gauging mechanism 16. When the contactor 17 engages the preset contactor 19, a change from rough to fine grinding feed is effected, and when the contactor 18 subsequently engages the contactor 17 now located by the preset contactor 19, a further change in feed is effected causing a stopping of this fine grinding feed and reversing both of the synchronous motors 22, 24 so that the contactors 26 and 19 will be retracted towards their starting positions. The reversal of these motors continues until the individually adjusted motor switches 77 and 145 respectively stop these motors with each of the contactors 26 and 19 precisely located at its predetermined starting position.

We claim:

1. In apparatus for regulating the grinding to size of one of a pair of articles under control of the size of the other article, gauging mechanism responsive to the size of the article being ground, grinding controlling means responsive to the gauging mechanism, and motor actuated mechanism controlled by the size of said other article for adjusting the position of the gauging mechanism at which the grinding controlling means is actuated.

2. In apparatus for regulating the grinding to size of one of a pair of articles under control of the size of the other article, a gauging mechanism for the article being ground and including a circuit controlling mechanism, feeding mechanism controlled by said circuit controlling mechanism for effecting a change in a grinding feed when said article reaches a desired size, gauging means for supporting and measuring the size of said other article, said gauging means being supported independently of the gauging mechanism, and motor actuated apparatus controlled by said gauging means for adjusting the circuit controlling mechanism.

3. In apparatus for regulating the grinding to size of one of a pair of articles under control of the size of the other article, gauging mechanism responsive to the size of the article being ground, a pair of contactors relatively moved by the gauging mechanism to control a circuit when the article being ground is reduced to a desired size, and motor operated mechanism responsive to the size of said other article for adjusting the relative movement of said contactors.

4. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, gauging mechanism responsive to the size of the article being ground, a pair of contactors relatively moved by the gauging mechanism to close a circuit when said article is reduced to a desired size, gauging means responsive to the size of said other article, and motor actuated mechanism controlled by said gauging means for controlling the circuit closing position of said contactors.

5. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a pair of contactors for establishing an electrical circuit, a member movable in accordance with the changing size of the article being ground and producing a relative contactor movement into contacting engagement, gauging means including an element movable to a position determined by the size of said other article, and motor operated mechanism responsive to the position of said element for adjustably controlling the engaging position of said contactors.

6. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, a pair of relatively movable contactors for establishing an electrical circuit and carried by said member, gauging means for said other article, an element for limiting the relative movement of said contactors, and electrically actuated mechanism controlled by the gauging means for adjustably positioning said element.

7. In apparatus for controlling the grinding to size of one of a pair of articles for mating re-

lation, gauging mechanism responsive to the size of the article being ground and including a pair of contactors relatively moved to control a circuit when the article being ground is reduced to a desired size, a movable element positioned in accordance with the size of said other article, and motor operated mechanism responsive to the position of said element for adjustably limiting the relative movement of said contactors.

8. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a pair of contactors for establishing an electrical circuit, a member movable in accordance with the changing size of the article being ground and producing a movement of one of the contactors with respect to the other to establish said circuit when said article is reduced to a desired size, measuring means responsive to the size of the other article, a motor, a motor operated mechanism for controlling the circuit establishing position of said contactors, means to start said motor, and switching mechanism controlled by said measuring means for stopping the motor.

9. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, measuring means for said other article, circuit controlling mechanism responsive to the position of the movable member for effecting a change in grinding feed when the article being ground reaches a desired size, and electrical mechanism including a pair of synchronously operated motors controlled by said measuring means for adjusting the position at which the circuit controlling mechanism responds to said movable member.

10. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, circuit controlling mechanism responsive to the position of said movable member, a movable element positioned in accordance with the size of said other article, a pair of movable contactors, and means to simultaneously advance said contactors from preset positions, one of the contactors adjustably controlling the position at which the circuit controlling mechanism responds to the movable member, and the other contactor moving into circuit closing relation with the movable element to simultaneously stop the advance of both contactors.

11. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, switching mechanism operated by said movable member when the article being ground attains a desired size, a movable element positioned in accordance with the size of said other article, said switching mechanism including a contactor movable from a preset position towards the movable member to adjustably control the switch operating position of said movable member, a second contactor movable from a preset position into engagement with the movable element to stop the movement of both contactors, means to simultaneously start both contactors moving, and means to return both contactors to their preset starting positions.

12. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, switching mechanism operated by said member when the article being ground is reduced to a desired size, a movable element positioned in accordance with the size of said other article, a pair of movable contactors, means to simultaneously advance the contactors, one contactor being advanced to a position which adjustably controls the switch operating position of said movable member, the other contactor being advanced into engagement with the movable element for simultaneously stopping the advance of both contactors, and means to return both contactors to individually adjustable starting positions.

13. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, circuit controlling means responsive to said movable member when the article being ground attains a desired size, a movable element positioned in accordance with the size of said other article, a contactor movable from a preset position towards the movable member to adjustably control the position at which the circuit controlling means responds to said movable member, a second contactor movable from a preset position into engagement with the movable element for stopping the movement of both contactors, means to start both contactors moving simultaneously, mechanism responsive to the operation of the circuit controlling means for returning both contactors towards their preset positions, and mechanism for stopping the contactors at their preset positions.

14. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, switching mechanism operated by said member when the article being ground reaches a desired size, a movable element positioned in accordance with the size of said other article, a pair of synchronous motors, an adjustable member advanced by one of said motors to adjust the switch operating position of the movable member, a contactor advanced by the other motor into circuit closing relation with the movable element to stop both motors, and means to start both motors operating simultaneously from preset starting positions.

15. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, switching mechanism operated by said member when the article being ground is reduced to a desired size, a movable element positioned in accordance with the size of said other article, a pair of synchronous motors, said switching mechanism including a contactor advanced through an adjustable extent by one of said motors to adjust the switch operating position of said movable member, a contactor advanced by the other motor into circuit closing relation with the movable element to stop both motors, means to start both motors simultaneously in a direction to advance the contactors, mechanism to reverse both motors, and individually adjustable mechanisms to stop the reversal of said motors for locating the contactors at predetermined starting positions.

16. In an apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground,

switching mechanism operated by said member for effecting a change in a grinding feed when the article being ground reaches a predetermined size, gauging means including a movable hand for indicating the size of said other article, a movable contactor, means for moving the contactor from a preset starting position into engagement with said hand to establish a circuit, mechanism controlled by the engagement of said contactor with said hand for controlling the switch operating position of the movable member, and means responsive to the switching mechanism for returning the contactor to its preset starting position.

17. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, circuit closing means operated by said movable member when the article being ground reaches a desired size, an indicator hand positioned in accordance with the size of said other article, said circuit closing means including a contactor movable from a preset position towards the movable member to adjustably control the position at which the circuit closing means is operated by said movable member, a second contactor movable from a preset starting position into engagement with the indicator hand to stop the movement of both contactors, means to start both contactors moving simultaneously towards their operative positions, mechanism controlled by said circuit closing means for effecting a retracting movement of the contactors towards their starting positions, and adjustable means for individually controlling the preset starting position to which each contactor is retracted.

18. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a movable member positioned in accordance with the changing size of the article being ground, circuit controlling means operated by said member for closing a circuit when the article being ground is reduced to a desired size, a movable element positioned in accordance with the size of said other article, a pair of reversible synchronous motors, a contactor advanced through an adjustable extent by one of said motors to adjust the closing position of the circuit controlling means, a contactor advanced by the other motor into engagement with said movable element to simultaneously stop both motors, means to start both motors simultaneously in a direction to advance the contactors, motor reversing mechanism responsive to the closing of said circuit for withdrawing the contactors towards their starting positions, and switches respectively operated by said motors for stopping the reversal of the motors to individually locate the starting position of each contactor.

19. In apparatus for controlling the grinding to size of one of a pair of articles for mating relation, a member movable in accordance with the changing size of the article being ground, circuit controlling means operated by said member to close a circuit when the article being ground reaches a desired size, a movable element positioned in accordance with the size of said other article, a pair of synchronous motors, means to start both motors simultaneously, a contactor advanced through an adjustable extent from a preset starting position by one of the motors for controlling the closing position of the circuit controlling means, a contactor advanced from a preset starting position by the other motor into engagement with said movable element for stopping both motors, mechanism responsive to the closing of said circuit for reversing both motors to withdraw the contactors towards their starting positions, mechanism disconnecting control of the motor reversing means from the circuit controlling means while said motors continue to reverse, switches respectively operated by each motor to individually stop the motors when the contactors reach said preset starting positions, and means for adjusting the operative relation between said switches and motors.

20. In the grinding of an angular contact double row ball bearing, apparatus for controlling the grinding of each inner raceway to a size for mating relation with a corresponding outer raceway and comprising a movable element positioned in accordance with the aggregate difference from standard size and from standard spacing of the outer raceways, and mechanism responsive to the position of said movable element for controlling the size to which each of the inner raceways is ground.

21. In the grinding of an angular contact double row ball bearing, apparatus for controlling successive grinding operations on each of a pair of inner raceways to a size for mating relation with corresponding outer raceways and comprising gauging means including an element movable to a position determined by the aggregate difference from standard size and from standard spacing of the outer raceways, a movable member positioned in accordance with the reduction in size of the raceway being ground, grinding feed controlling means responsive to the position of said member, and mechanism responsive to the position of said movable element for adjusting the position at which the grinding feed controlling means responds to said movable member.

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The following references are of record in the file of this patent:

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Number	Name	Date
1,893,205	Hughes	Jan. 3, 1933

Certificate of Correction

Patent No. 2,460,232. January 25, 1949.

HENRY MICHELSEN ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 39, after the word "inner" insert *race*; column 8, lines 19 and 21, for "present" read *preset*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 24th day of May, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.