Oct. 13, 1959 C. J. ENNIS 2,908,115

HONING MECHANISM

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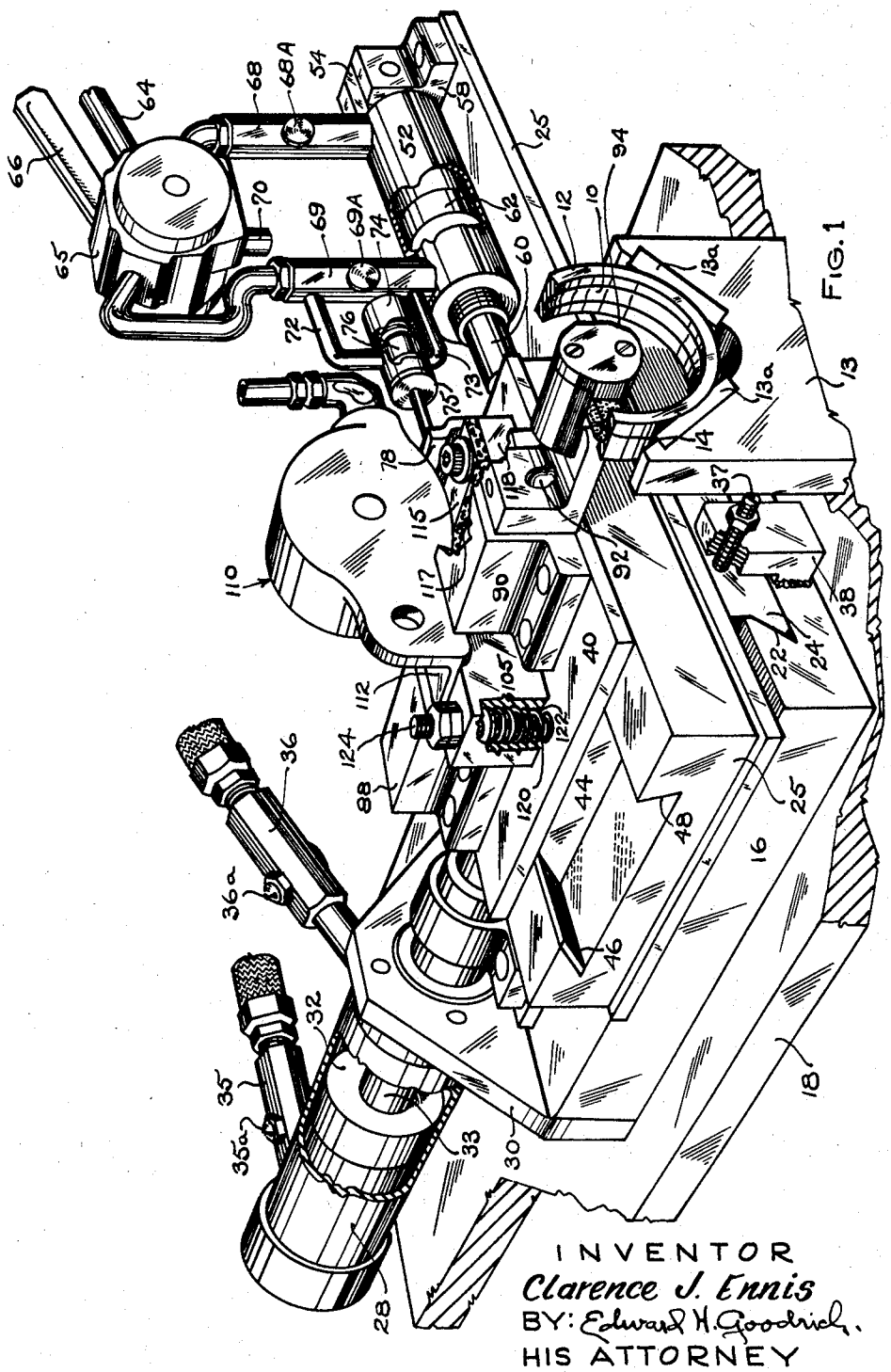


FIG. 1

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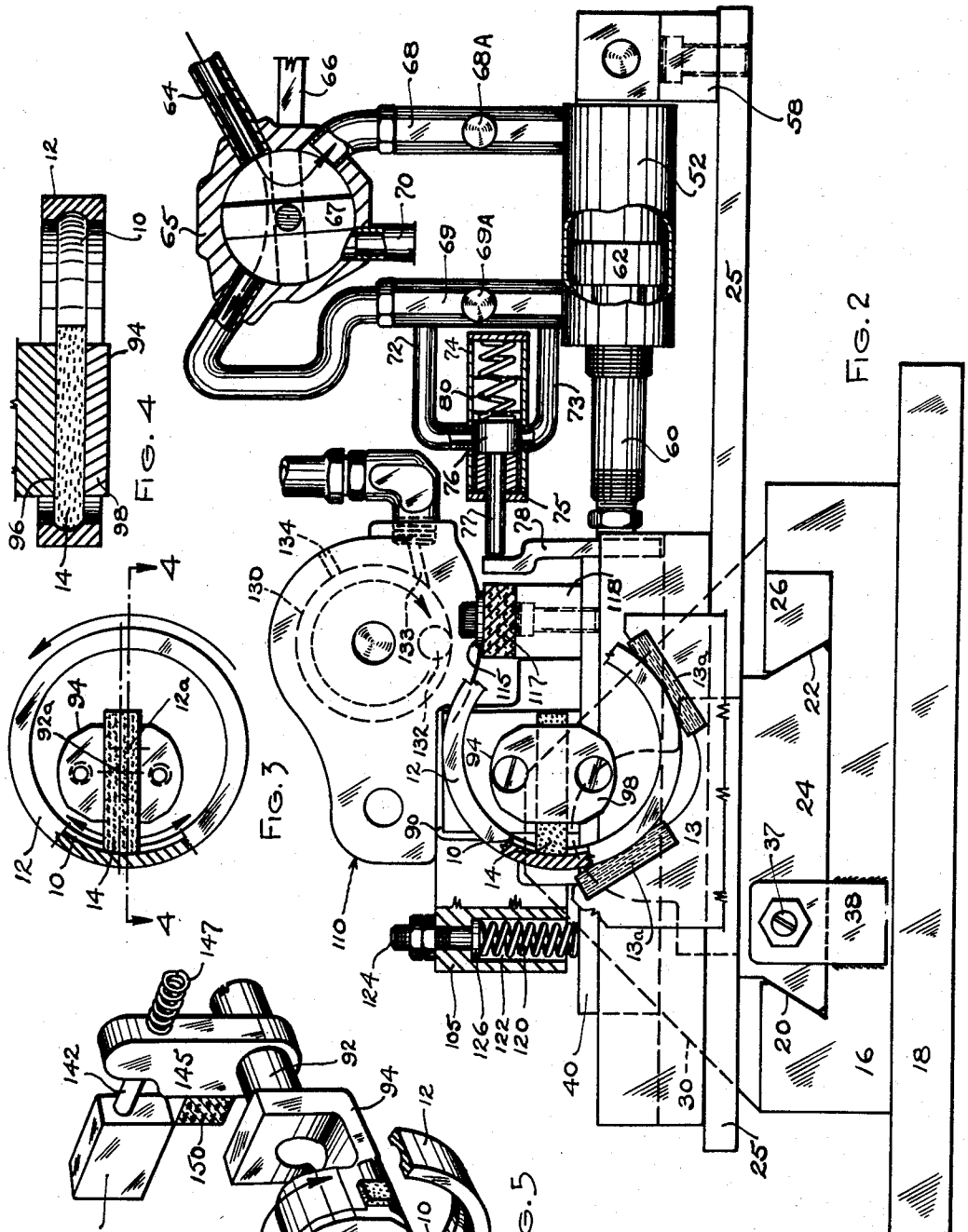


FIG. 2

FIG. 3

FIG. 4

FIG. 5

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HONING MECHANISM

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14 Claims. (Cl. 51—58)

This invention relates to honing and particularly to the precision finishing of the annular raceways for antifriction bearings.

It has been common practice for supporting rolling elements in various machines to provide roller and/or ball bearings which have their annular raceways and their rolling elements carefully ground within very close limits of accuracy to support various members for antifrictional rotation about predetermined axes. The ever increasing demands of modern precision machinery require antifriction bearings which can be rapidly produced to a better degree of accuracy than in present bearings and which have much lower starting and running torques as well as the capabilities of operating at very high speeds without introducing objectionable vibrations to the rotatable members which these bearings support. The rolling elements such as the balls and/or rollers which are used in these bearings can usually be ground and lapped to a much greater precision than that of the raceways in the race rings which are engaged by these rolling elements. Hence, the problem of providing more accurate antifraction bearings resides to a great extent in producing raceways to much more accurate and smoother contours. In the grinding of a raceway such as the raceway in the outer race ring of a ball bearing, the multiplicity of radially projecting abrasive teeth in the grinding wheel produce in even the most accurately ground raceway a grooved grinding pattern dependent upon the relative movements between the high speed rotating grinding wheel and the raceway being ground. Also, the stresses and strains set up within the grinding wheel spindle and other machine parts during such a grinding operation, produce minute inaccuracies of grinding contour which detrimentally affect the accuracy of operation of the bearing under conditions of high speed rotation and the exacting demands of precision.

It is, therefore, an object of this invention to provide a honing machine and a honing method which will improve the contour and surface finish of a precisely ground annular raceway.

It is a further object of my invention to provide an improved raceway honing machine which corrects the inaccuracies of a prior grinding operation and which removes the grinding pattern produced in the raceway during this prior grinding operation.

It is a further object of my invention to provide an improved honing machine and method wherein a preformed abrasive honing member is fitted against a raceway and subjected to a predetermined controlled arcuate movement to improve the surface finish of the raceway.

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

illustrative purposes in the accompanying drawings wherein

Figure 1 is a perspective view of my honing device with certain parts broken away to show their operative relation during a honing operation.

Figure 2 is a fragmentary front end view of the invention;

Figure 3 is a fragmentary end view showing my honing mechanism in operative position against a bearing raceway;

Figure 4 is a diametrical fragmentary section taken along the line 4—4 of Figure 3; and

Figure 5 is a fragmentary perspective showing of another embodiment of my honing mechanism.

My honing device is illustrated as performing a precision honing operation upon the transversely curved raceway 10 of an outer race ring 12 of a ball bearing. However, it should be appreciated that other surfaces of the revolution may be accurately honed by my invention and in the same general manner.

Generally considered, the outer race ring 12 is rotated about its axis in a fixed position while a preformed honing stone 14 is yieldably pressed endwise into fitting relation within the raceway and arcuately oscillated in the plane of raceway rotation, the center of this oscillation being preferably slightly offset from a horizontal diameter of the race ring. The race ring 12 is suitably supported and rotated about its axis 12*a*. For convenience, this ring is shown supported on spaced shoes 13*a* on a member 13.

A bed 16, fastened to a base 18, has angularly disposed ways 20 and 22 which slidably receive a depending dove-tailed portion 24 on a carriage 25 to permit rectilinear feeding movement of the carriage towards and from the support 13. A gib 26 secured to the bed at one side of the dovetailed portion, limits the carriage to a movement parallel to the axis of rotation of the race ring 12 in the support 13. A cylinder 28, secured to a bracket 30 on the bed, slidably receives a piston 32 connected to a piston rod 33 fastened to the carriage. Fluid as air under controlled pressure is selectively directed from a suitable reversing valve (not shown) through pipes 35 and 36 at each side of the piston to control the longitudinal shifting of the carriage to advance and retract the honing stone 14. As is common in reversing valves, one of these pipes 35 or 36 will be selectively connected to a pressure duct and the other will be connected to an exhaust duct and throttling valves 35*a* and 36*a* will serve to adjustably control the speed of advance and retraction of the carriage 25. An adjustable stop screw 37 in a bracket 38 secured to the bed 16 limits the forward position of carriage 25 to locate the honing stone 14 in the plane of the raceway during honing. A second carriage 40 slidably supported on the flat upper face of the carriage 25 has a depending dove-tailed portion 44 slidably received within opposing ways 46 and 48 which limit the carriage 40 to a longitudinal transverse movement at right angles to the axis of the race ring 12.

A cylinder 52 has a rearward projection 54 secured as by a pin within the bifurcated portion of a boss 58 fastened to and projecting upwardly from the carriage 25. A piston rod 60 adjustably secured to the carriage 40, slidably extends through the forward end of the cylinder 52 and is secured at its rearward end to a piston 62 slidable within the cylinder. Fluid under controlled pressure from a suitable source, is directed from a pipe 64 into a reversing valve 65. An operating means, as a hand lever 66, may be shifted to selectively position a vane 67 in this valve to a full line or to a dotted line indicated position to direct fluid under pressure through a pipe 68 causing an advance of the honing stone 14 generally

radially towards a honing position or through a pipe **69** causing a retraction of the hone. Fluid is exhausted from the valve through a pipe **70**. Throttle valves **68A** and **69A** adjustably control the flow of fluid from the cylinder **52** to regulate the feeding movement of the honing stone into and out of operating position. The throttle valve **69A** is preferably adjusted to control the fluid exhaust from the forward end of the cylinder **52** at such a slow rate that the honing stone **14** will be held against the raceway with a uniform and predetermined pressure as the honing stone gradually wears away. The fluid fed through the reversing valve is preferably air in which event the honing stone is held in position against the raceway under a predetermined yieldable pressure.

Pipes **72** and **73** respectively connect with the pipe **69** at opposite sides of the throttle valve **69A** and communicate with the interior of a cylinder **74** in a bypass valve **75**. A piston **76** slidable in this cylinder, is secured to a piston rod **77** slidably extending through the front end wall of the cylinder and engageable with an arm **78** which is fixed to and extends upwardly from the carriage **40**. A coiled spring **80** within the cylinder **74** resiliently urges the piston **76** towards the left to a final position wherein the piston closes the inner ends of both pipes **72** and **73** preventing a bypass of fluid around the throttle valve **69A**. The extreme left hand position of this piston is limited by the engagement of a sleeve member about the piston rod abutting the front end cylinder wall.

When the carriage **40** is withdrawn to locate the honing stone remote from its operative position, the arm **78** in engagement with the piston rod **77** locates the piston **76** in a dot-indicated position wherein fluid can bypass the throttle valve **69A** through the pipes **73** and **72** and through the forward end of the cylinder **74**. At this time fluid under pressure entering the rearward end of the cylinder **52** urges the carriage **40** forwardly and the honing stone **14** rapidly approaches an operative position since there is a free flow of exhaust fluid around the valve **69A** and into the exhaust pipe **70**.

When the advance of the carriage **40** locates the honing stone **14** close to but still out of operative engagement with the raceway **10**, the spring urged advancing piston **76** under control of the arm **78** closes off the inner ends of both pipes **72** and **73** resulting in further exhaust from the forward end of the cylinder **52** only through the throttle valve **69A** thereby causing the honing stone to very slowly move the short remaining distance into operative raceway engaging position after which it is yieldably held against the work under control of the fluid pressure entering and exhausting from the cylinder **52**.

When the reversing valve is shifted to a reversed position, as indicated by the dash line position of the vane **67**, a reduced fluid pressure is directed through pipe **69** and throttle valve **69A** into the forward end of the cylinder **52** causing the honing stone to first slowly retract from operative position and then retract at a fast maximum rate as the piston **76** uncovers the ends of the pipes **72** and **73** allowing full line pressure to bypass through these pipes and into the forward ends of the cylinder. The rate of retraction of the honing stone and carriage from operative position may be controlled by a throttle valve **68A** which is now connected in the exhaust circuit.

A pair of spaced bearing blocks **88** and **90**, secured to the upper part of the carriage **40** are coaxially bored to closely but rotatably receive a rock shaft **92** terminating at its outer end in a honing head **94**. A rectangular shaped slot **96** extends laterally through the honing head and slidably receives the generally rectangular-shaped elongated honing stone **14** in closely fitting relation for longitudinal adjustment. The outer wall of the slot **96** is formed by a cover plate **98** demountably secured as by screws to the end of the honing head **94** to clamp the honing stone in its adjusted position. An agitator block **105** is tightly secured to the shaft **92** between the bearing blocks **88** and **90** and in spaced relation to the carriage **40**. This agitator block has opposed side faces in slightly spaced relation to the opposing adjacent inner side faces of the bearing blocks **88** and **90** thus providing a slight axial float of the shaft **92** to assure self-seating of the rounded honing stone end within the raceway **10**.

An agitator generally indicated at **110** has a projecting foot **112** suitably secured as by screws within a stepped portion of the block **105**. A rearward foot **115** of the agitator rests upon a cushion member as a felt pad **117** supported on the upper end of an upwardly projecting boss **118**. A coiled spring **120** seated at its lower end upon the upper face of the carriage **40**, extends upwardly into a counterbore **122** in the forward end of the agitator block **105**. An adjustment screw **124** threaded through the block **105** and secured in preadjusted position by a lock nut, extends into the counterbore **122** and engages at its lower end against a circular plate **126** slidable within the counterbore **122** and resting on the top of the coiled spring **120**. The agitator **110** contains an annular generally torus-shaped raceway **130** in which a ball **132** is free to roll with a gyratory motion as indicated. Fluid, as air under pressure, is directed into this raceway through a generally tangential passage **133** and escapes through a passage **134**. By regulating the air pressure through the passage **133**, the gyrating ball imparts a controlled periodic rocking pulse to the pivotally mounted agitator block **105**. Tightening of the screw **124** compresses the spring **120** and tilts the agitator block **105** clockwise as shown in Figure 2 to compress the foot **115** against the yieldable felt pad **117** so that the gyratory movement of the ball **132** in its track will effect an arcuate rocking movement of the shaft **92** through a predetermined extent.

The axis **92*a*** of the shaft **92** is preferably located above the transverse diameter of the race ring **12** and displaced laterally from the race ring axis **12*a*** during a honing operation as best illustrated in Figure 3. With this arrangement, the rounded nose of the honing stone **14** which conforms in transverse and generally circumferentially curvature to that of the raceway against which it fits, will be urged by the spring **120** generally arcuately upwardly into closely fitting raceway engagement. The rapid arcuate oscillation transmitted to this honing stone through the shaft **92** from the agitator block **105** will be in a direction back and forth circumferentially of the raceway thus slightly relieving the fitting engagement of the stone against the raceway and immediately bringing it back to fitting engagement therewith. As is usual in honing operations, a light lubricant as kerosene or other suitable fluid, is flooded about the nose of the honing stone during a honing operation to prevent overheating, and wash away excess abrasive and bond from the nose of the stone as the stone wears down as well as to provide a suitable paste or slurry between the nose of this stone and the raceway to further aid the honing operation.

Figure 5 shows another embodiment of my invention wherein a suitable agitator such as a mechanical or an electric vibrator **140** acts to rapidly and longitudinally reciprocate a rod **142** through a very short distance. A crank arm **145** secured to a shaft **92** is urged through a spring **147** against the end of the rod **142**. The outer end of the spring **147** is supported in any suitable manner. If desired, this spring may be adjustably mounted in the same manner as described and illustrated with respect to the spring **120**. The clockwise movement of the lever **145** as viewed in Figure 5 is dampened and cushioned by a suitably supported felt pad **150**. The controlled rocking movement of the crank arm **145** imparts a regulated rocking movement to the shaft **92** and an arcuate hone movement in the manner previously described.

I claim:

1. The method of honing an internal surface of revolution on a work piece comprising the steps of rotating the work piece about an axis concentric with the surface of revolution, applying a hone against the surface of revolution, and arcuately oscillating the hone circumferentially of the work piece and about an axis spaced from the axis of work piece rotation to provide a changing pressure of the hone against the work piece.

2. The method of honing an internal surface of revolution on a work piece comprising the steps of rotating the work piece about an axis extending therethrough and concentric with said surface of revolution, applying a hone under yielding pressure against said rotating surface of revolution, and arcuately oscillating the hone about an axis within the work piece and in spaced parallel relation to the axis of work piece rotation, to intermittently relieve the pressure of the hone against the rotating work piece.

3. The method of honing an internal surface of revolution on a work piece comprising the steps of rotating the work piece about an axis concentric with the surface of revolution, applying a hone under predetermined yieldable pressure against said rotating surface of revolution, and arcuately oscillating the hone against said surface of revolution and about an axis located between the work piece axis and the zone being honed to periodically change the pressure of the hone against the work piece.

4. The method of honing a transversely arcuate annular raceway within an annular race ring comprising the steps of rotating the raceway about a central axis concentric with the raceway, applying a honing member against the rotating raceway, arcuately oscillating the honing member in the plane of the raceway and about an axis above and laterally offset from the axis of the race ring to intermittently change the honing pressure, and yieldably urging the hone against the raceway during said arcuate oscillation.

5. In a honing machine for finishing a surface of revolution within a work piece rotated about a fixed axis concentric with said surface, a honing member having a curved portion engageable with said surface, means yieldably locating the curved portion of the honing member in engagement with said surface of revolution, and agitating mechanism for arcuately oscillating the honing member about an axis extending through the work piece between the surface being honed and the axis of work piece rotation.

6. In a honing machine for finishing a surface of revolution on a work piece rotated about a fixed axis, a honing member having a rounded end engageable with and generally conforming to the curvature of said surface, means yieldably urging the honing member against said surface, and mechanism for arcuately oscillating the honing member through a predetermined adjustable extent in engagement with said surface and about an axis offset from and parallel to the axis of work piece rotation whereby the honing member will yieldably engage the work piece under a periodically changing pressure.

7. In a honing machine for finishing an internal surface of revolution on a work piece rotated about a fixed axis, a honing member having a rounded end for abrading engagement with said surface, mechanism for shifting the honing member axially into and out of the work piece towards and from a predetermined plane normal to said axis and through the work piece, feeding mechanism shifting the honing member radially of the work piece within said plane into and out of yieldable engagement with the work, an agitator for arcuately oscillating the honing member within the work piece in a direction circumferentially of said surface of revolution and means to adjust the extent of said oscillation.

8. In a honing machine for finishing an annular transversely curved raceway within a race ring rotated about the axis of the raceway, a honing member having a rounded end conformingly engageable with the raceway, means presenting and yieldably locating the honing member against the raceway under predetermined pressure, a rotatable support for the honing member, said support being provided with an axis of rotation generally parallel to and laterally spaced from the race ring axis, an agitator secured to the support for oscillating the support through a partial rotation, and mechanism connected to the agitator for regulating the angular extent of said oscillation whereby the honing member will be arcuately oscillated in the plane of the raceway with a periodic varying pressure against the raceway.

9. In a honing machine for finishing an internal surface of revolution on a work piece rotated about a fixed axis, a honing member having a rounded abrading end matingly engageable with said surface, mechanism feeding the honing member into and out of the work piece towards and from a predetermined position adjacent the surface to be finished, feeding mechanism shifting the honing member generally radially of the work piece and into and out of yieldable work piece engagement, an agitator, tiltably mounted about an axis laterally offset from the work piece axis to arcuately oscillate the honing member in a direction circumferentially of the surface of revolution, and yieldable means on said agitator to regulate the extent of said oscillation.

10. In a honing machine for finishing a surface of revolution on a work piece rotated about a fixed axis, a honing member having a rounded abrading end engageable with said surface, a carriage, a rotatable shaft supported by the carriage, a honing head on the shaft supporting the honing member, a tiltable agitator block secured to the shaft, an agitator connected to said block and arranged to rock the shaft with a controlled movement for arcuately oscillating the honing member in a direction circumferentially of said surface, means to yieldably feed the carriage transversely to locate the honing member in yieldable engagement with said surface, and carriage feeding mechanism for positioning the honing member axially of the work piece.

11. In a honing machine for finishing an annular raceway within a race ring rotated about its axis, a honing member having a rounded abrading end engageable with said raceway, a carriage, a rock shaft journalled in the carriage and having an axis of rotation generally parallel to and offset from the race ring axis, a honing member support on said shaft, fluid pressure actuated carriage feeding mechanism to present and hold the hone against the raceway, rocking mechanism secured to the shaft and engageable with the carriage, and adjustable resilient means between the rocking mechanism and said carriage.

12. In a honing machine for finishing an annular raceway within a race ring rotated about an axis concentric with the raceway, a honing member having a rounded abrading end engageable with the raceway, feeding mechanism for moving the honing member axially of the race ring, a carriage supported by the feeding mechanism, a rock shaft journalled in the carriage and having an axis of rotation generally parallel to and laterally offset from the race ring axis, a honing member support fastened to the shaft, gas operated mechanism for feeding the carriage to present and resiliently locate the honing member against the raceway, an agitator for rocking the shaft and adjustable resilient means on the carriage to regulate the extent of shaft rocking movement.

13. In a honing machine for finishing an annular raceway within a race ring rotated about an axis concentric with the raceway, a honing member engageable with the raceway, air operated feeding mechanism for rapidly moving the honing member towards and from the raceway, a throttle valve in the feeding mechanism responsive to the position of the honing member causing the rapid infeed of the honing member to change to a slow regulating feed and gently present the hone against the raceway under predetermined yieldable pressure, and

means to arcuately rock the hone circumferentially of the raceway through a controlled extent.

14. In a honing machine for finishing an annular raceway within a race ring rotated about an axis concentric with the raceway, a hone having a rounded end engageable with the raceway, feeding mechanism for traversing the hone axially of the race ring, a carriage supported by the feeding mechanism, a rock shaft journalled in the carriage and having an axis offset from and parallel to the race ring axis, a hone support secured to the shaft, and air piston and cylinder for feeding the carriage to move the hone into and from operative position, a throttle valve connected to said cylinder, and carriage operated

means for actuating the throttle valve to reduce the final feed of the hone adjacent the raceway and to locate the hone in operative position under predetermined yieldable pressure, and adjustable agitator mechanism for imparting an arcuate oscillation to the hone in the plane of said raceway.

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