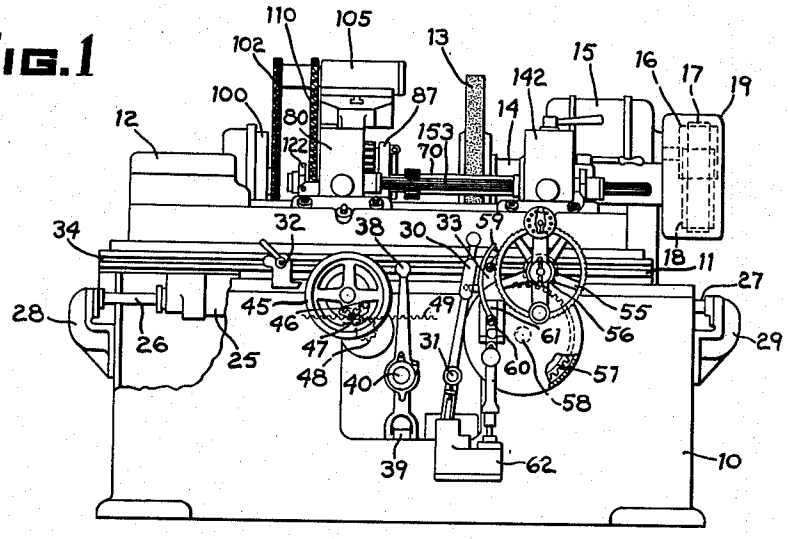
Feb. 13, 1940. E. STUBBS 2,189,931

GRINDING MACHINE

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FIG. 1



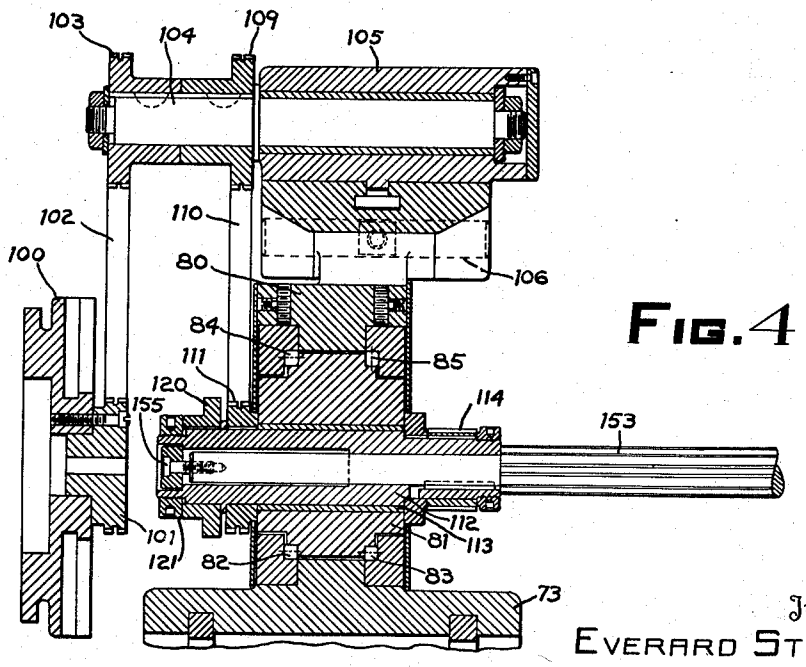


FIG. 4

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FIG. 3

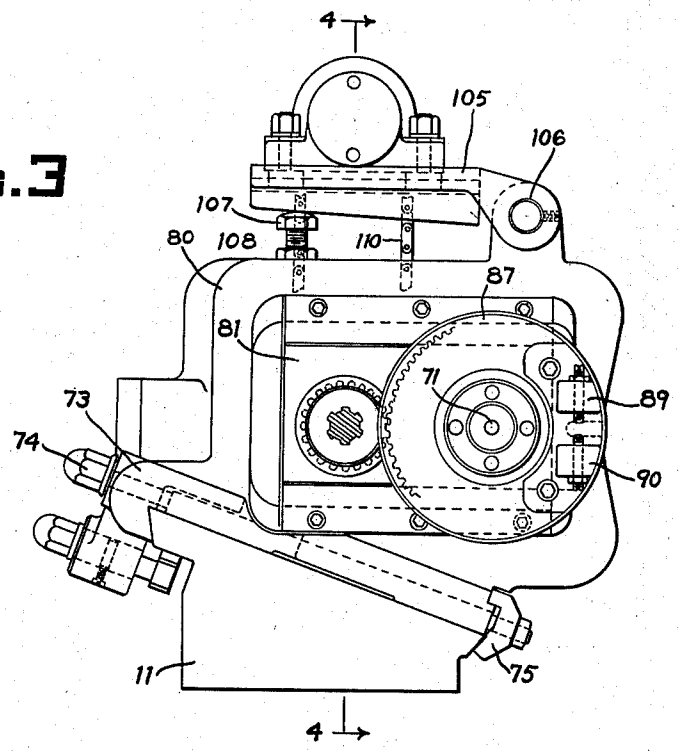
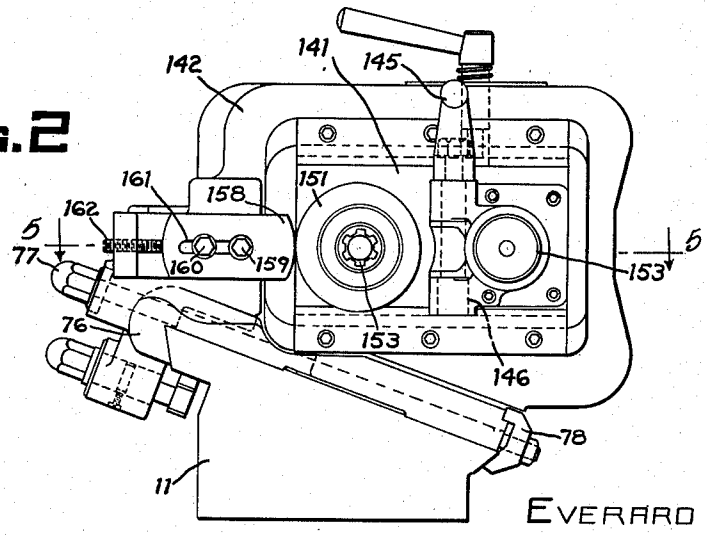


FIG. 2



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FIG. 6

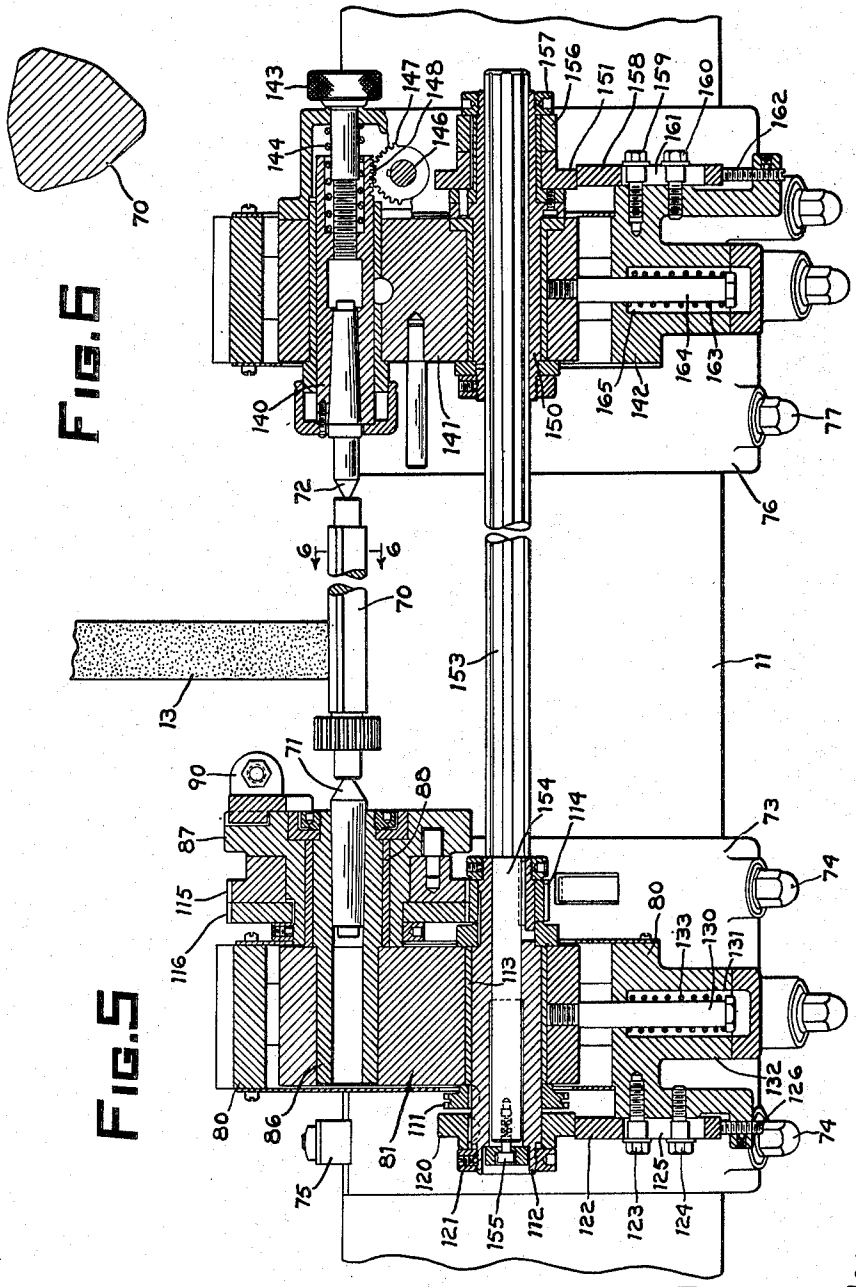


FIG. 5

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UNITED STATES PATENT OFFICE

2,189,931

GRINDING MACHINE

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Application January 27, 1939, Serial No. 253,152

9 Claims. (Cl. 51—101)

The invention relates to grinding machines, and more particularly to a grinding machine adapted to finish a work piece having an irregular contour.

One object of the invention is to provide a simple and thoroughly practical grinding apparatus for grinding an irregular object, such as a cam or eccentric or isodiametric objects. Another object of the invention is to provide an improved grinding machine in which the work support is moved transversely toward and from the grinding wheel in a straight line motion as controlled by a cam and a follower. A further object of the invention is to provide a grinding machine having a transversely movable headstock and a transversely movable footstock each of which is independently moved transversely by means of a pair of synchronously rotated master cams and followers. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is shown one of various possible embodiments of the mechanical features of this invention,

Fig. 1 is a front elevation of an improved grinding machine embodying this invention, having parts of the base broken away more clearly to show the operating construction;

Fig. 2 is a left-hand end elevation, on an enlarged scale, of the footstock and the master cam and follower for controlling the same;

Fig. 3 is a right-hand end elevation, on an enlarged scale, of the headstock mechanism;

Fig. 4 is a vertical sectional view through the headstock, taken approximately on the line 4—4 of Fig. 3;

Fig. 5 is a fragmentary horizontal sectional view, on an enlarged scale, taken approximately on the line 5—5 of Fig. 2; and

Fig. 6 is a sectional view, on an enlarged scale, taken approximately on the line 6—6 of Fig. 5, showing the cross sectional view through the work piece.

The improved grinding machine as illustrated in the embodiment may comprise a base 10 which supports a longitudinally reciprocable work supporting table 11 on the usual V-way and flat way (not shown) for a longitudinal reciprocatory movement relative to the base 10. A headstock 12 is mounted on the table 11 and serves as a driving means for a rotatable work supporting mechanism to be hereinafter described.

A rotatable grinding wheel 13 is supported on a transversely movable wheel slide 14 which is mounted to slide transversely relative to the base 10 in a manner similar to that which is old and well known in the art, as shown, for example, in the U. S. patent to Norton No. 762,838 dated June 14, 1904, to which reference may be had for details of disclosure not contained herein. In the preferred form, an electric motor 15 is mounted on the upper surface of the wheel slide 14. The motor 15 is provided with a driving pulley 16 which is connected by a driving belt 17 with a pulley 18 mounted on the outer end of the grinding wheel spindle (not shown). As illustrated in Fig. 1, the wheel spindle driving belt 17 above described is contained within a belt guard or housing 19.

A fluid pressure mechanism is provided to reciprocate the table 11. In the form illustrated, a cylinder 25 is fixedly mounted to the under side of the table 11. The cylinder 25 contains a pair of spaced pistons (not shown) which are connected by a pair of hollow piston rods 26 and 27, respectively, with a pair of hollow brackets 28 and 29, respectively, which are fixedly mounted on opposite ends of the base 10. The table operating or reciprocating mechanism, as indicated in Fig. 1, is substantially identical to that shown in the prior United States patent to Wallace H. Wood No. 2,071,677 dated February 23, 1937, to which reference may be had for details of disclosure not contained herein.

A table operated reversing lever 30 is pivotally mounted on a stud 31 on the base 10 and is connected in a manner shown in the above-mentioned Wood patent to operate a control valve (not shown) to reverse the direction of movement of the table 11. The lever 30 is actuated by a pair of table dogs 32 and 33 which are adjustably positioned in a T-slot 34 mounted in the front edge of the table 11. A manually operable lever 38 is pivotally mounted on a bracket 39 and is connected through a knob 40 and valve stem (not shown) to operate a throttle valve (not shown) which also serves as a stop and start valve. This valve together with the table reversing valve is identical with that shown in the above-mentioned prior patent to Wood and consequently has not been illustrated in detail in the present case since it is not considered to be a part of the present invention.

The table 11 may also be moved manually by means of a manually operable table traverse mechanism comprising a manually operable rotatable hand wheel 45 which is rotatably supported relative to the base 10. The hand wheel 45 serves to rotate a gear 46 meshing with a gear 47. A gear 48 is arranged to rotate with the gear 47 and meshes with a rack bar 49 which is in turn fixedly mounted to the under side of the table 11.

In order to produce a desired and predetermined feed of the grinding wheel, a manually

operable feeding mechanism is provided comprising a manually operable feed wheel 55 which carries a small gear 56 meshing with a gear 57 mounted on the outer end of a rotatable feed screw shaft 58. The feed screw shaft 58 is provided with a feed screw threaded portion projecting under the wheel slide 14 and meshing with a half nut (not shown) depending from the under side of the wheel slide 14, in a manner such as that shown in the above-mentioned prior patent to Norton.

The feed wheel 55 may be manually rotated to cause a transverse movement of the wheel either toward or from the work piece to be ground, if desired. The grinding wheel 13 may also be fed automatically and intermittently at the ends of the reciprocatory stroke of the table 11 by means of a wheel feeding pawl 59 which is pivotally mounted on a stud 60. The stud 60 is carried by a vertically movable reciprocable slide 61 which is reciprocated by a fluid pressure motor contained within the housing 62. This feeding motor is identical with that shown in the above-mentioned prior patent to Wood No. 2,071,677 and consequently has not been illustrated in detail herein. Reference may be had to the above-mentioned patent for details of disclosure not found herein.

Rotatable work holder

As illustrated in Figs. 5 and 6 of the drawings, a work piece 70 of iso-diametric cross section, such as is disclosed in my prior U. S. Patent No. 1,912,412 dated June 6, 1933, is supported on a headstock center 71 and a footstock center 72. A cam attachment headstock bracket 73 is clamped in position on the table 11 by means of a clamping stud 74 and a clamping block 75. A footstock supporting frame 76 is clamped in position on the table 11 by a clamping stud 77 and a clamping block 78.

The headstock bracket 73 is provided with an integral upwardly extending portion 80 which is hollow and is provided with a transversely movable slide 81. The slide 81 is supported on anti-friction bearings comprising four spaced lines or rows of anti-friction rollers 82, 83, 84 and 85 (Fig. 4). Alternate rollers in each of the rows are arranged with their axes at right angles to each other so as to facilitate free movement of the slide 81 to precisely control the transverse movement of the headstock work supporting center 71 and thereby control the contour of the work piece 70 being ground. The slide 81 is provided with a spindle 86 which supports the headstock center 71. A face plate 87 is rotatably supported on a bearing 88 which rotates on the spindle 86. The face plate 87 is provided with spaced lugs 89 and 90 (Fig. 3) each of which is provided with a set screw to engage a work piece driving dog which is fastened to the end of the work piece 70 in a manner similar to that employed in camshaft and cylindrical grinding operations.

This cam grinding apparatus is particularly arranged and adapted for use as an attachment which may be readily applied to a standard cylindrical grinding machine. To facilitate rotation of the work piece, a rotatable headstock face plate 100 supported by the grinding machine headstock 12 carries a sprocket 101 which is connected by means of a driving link chain 102 with a sprocket 103 which is keyed to a rotatable shaft 104. The shaft 104 is rotatably supported in a bracket 105 pivotally supported on a stud or shaft 106 which is carried by the projection 80 of the headstock attachment 73. The bracket 105 is pivotally mounted to facilitate taking up slack in the driving chain 102 and also in a driving chain to be hereinafter described. An adjusting screw 107 is screw threaded into the projection 80 of the headstock frame 73 and its head bears against the under side of the bracket 105 and serves to facilitate adjustment of the bracket 105. A lock nut 108 serves to lock the screw 107 in adjusted position.

A sprocket 109 which is keyed to the shaft 104 is connected by means of a link driving chain 110 with a sprocket 111 which is keyed to a rotatable sleeve 112. The sleeve 112 is rotatably supported in a bushing 113 mounted in the transversely movable slide 81. A small gear or pinion 114 is keyed to a left-hand reduced end portion of the sleeve 112. The pinion or gear 114 meshes with a larger gear 115 which is fixedly mounted to rotate the face plate 87 and thereby transmit a rotary motion to the work piece 70. The gear 115 is preferably formed as a split gear having a second part 116 which may be adjusted relative to the gear 115 so as to facilitate taking up backlash between the gear 115 and the sprockets 114.

In order to transmit a transverse movement of the slide 81 and the work piece 70 to produce a predetermined contour on a work piece to be ground, a cam actuated mechanism is provided including a master cam 120 which is keyed to the outer end of the sleeve 112. The master cam 120 is held in position against any endwise movement by means of a collar 121. This collar 121 may be readily removed when desired to facilitate replacement of the master cam 120 for a similar cam of a different shape for producing a differently shaped work piece. A follower 122 is mounted on the fixed part of the frame 80 by means of a pair of clamping studs or screws 123 and 124 which pass through an elongated slot 125 in the follower 124 and are screw threaded into the frame 80. An adjusting screw 126 serves as a backing and adjusting screw and also serves to facilitate adjustment of the follower 122 in a transverse direction. It will be readily apparent from the foregoing disclosure that when the headstock face plate 100 is rotated, a rotary motion will be transmitted through the chain drive above described to rotate the sprocket 111 and the sleeve 112 and thereby rotate the attachment face plate spindle 87 and the work piece 70. When the sleeve 112 is rotated, it also serves to rotate the master cam 120 which in turn cooperates with the follower and causes a transverse movement of the slide 81 and the work piece 70.

In order to facilitate the master cam 120 remaining at all times in operative engagement with the follower 122 so that the cam will produce the desired transverse movement of the slide 81, a stud 130 is screw threaded into the slide 81 and passes through a clearance aperture in the frame 80 and extends into an enlarged hole 131 within the projecting boss 132 of the frame 80. A compression spring 133 surrounds the stud 130 and is interposed between a head on the stud 130 and the bottom of the enlarged hole 131. This spring has sufficient compression so that the cam 120 is at all times maintained in operative engagement with the follower 122.

In order to attain one of the main objects of the invention, it is desirable that the footstock center 72 be moved transversely in synchronism with the headstock center 71 so that the work piece 70 may be ground throughout its length to

the desired and predetermined contour. The footstock center 72 is supported in a slidably mounted footstock sleeve 140 which is in turn supported in a transversely movable slide 141. The slide 141 is arranged to slide transversely relative to a frame 142 formed integral with the footstock frame 76. An adjusting screw 143 is provided which serves as a stop to limit the movement of the footstock center toward the left. A compression spring 144 serves normally to hold the footstock center in operative engagement with the work piece. The footstock spindle 140 is arranged so that it may be rapidly withdrawn to facilitate loading of work pieces into the machine by means of an actuating handle 145 which is mounted on the upper end of a rotatable shaft 146. A gear segment 147 is mounted on the shaft 146 which meshes with rack teeth 148 formed on the periphery of the spindle 140. By rotation of the gear segment 147 (Fig. 5) in a clockwise direction, the footstock center 72 and the spindle 140 may be moved toward the right to withdraw the center from operative engagement with the work piece 70.

The footstock slide 141 supports a rotatable sleeve 150 which in turn supports on its outer end a master cam 151. The master cam 151 is accurately timed to rotate in synchronism with the master cam 120. The master cam 151 is accurately timed to rotate in synchronism with the master cam 120. This is preferably accomplished by means of a multiple splined shaft 153. The splined shaft 153 has a left-hand end reduced diameter portion 154 which is slidably keyed within an aperture in the sleeve 112 and is held in longitudinal adjusted position relative to the sleeve 112 by means of a screw 155. The right-hand end of the multiple splined shaft 153 passes through a multiple splined aperture within the rotatable sleeve 150 so that rotation of the sleeve 112 rotates sleeve 150 synchronously therewith, thus synchronizing the rotation of the master cams 120 and 150, and the transverse movement of the opposite ends of the work piece 70.

The master cam 151 is held in adjusted position on the sleeve 150 by means of the collars 156 and 157. The master cam 151 is accurately timed relative to the master cam 120 so that both cams are arranged to synchronously move the slides 81 and 141 toward and from the grinding wheel 13 to produce a desired and predetermined contour throughout the length of the work piece 70.

A follower 158 is held in adjusted position by means of screws 159 and 160 which pass through an elongated slot 161 in the follower 158 and are screw threaded into the frame 142. An adjusting or backing screw 162 is screw threaded through a projecting lug in the frame 142 and serves to back up the follower plate 158 and also to facilitate adjustment of the follower in setting up the machine. The cam 151 is maintained in operative engagement with the follower 158 by means of a spring 163 which surrounds a stud 164 carried by the slide 141 and is interposed between a head on the stud 164 and the bottom of a hole 165 in the frame 142.

As illustrated in Fig. 5 of the drawings, a three to one reduction is provided between the work drive face plate 87 and the sleeve 112 so that the sleeve 112 rotates three times while the face plate 87 and the work piece 70 rotate once. The work piece 70 as illustrated is commonly known as a tri-lobe shaft, as shown in cross section in Fig. 6, and it is only necessary to produce one-third of the shape on the cam 120. Thus the contour of the cam 120 and the cam 151 causes the slides 81 and 141 respectively to move toward and from the wheel axis three times during one rotation of the work piece 70 and consequently produce three portions of the work of the same identical shape.

As illustrated in the drawings, the grinding apparatus is set up for grinding a shaft having a triangularly shaped cross section (Fig. 5) which is known as a tri-lobe shaft. This shaft has three projecting lobes which fit within a correspondingly shaped aperture and serve to replace the commonly used multiple splined shaft. By utilizing a three to one reduction in the drive between the sleeve 112 and the work driving face plate 87, a master cam 120 may be utilized which is shaped to produce only one lobe on the shaft. Due to the three to one reduction, the master cam 120 rotates three times to a single rotation of the face plate 87 and work piece 70. By utilizing such a construction, it is easier to produce a master cam formed accurately to produce a single lobe and inasmuch as the same cam surface produces each lobe on the shaft, three identically shaped lobes will be accurately produced. Similarly the master cam 151, which is synchronously rotated with the master cam 120, produces a synchronous movement of the footstock center 72 so that both ends of the shaft are synchronously moved toward and from the grinding wheel to facilitate grinding a shaft having an identical cross section from end to end. The cam 151 is shaped exactly to correspond with the master cam 120 and is accurately timed therewith.

While the illustration in the drawings shows a three to one reduction for producing a tri-lobe shaft, this reduction may be readily varied to meet the needs of the particular grinding job. The master cams 120 and 151 are readily removable so that they may be replaced by cams of different contours to produce other shapes on a work piece. The multiple splined shaft 153 may be readily withdrawn by removing the screw 155, and the gears 114, 115 and 116 may be readily changed so that a one to one relation may be obtained or any desired gear reduction may be obtained between the sleeve supporting the master cams and the work supporting and rotating members.

The operation of this improved grinding apparatus will be readily apparent from the foregoing disclosure. Assuming all of the parts to have been previously adjusted, and the proper master cams 120 and 151 mounted in place and the desired gear ratio provided between the driving sleeve 112 and the work drive face plate 87, the footstock center 72 is withdrawn by manual operation of the lever 145 and a work piece 70 is inserted between the headstock center 71 and the footstock center 72. The grinding wheel may then be set in rotation and the rotation of the work started through the headstock 12 and the table traversed or reciprocated, either manually or by power, as above described. As the work piece 70 rotates in operative contact with the grinding wheel, the master cams 120 and 151 produce a synchronous horizontal transverse movement of the slides 81 and 141 toward and from the wheel axis so as to generate a predetermined contour on the periphery of the work piece 70. The grinding operation proceeds until

the shaft 70 has been ground to the required predetermined size and contour.

While this machine has been shown as set up for grinding a tri-lobe shaft, it is equally applicable to grinding irregularly shaped objects, such as eccentrics, cams and the like.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said grinding wheel transversely, a longitudinally movable table, a rotatable work support thereon including independent transversely movable headstock and footstock centers, and means including a cam and a follower synchronously to move said centers transversely toward and from the grinding wheel to grind a predetermined contour on the work piece.

2. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable table, a rotatable work support thereon including a headstock and a footstock center, spaced independent transversely movable slides on said table to support said headstock and footstock centers, and means including a cam and a follower synchronously to move said slides to produce a transverse movement of said centers to grind a predetermined contour on the work piece.

3. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable work table, a rotatable work support thereon including a headstock and a footstock center, a pair of spaced independent transversely movable slides to support said headstock and footstock centers, and an independent cam and follower to move each of said slides transversely to grind a work piece to a predetermined contour.

4. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable table, a rotatable work support including a headstock and a footstock center, spaced independent horizontally movable slides on said table to support said headstock and footstock centers, a master cam and a follower associated with each of said slides which are arranged to move said slides transversely toward and from the grinding wheel, and means synchronously to actuate said cam simultaneously to move said headstock and footstock centers toward and from the grinding wheel periphery to grind a work piece to a predetermined contour.

5. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable table, a rotatable work support including a headstock and a footstock center, spaced independent horizontally movable slides on said table to support said headstock and footstock centers, a master cam and a follower to move said headstock center toward and from the grinding wheel, a second master cam and follower to move said footstock center toward and from the grinding wheel, and a driving mechanism synchronously to rotate said master cams synchronously to move said centers transversely to generate a predetermined contour on the work piece.

6. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable table, a transversely movable headstock and a transversely movable footstock on said table, headstock and footstock centers supported thereon, a rotatable master cam and a follower to move said headstock transversely toward and from the grinding wheel, a rotatable master cam and a follower to move said footstock transversely toward and from the grinding wheel, and means synchronously to rotate said master cams simultaneously to move the headstock and footstock toward and from the grinding wheel periphery to generate a predetermined form thereon.

7. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable table, a rotatable work support including a transversely movable headstock and a transversely movable footstock thereon, a rotatable work drive face plate on said headstock, spaced independent rotatable master cams and followers to move said headstock and footstock transversely, a driving shaft between said master cams synchronously to rotate said cams, means to rotate said driving shaft, and driving connections between said shaft and headstock face plate synchronously to rotate said face plate in timed relation with the master cams.

8. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable table, a rotatable work support including a transversely movable headstock and a transversely movable footstock thereon, a rotatable work drive face plate on said headstock, spaced independent rotatable master cams and followers to move said headstock and footstock transversely, a driving shaft between said master cams synchronously to rotate said cams, means to rotate said driving shaft, and reduction gearing between the driving shaft and the headstock face plate to rotate the work drive face plate at a slower speed so that the master cam rotates a plurality of rotations while the face plate rotates once so that a single lobed master cam produces a multiple lobed ground surface.

9. A grinding machine having a rotatable transversely movable grinding wheel, means to feed said wheel transversely, a longitudinally movable table, a rotatable work support including a transversely movable headstock and a transversely movable footstock thereon, a rotatable work drive face plate on said headstock, spaced independent rotatable master cams and followers to move said headstock and footstock transversely, a driving shaft between said master cams synchronously to rotate said cams, means to rotate said driving shaft, and reduction gearing between said shaft and headstock face plate synchronously to rotate the face plate once while the shaft and master cams rotate three times so that a single lobed master cam produces a trilobed ground surface.

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