

June 21, 1932.

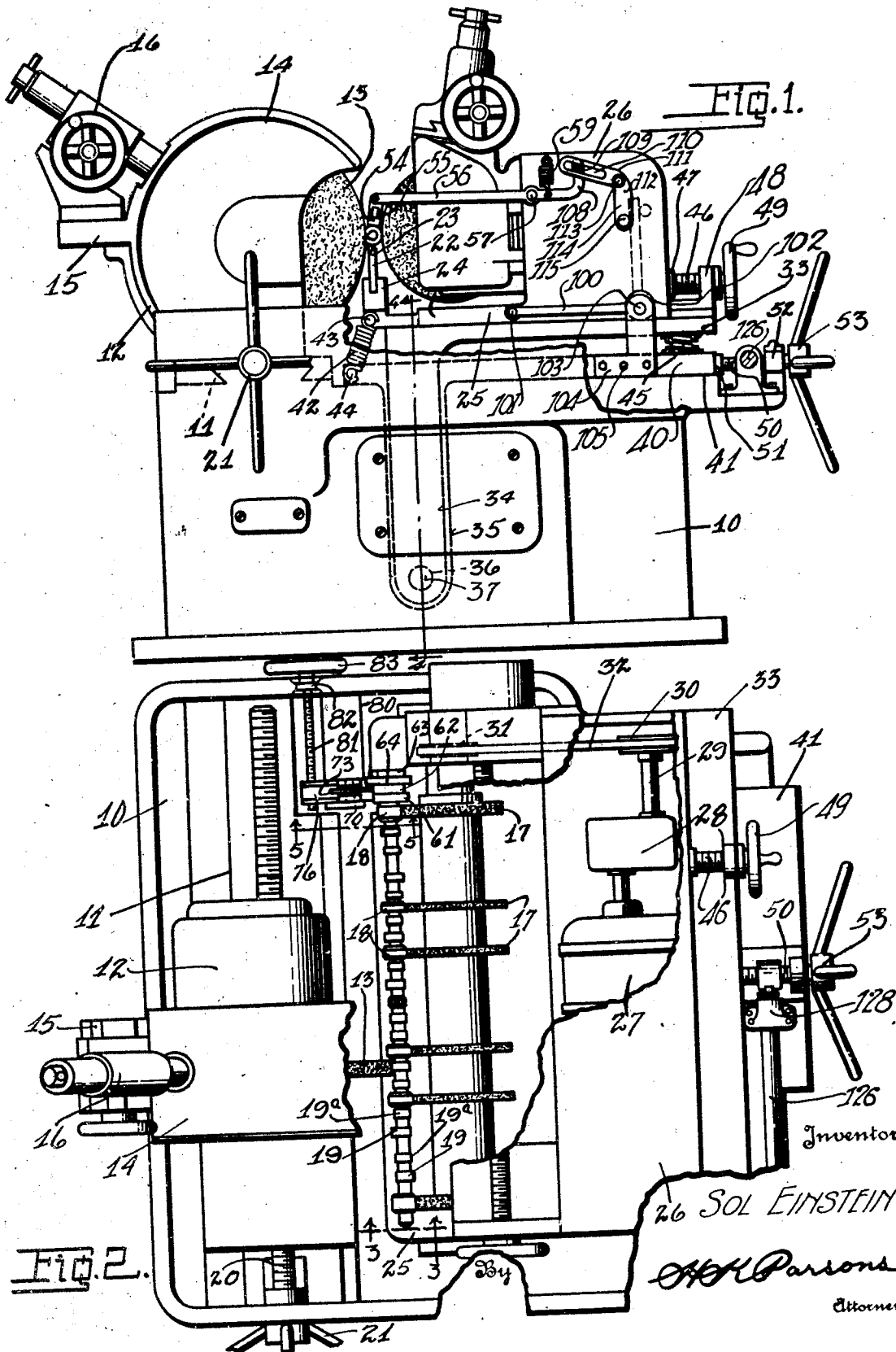
S. EINSTEIN

1,864,486

ART OF GRINDING

Filed Jan. 30, 1931

3 Sheets-Sheet 1



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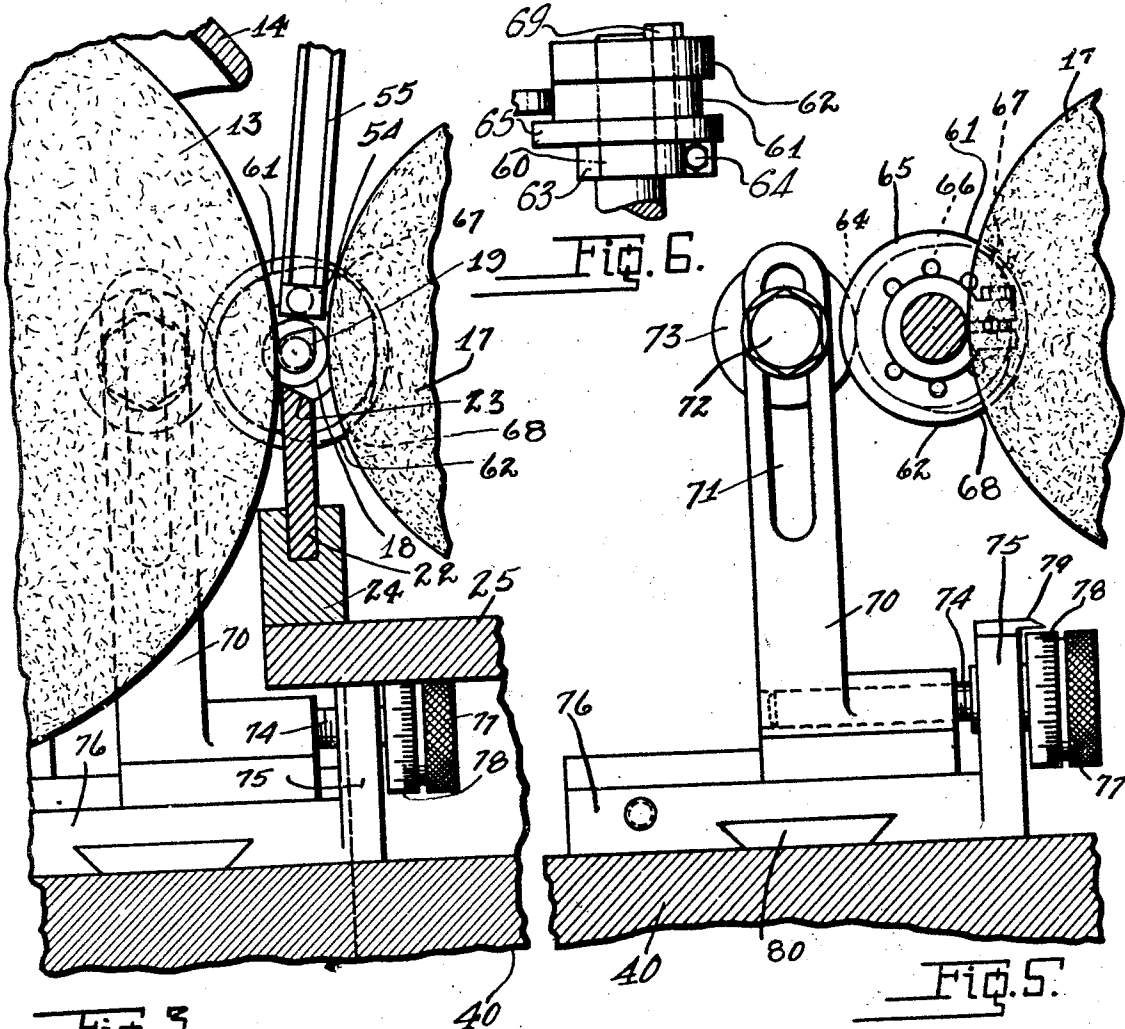
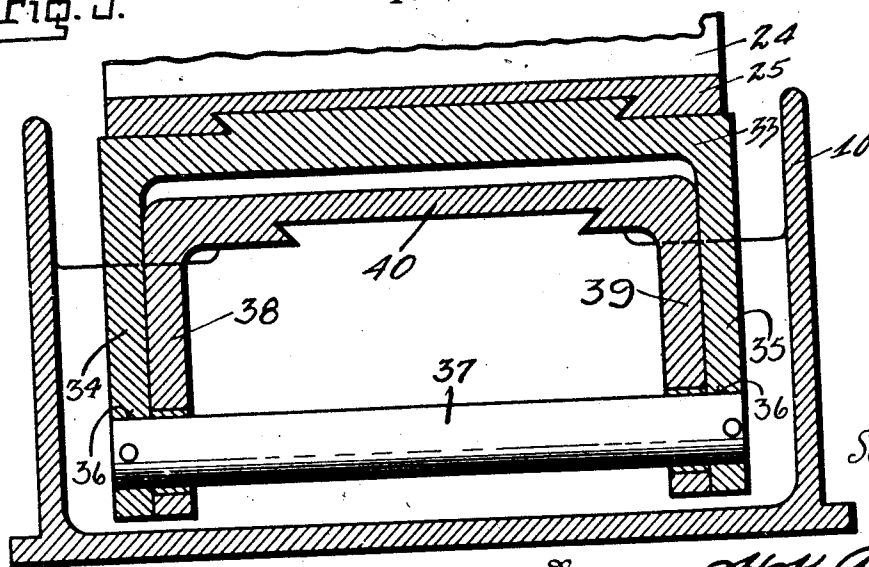
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Filed Jan. 30, 1931

3 Sheets-Sheet 2



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ART OF GRINDING

Application filed January 30, 1931. Serial No. 512,389.

This invention relates to improvements in the art of grinding and especially to improvements in a device for grinding irregularly shaped portions of a relatively elongated work piece about a predetermined axis of rotation.

An object of the invention is the provision of a centerless grinder for generating a contoured or non-circular surface.

Another object of the invention is the provision of a centerless grinder for grinding or generating a cam or non-circular contoured surface which is controlled and determined by a suitable master cam or template.

A further object of the invention is the provision of an improved centerless grinder construction for generating or grinding a cam or non-circular contoured surface in which an in and out movement is effected between the work and grinding wheel while the said cam or non-circular contoured surface is being ground.

A still further object of the invention is the provision of improved means for supporting, rotating and grinding a work piece having portions thereon of non-circular cross section to be ground or finished about an axis determined by other circular portions on the work.

Also it is an object of the invention to provide improved means for finishing the surface of irregular shaped objects, such as cams or the like, about an axis thereof not necessarily the axis of the mass.

Specifically the invention consists in the provision of an improved centerless grinder for grinding the cam portions of cam shafts concentric to the axis of a plurality of bearing portions of the shaft.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification considered in conjunction with the accompanying drawings forming a part thereof and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

In the drawings:

Figure 1 is a front elevational view of a centerless grinder embodying the improvements of this invention.

Figure 2 is a plan view of the machine shown in Figure 1.

Figure 3 is an enlarged fragmentary sectional view as seen from line 3—3 of Figure 2.

Figure 4 is an enlarged fragmentary sectional view as seen from line 4—4 of Figure 1.

Figure 5 is an enlarged fragmentary sectional view as seen from line 5—5 of Figure 2.

Figure 6 is a fragmentary elevational view of the master control cams shown in Figure 1 forming a detail of the invention.

Figure 7 is an end elevational view of the machine shown in Figures 1 and 2.

Figure 8 is a sectional view taken on line 8—8 of Figure 7.

Figure 9 is a perspective view of the hold down shoe operating mechanism forming a detail of the invention.

Throughout the several views of the drawings similar reference characters are employed to denote the same or similar parts.

In the past, centerless grinders have been employed for grinding the external or internal surfaces of work pieces about an axis determined by the mass while floating on a suitable support in the throat of a centerless grinder. These machines have also been employed for the production of surfaces of revolution concentric to other surfaces of revolution of the same work piece by limiting the floating action of the work on the work rest blade and forcing same to rotate about the axis determined by the previously formed portions thereof. By this invention it is proposed to form surfaces of revolution of non-circular form concentric to a predetermined axis of said surfaces which axis is that established while forming or grinding certain cylindrical portions of the work by a previous operation. The particular work piece chosen for illustrative purpose is the valve operating or cam shaft commonly employed with multi-cylinder internal combustion engines which shaft is integral in form having formed thereon a pair of cams for each cylinder, each cam respectively controlling

the in-take valve and the exhaust valve of each cylinder, as is well known in the art. These valve surfaces must be formed concentric to the axis of the bearings of the shaft which bearings support the shaft for rotative movement to effect the operation of the valves aforesaid.

The device shown in the drawings may comprise a bed 10 having formed on the upper surface thereof and extending transversely of the bed a slideway 11 for the grinding wheel slide 12 which rotatably supports the grinding wheel spindle to which is secured the grinding wheel 13. This wheel 13 is driven by any suitable or desirable source at a high grinding rate of speed with its active face traveling in a clockwise direction. The slide 12 has formed integral therewith the grinding wheel guard or housing 14 having a bracket 15 formed on the rear side thereof supporting for movement across the active face of grinding wheel 13 a truing mechanism 16.

As mentioned above, a standard centerless grinder has a pair of opposed grinding and regulating wheels between which the work is freely floated, the said wheels simultaneously contacting the work at opposed points on the periphery. The present invention contemplates a plurality of regulating wheels 17 opposed to the grinding wheel, each regulating wheel engaging a bearing portion 18 on the particular work piece illustrated in Figure 2 of the drawings. The grinding wheel 13 is advanced from one cam portion 19 to the next for grinding or finishing said portions while the rotation of the work is being controlled by the engagement of the regulating wheels 17 with the bearing portions 18. In order to advance the grinding wheel the slide 12 meshes with the threaded portion of adjusting screw 20 journaled in the front and rear walls of the bed 10. A hand or pilot wheel 21 is secured to the screw 20 exteriorly of the front wall within convenient reach of the operator. From this it will be seen that the grinding wheel may be readily traversed from station to station transversely of the bed 10.

The work, while being operated upon, is peripherally supported by a work rest blade 22 beneath the work throughout its length and contacting with the bearing portions 18 of the work at points beneath the work and to one side of the axis thereof opposite to that contacted by the regulating wheels. The work rest blade 22 is provided with an active supporting upper surface 23 inclining in the general direction of the regulating wheels 17 and forming with the active surfaces of said wheels a work receiving trough capable of supporting the work while being advanced toward the grinding wheel by means to be later described.

The work rest blade 22 is suitably adjust-

ably supported by a block 24 mounted at the forward end of a swinging bracket 33. A slide 25 is provided and has formed integral therewith a housing or the like 26 enclosing the regulating wheel drive which may be a cone pulley, speed reduction gear or the like, coupled with a source of power outside the machine or, and as shown in Figure 2, may enclose a prime mover 27 coupled through speed reducing gearing 28 to a countershaft 29 having secured thereto a pulley 30. A second pulley 31 on the spindle supporting the regulating wheels 17 is belted by means of transmission belt 32 with the pulley 30 whereby motion is transmitted to the regulating wheels 17 from the motor 27. As is usual in centerless grinders the regulating wheels 17 are rotated at a relatively slow work controlling rate of speed in a clockwise direction whereby the surfaces of said wheels adjacent the work rest blade 22 travel downwardly as compared with the adjacent surface of the grinding wheel 13 which moves upwardly.

The work and grinding wheel are adapted to have a relative movement independent of the normal feed, to be later described, while being supported by the blade 22 and rotated by the regulating wheels 17 for which purpose the slide 25 is carried by a swinging bracket 33 having depending therefrom the arms 34 and 35 through the lower ends of which perforations 36 are formed for the pivot shaft 37. The pivot shaft 37 is supported by arms 38 and 39 depending from adjustable bed plate 40 mounted upon a suitable slideway 41 formed integral with or secured to the bed 10. On each side of the bracket 33 there is provided a compression spring or the like 42 having their opposite ends respectively secured at 43 to the inner end of slide 25 and at 44 to the corresponding end of the bed plate 40. Expansion springs 45 are mounted on the rear end of bed plate 40 and have their opposite ends contacting with the outer extremity of the swinging bracket 33. The compound action of compression springs 42 and expansion springs 45 effect a relative in and out movement of the work and grinding wheel by oscillating the bracket 33 and slide 25 and parts carried thereby about the axis of the pivot shaft 37 which relative movement is controlled, as will later appear.

It will be noted by reference to the drawings that the arms 34 and 35, depending from the swinging bracket 33, and the arms 38 and 39 of the bed plate 40 extend nearly to the base of the machine, placing the axis of pivotance as far as possible from the axis of the work. By this construction the work is given a movement toward and from the grinding wheel in an arcuate path, it is true, but in a path which is very nearly a straight line movement radially of the center of the grinding wheel, which movement enables the

mechanism to more accurately follow and reproduce a given configuration or contour, as will later appear.

The positions of the slide 25, housing 26 and regulating wheels 17 relative to the bracket 33 may be adjusted to suit different sizes and kinds of work for which purpose adjusting screw 46 is provided being threadedly connected with a nut 47 carried by the housing 26. The outer end of the screw 46 is journaled in a lug 48 extending upwardly from the bracket 33 and a hand wheel 49 is secured to the nut exteriorly of the lug 48. Similarly, the bed plate 40 may be adjusted relative to the slideway 41 for changing the position of the bracket 33 and parts carried thereby relative to the grinding wheel 13 by an adjusting screw 50 threadedly received in a nut 51 mounted in the end of the bed plate 40. This screw 50 is likewise journaled in a lug or bracket 52 extending upwardly from the slideway 41 and a pilot or hand wheel 53 is secured to the screw 50 exteriorly of the bracket 52. These adjustments are employed primarily for initial setup for positioning the parts to provide the proper size of grinding throat and for taking up wheel wear and the like. While to cause a feeding movement between the work and grinding wheel use is made of infeed lever 125 secured to the outer end of a transverse shaft 126. The shaft 126 extends transversely of the bed 10 and is oscillatably journaled in bearings 127 and 128 secured to the slideway 41, one adjacent the lever 125 and the other near the adjusting screw 50. Beyond the bearing 128 the shaft 126 carries a plate 129 from which an eccentric pin 130 projects and the said pin carries a roller 131 received in groove 132 of sleeve 133. This sleeve 133 has journaled therein the screw 50 so that the screw may be rotated, as by the pilot wheel 53, without rotating the sleeve 133 but the said sleeve is held against axial movement independently of the screw 50 by suitable nuts or collars 134 secured to the screw on opposite ends of sleeve 133. Therefore oscillation of the lever 125 in a counter-clockwise direction similarly oscillates the shaft 126 and plate 129 which movement through the eccentric pin 130 axially shifts the sleeve 133, screw 50, and all parts carried by bed plate, including the work, toward the grinding wheel. From the foregoing it will be seen that the parts may be relatively adjusted to take care of varying sizes of work, the work and grinding wheel may be relatively shifted to effect a stock removal from the work, as well as the grinding wheel may be adjusted or advanced from station to station to perform intermittent grinding operations on an integral elongated work piece. In order to place a work piece on and remove same from the work rest there is pro-

vided a lever 100 which has a handle 101 at one end and an eccentric 102 at the other end. The eccentric 102 is oscillatably mounted at 103 to a bracket 104 secured by any desirable means, such as bolts 105, to the bed plate 40. The position of the parts is such that the periphery 106 of the eccentric 102 contacts with the upper surface 107 of the swinging bracket 33, or with a ledge provided thereon for that purpose, so that actuation of the eccentric about its pivot permits the springs 42 and 45 to expand, or effects tensioning thereof depending on whether the lever 100 is actuated from the dotted line position to the full line position or vice versa, as shown in Figure 1.

In order to hold the work in engagement with the work rest blade and regulating wheels and to prevent a tendency in the work to tilt because of the pressure between the master cams and limit roll to determine the axis of the work while being rotated, an overhead guide shoe 54 is provided being frictionally pivotally secured by arms 55 to the levers 56. The levers 56 are pivoted at 57 to opposite ends of housing 26 and the said arms are yieldingly actuated about the pivots in the direction of the work by yielding means, such as springs 59, having opposite ends secured to the levers 56 and the said end walls of the housing 26. The free end of one of the arms 56 is turned upwardly as at 108 to form a bell crank. The portion 108 of this arm 56 is provided with a pin 109 received in a slot 110 formed in one arm 111 of bell crank 112 pivoted at 113 to the end wall of the housing 26. The other arm 114 of said bell crank 112 is provided with a pin 115 projecting outwardly therefrom and the said pin lies in the path of movement of and is adapted to be engaged by the lever 100 when shifted from the solid line position shown in Figure 1 to the normal operative or dotted line position there shown. As the lever 100 is moved to its normal position the bell crank 112 is actuated about its pivot 113 in counter-clockwise direction, which through the pin and slot connection 109-110 actuates the levers 56 about the pivots 57 in a clock-wise direction to raise the shoe 54 from the work and permit a replacement of the finished work piece in the grinding throat.

As was mentioned above, the various portions 19 of the work to be ground are cam shaped and the said portions are in varying relation to one another so that the several valves operated thereby are actuated in proper timed sequential order. Adjacent cam portions 19 and 19a are of slightly different contour and bear a definite relation to one another. Each succeeding pair of cams 19-19a are advanced as respects the preceding pair so that succeeding cylinders of a multi-cylinder internal combustion engine

will properly function. In order to control the formation of the different portions of the cams being ground master cams have been provided for controlling the engagement of the work with the grinding wheel. As seen in Figures 3, 5 and 6, the work is provided on one end with a portion 60 extending beyond the last bearing portion 18 on which is mounted a pair of cams 61 and 62. A collar 63 is secured to the portion 60 of the work by a suitable clamp screw 64 or the like. The collar 63 has integral therewith a flange 65 having formed therein perforations 66, see Figure 5, spaced from one another the amount the several pairs of cams 19-19a are advanced, one with respect to the other. As will be noted in Figure 5 the flange 65 has formed therein eight perforations and, as will be seen from Figure 2, the work is provided with eight pairs of adjacent cams 19-19a. This cam shaft is designed for use with an eight cylinder internal combustion engine and it will be understood that any desired number of pairs of cams may be formed upon the cam shaft depending upon the number of cylinders in the engine with which the shaft is to be used. The master cams 61 and 62 may be formed integral with one another having their apexes 67 and 68 definitely spaced from one another, as determined in actual practice, or the said cams may be made separately and suitably clamped together. The cams 61 and 62 are each provided with a perforation adapted to register with the perforations 66 in the flange 65 and a bolt or locking pin 69 extends through the aligned perforation in the flange 65 and cams 61 and 62 for locking the said parts together as a unit.

Mounted on the bed plate 40 for transverse and longitudinal movement thereof is a bracket 70 having an elongated perforation 71 formed therein receiving the axle bolt 72 of contact roller 73 adapted to bear against the periphery of the master cams 61 and 62. The elongated perforations 71 permit the vertical adjustment of the axle bolt 72 to align the roller 73 with the axis of the shaft depending upon the vertical adjustment of the work rest blade 22. An adjusting screw 74 having threaded engagement with the bracket 70 is provided for actuating the said bracket longitudinally of the bed or in the direction of feed of the work toward the grinding wheel. This adjusting screw 74 is rotatably journaled in a lug or bearing 75 extending upwardly from transverse slide 76 and the screw 74 is provided with a knob 77 exteriorly of the bearing 75 which knob has formed thereon suitable graduations 78 cooperating with a suitable pointer or the like 79 secured to the lug 75. The slide 76 engages a suitable slideway 80 formed transversely of the bed plate for guiding the said slide 76 in its movement which is effected by an adjusting screw 81, see Figure 1, having threaded connection therewith and rotatably journaled in a lug 82 extending upwardly from the bed plate 40 near the rear end thereof. A hand wheel 83 is secured to the screw 81 exteriorly of the lug 82 whereby the said screw is operated.

The operation of the mechanism is as follows: The lever 100 at the beginning of the operation on a crank shaft is in the dotted line position shown in Figure 1 with the grinding throat enlarged to permit the placement of a piece of work on the work rest blade 22. The lever 100 is then actuated in a counter-clockwise direction whereupon the springs 42 and 45 expand and cause the bracket 33 to swing about the axis of the pivot shaft 37 toward the grinding wheel. Since the work rest blade 22, regulating wheels 17, slide 25 and associated parts are carried by the bracket 33 they all swing as a unit. It will be noted, however, that the axis of the work even though approaching the grinding wheel does not shift its position relative to the support and does not change its parallel relationship with the axis of the grinding wheel. When the lever 100 is initially moved from the dotted line position in Figure 1 the pin 115 of lever 114 is released thereby permitting spring 59 to actuate arms 56 about their pivots 57 to place the overhead shoe 54 against the work. As the work approaches the grinding wheel, the particular master cam 61 or 62 will engage the limiting roll 73 depending upon the particular cam 19 or 19a being ground. Assuming the cam portion 19 is to be generated or formed first, then the cam 61 will engage the roll 73 and effect a relative in and out movement between the grinding wheel and work as determined by the contour of master cam.

The rotation of the work while in engagement with the contact roller 73 causes a continuous oscillation of the work, and all parts associated therewith and carried by the bracket 33 about the axis of the pivot shaft 37 toward and from the grinding wheel. At this time the infeed lever 100 is actuated in a counter-clockwise direction for shifting the bed plate 40 and mechanism carried thereby toward the grinding wheel to feed the work into said grinding wheel and effect a stock removal from the cam portion 19 being ground. It should be remembered that the oscillation of the bracket 33 continues during this infeed movement so that an equal amount of stock is removed all around the periphery of the cam. The lever is moved from a vertical position to a horizontal one which causes the work to be reduced not only to the desired form but also to the desired size. The lever 125 is then returned to its vertical position. As soon as the cam portion 19 is reduced to size the grinding wheel 13 is advanced through the medium of hand wheel 21 and

adjusting screw 20 to the cam portion 19a and the slide 76 is advanced along the slide-way 80 until the roller 73 contacts with the master cam 62 which corresponds in contour with the cam portion 19a now to be ground. The work and supporting slides are now actuated in a counterclockwise direction by springs 42 and 45 toward the grinding wheel, as above described, to effect a stock removal from the cam portion 19a. This continues until the said portion is reduced to the desired size and contour as determined by the master cam 62 and contacting or limiting roller 73.

The grinding wheel is then advanced to the next pair of cams 19—19a and the roller 73 adjusted for contact with the desired cam 61—62 now to be operated upon. The operation of the grinding of this pair of cams continues until they are reduced to the desired size and contour. It will be noted that the work is supported and rotated upon the previously finished surfaces of the bearing portions 18 which portions determine the axis about which the shaft and parts carried thereby will rotate so that each of the cams 19—19a will have its active periphery ground concentrically to the axis of the bearing portions 18.

What is claimed is:

1. In a centerless cam shaft grinder, the combination of opposed grinding and regulating wheels forming a grinding throat therebetween, a work rest blade within said throat for supporting the work, a master cam conforming to the desired configuration to be formed on the work piece, and a stop member for engagement with the master cam to control the action of the grinding wheel on the work.

2. A machine for grinding a cam shaft comprising a yieldable support, a work rest and a regulating wheel on said support, said work rest supporting the work in engagement with and while being rotated by the regulating wheel, a grinding wheel, and means for effecting a relative movement between the yieldable work support and parts carried thereby and the grinding wheel.

3. A machine for grinding a cam shaft comprising a yieldable support, a work rest and a regulating wheel on said support, said work rest supporting the work in engagement with and while being rotated by the regulating wheels, a grinding wheel, and means for effecting a relative movement between the yieldable work support and parts carried thereby and the grinding wheel, said means including a master cam carried by the work, and a limiting roll for engagement with the master cam.

4. In a machine for grinding a multiple diameter shaft, the combination of a plurality of regulating wheels engaging one diameter of the shaft, and a grinding wheel engag-

ing another diameter of the shaft between the regulating wheels.

5. In a machine for grinding a multiple diameter shaft, the combination of a plurality of regulating wheels engaging one diameter of the shaft, a grinding wheel engaging another diameter of the shaft between the regulating wheels, and means effecting an in and an out movement of the shaft and grinding wheel to generate a cam on the shaft.

6. In a machine of the class described, the combination of opposed grinding and regulating wheels forming a grinding throat therebetween, a work rest blade within the grinding throat supporting the work piece in position for engagement with the grinding wheel, and a templet carried by the work for effecting a controlled in and out movement of the work and grinding wheel to generate a cam on the work.

7. In a machine of the class described, the combination of opposed grinding and regulating wheels forming a grinding throat therebetween, a work rest blade within the grinding throat supporting the work piece in position for engagement with the grinding wheel, a templet carried by the work for effecting a controlled in and out movement of the work and grinding wheel to generate a cam on the work, and additional means for effecting a feeding movement of the work and grinding wheel independent of the movement thereof caused by the templet on the work.

8. In a machine of the character described the combination of a bed, means on the bed for supporting a work piece for rotation thereon, a grinding wheel on one side of the work support for engagement with individual spaced portions of the work, means for axially advancing the grinding wheel relative to the work, and means on the other side of the work for frictionally engaging and controlling its rotation.

9. In a machine of the character described the combination of a bed, means on the bed for supporting a work piece for rotation thereon, a grinding wheel on one side of the work support for engagement with individual portions of the work, means for axially advancing the grinding wheel relative to the work, means on the other side of the work for frictionally engaging and controlling its rotation, yielding means for effecting an oscillation of the work and wheel relative to one another, and means controlling the said oscillation to control and determine the final contour of the work.

10. In a machine of the character described the combination of a bed, means on the bed for supporting a work piece for rotation thereon, a grinding wheel on one side of the work support for engagement with individual portions of the work, means for axially advancing the grinding wheel rela-

- tive to the work, means on the other side of the work for frictionally engaging and controlling its rotation, yielding means for effecting an oscillation of the work and wheel relative to one another, and means controlling the said oscillation of the work and grinding wheel to determine the final contour of the work, said means comprising a templet carried by the work, and a templet follower roll for engagement with the templet.
11. In a centerless grinder for grinding relatively long work pieces, the combination of opposed grinding and regulating wheels forming a grinding throat therebetween, a work rest blade within said throat supporting the work piece in simultaneous engagement with said wheel, means engaging the work and holding same against the work rest blade to determine the axis of the work while being rotated, and means rendering said last mentioned means inoperative to permit a replacement of the work on the work rest blade.
12. In a centerless grinder for grinding relatively long work pieces, the combination of opposed grinding and regulating wheels forming a grinding throat therebetween, a work rest blade within said throat supporting the work piece in simultaneous engagement with said wheel, means engaging the work and holding the same against the work rest blade to determine the axis of the work while being rotated, means rendering said last mentioned means inoperative to permit a replacement of the work on the work rest blade, means yieldingly effecting oscillation of the work and grinding wheel, and means for rendering said oscillating means inoperative.
13. In a centerless grinder for grinding relatively long work pieces, the combination of opposed grinding and regulating wheels forming a grinding throat therebetween, a work rest blade within said throat supporting the work piece in simultaneous engagement with said wheel, means, including a hold down shoe, engaging the work and holding same against the work rest blade to determine the axis of the work while being rotated, means rendering said last mentioned means inoperative to permit a replacement of the work on the work rest blade, means yieldingly effecting oscillation of the work and grinding wheel, means for rendering said oscillating means inoperative, and additional means coupling the hold down shoe operating means and the means for rendering the work oscillation means inoperative for sequential operation.
14. In a centerless grinder for grinding work pieces of the class described, the combination of a bed, a grinding wheel carried thereby, a slide carried by the bed for movement relative thereto toward and from the grinding wheel, a swinging bracket carried by the slide, a regulating wheel on the bracket in opposition to the grinding wheel and forming a grinding throat therebetween, a work rest blade in the throat on the bracket for movement therewith, and cooperating means carried by the work and slide for effecting oscillation of the bracket.
15. In a centerless grinder for grinding work pieces of the class described, the combination of a bed, a grinding wheel carried thereby, a slide carried by the bed for movement relative thereto toward and from the grinding wheel, a swinging bracket carried by the slide, a regulating wheel on the bracket in opposition to the grinding wheel and forming a grinding throat therebetween, a work rest blade in the throat on the bracket for movement therewith, cooperating means carried by the work and slide for effecting oscillation of the bracket, and means carried by the slide for rendering the oscillation means inoperative.
16. In a grinding machine for grinding non-circular work pieces, the combination of a grinding wheel, a work rest adjacent the grinding wheel for supporting a work piece, and means carried by the work piece for effecting an axial approach and retraction of the work and grinding wheel.
17. In a grinding machine for grinding non-circular work pieces, the combination of a grinding wheel, a work rest adjacent the grinding wheel for supporting a work piece, means carried by the work piece for effecting an axial approach and retraction of the work and grinding wheel, and a regulating wheel on the other side of the work rest frictionally engaging and controlling the rotation of the work.
18. In a grinding machine of the class described the combination of a grinding wheel, a bed supporting the grinding wheel, a work support mechanism carried by the bed for movement toward and from the grinding wheel including a bracket, a work rest on said bracket, relatively long depending arms carried by the bracket, means pivotally connecting the extremities of the arms to the work supporting mechanism, and means carried by the work for effecting an oscillation of the bracket about its pivotal connection.
19. A centerless grinder for grinding the cam portions of a cam shaft for an internal combustion engine comprising a bed, a work rest blade for peripherally supporting the cam shaft by engaging the bearing portions of said shaft, a plurality of regulating wheels on one side of said work rest blade for frictionally controlling the rotation of the cam shaft by frictional engagement with said bearing portions, a grinding wheel carried by the bed on the other side of the work rest blade for grinding the cam portions

of the shaft, means for axially advancing the grinding wheel relative to the work rest blade and regulating wheels from cam to cam, a slide supported by the bed, a bracket for the work rest blade and regulating wheels, means pivotally mounting the bracket on the slide, yielding means for effecting a relative feed between the cam shaft, supporting bracket and grinding wheel, and means for limiting said relative feed between the grinding wheel and cam shaft.

20. A centerless grinder for grinding the cam portions of a cam shaft for an internal combustion engine comprising a bed, a work rest blade for peripherally supporting the cam shaft by engaging the bearing portions of said shaft, a plurality of regulating wheels on one side of said work rest blade for frictionally controlling the rotation of the cam shaft by frictional engagement with said bearing portions, a grinding wheel carried by the bed on the other side of the work rest blade for grinding the cam portions of the shaft, means for axially advancing the grinding wheel relative to the work rest blade and regulating wheels from cam to cam, a slide supported by the bed, a bracket for the work rest blade and regulating wheels, means pivotally mounting the bracket on the slide, yielding means for effecting a relative feed between the cam shaft, supporting bracket and grinding wheel, means for limiting said relative feed comprising a pair of master cams carried by the cam shaft, one corresponding to the contour of the in-take cam and the other to the contour of the exhaust cam, and means for individually contacting said master cams to control the operative engagement between the cam shaft and the grinding wheel.

In testimony whereof I affix my signature.
SOL EINSTEIN.

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