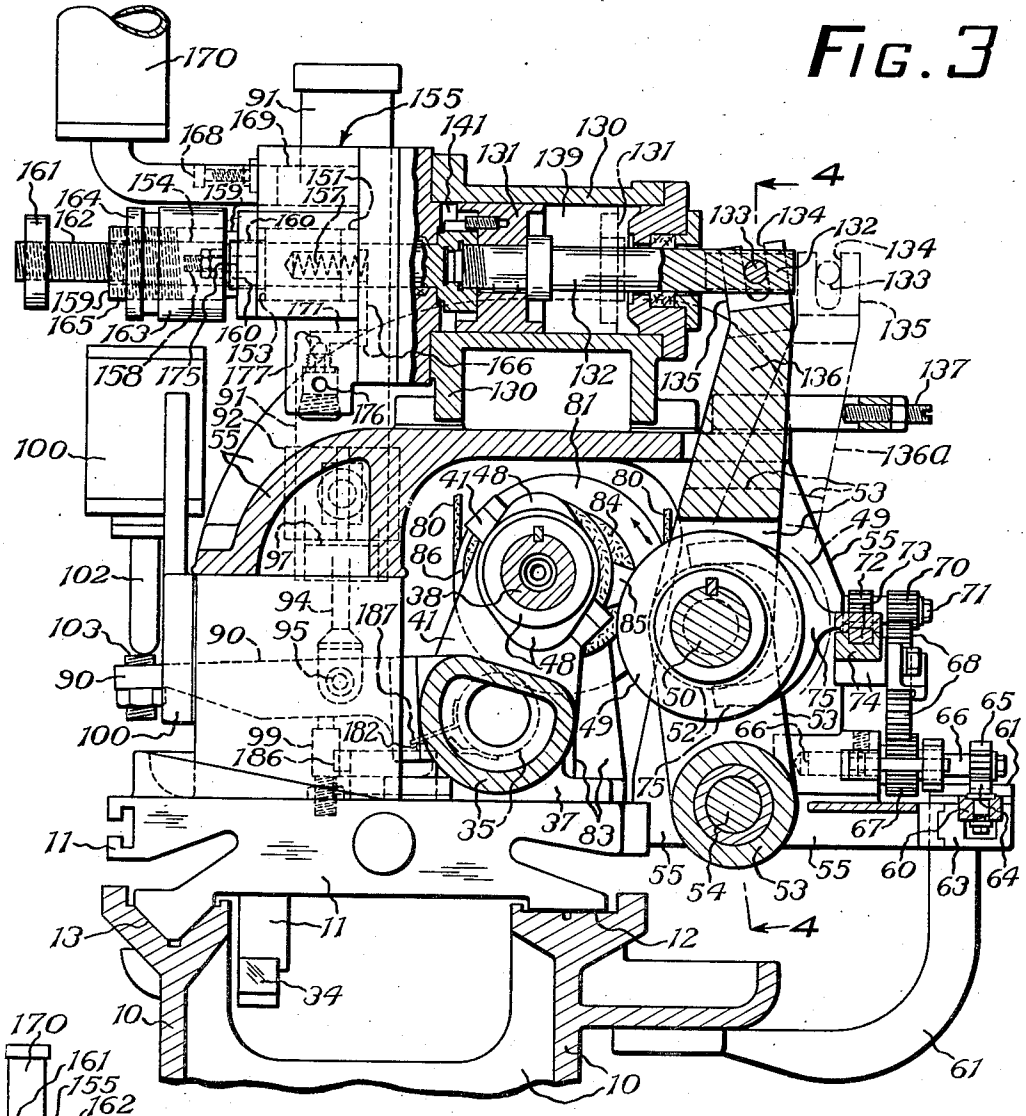
Aug. 5, 1941. C. J. GREEN 2,251,882

CAM GRINDING MACHINE

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FIG. 3



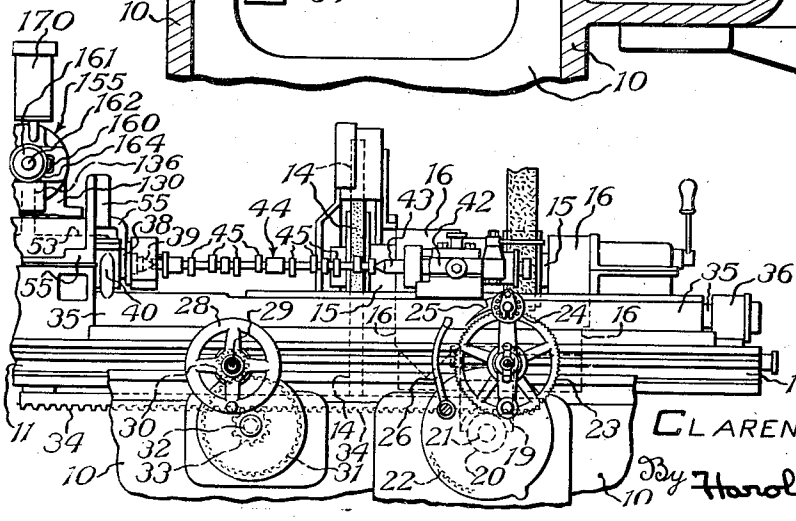


FIG. 1

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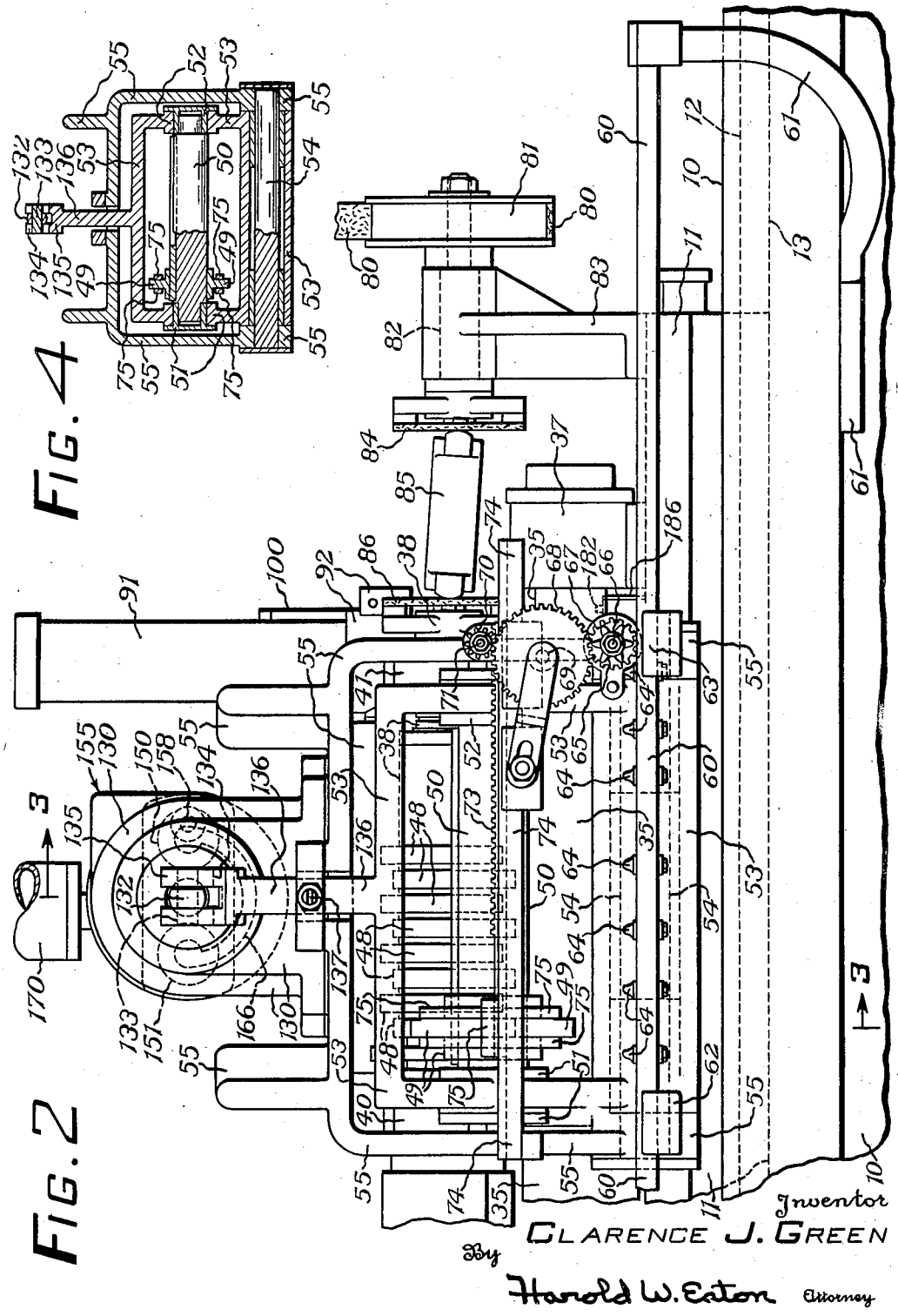


FIG. 4

FIG. 2

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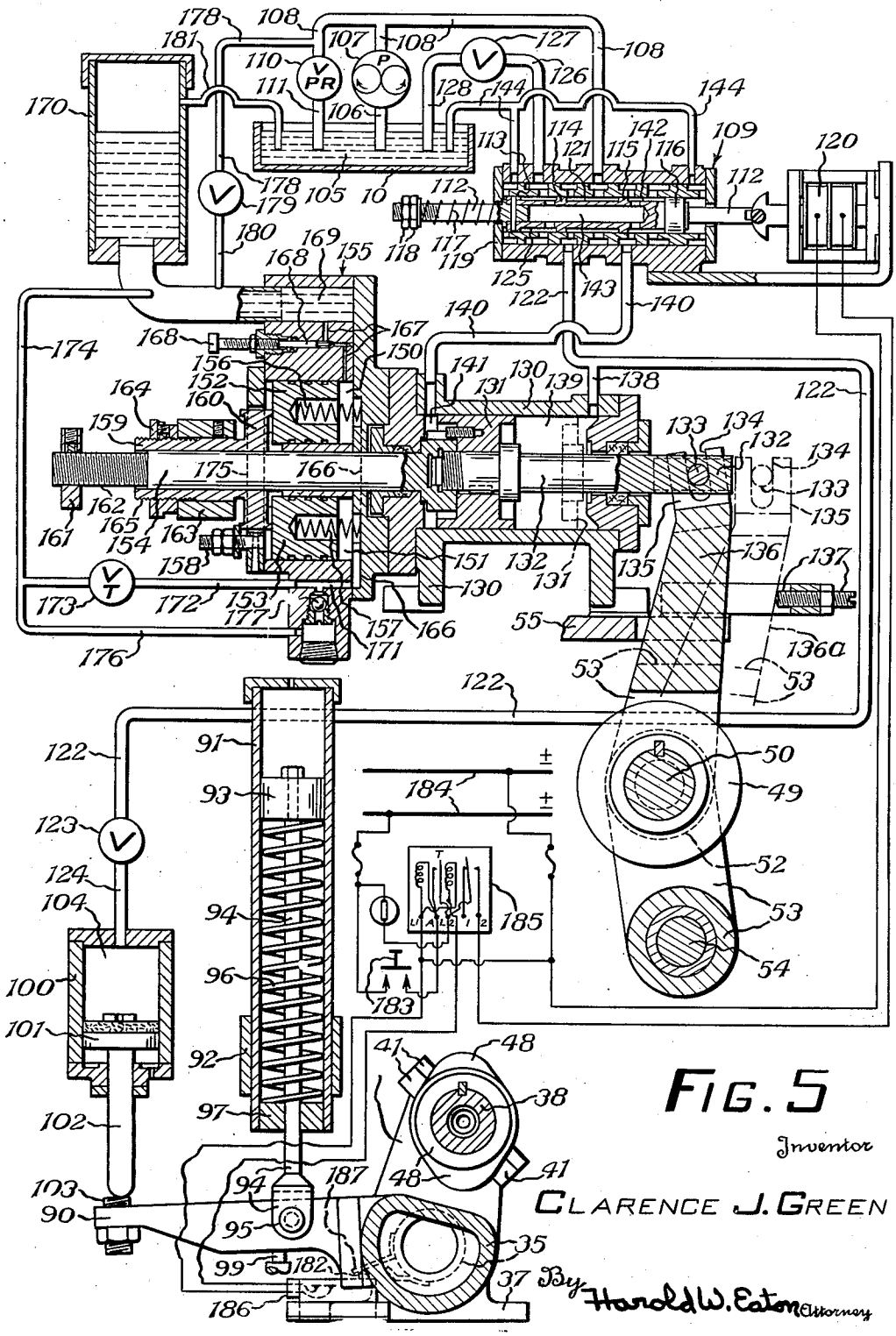


FIG. 5

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UNITED STATES PATENT OFFICE

2,251,882

CAM GRINDING MACHINE

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Application May 17, 1940, Serial No. 335,656

5 Claims. (Cl. 51—101)

The invention relates to grinding machines, and more particularly to a camshaft grinding machine.

One object of the invention is to provide a simple and thoroughly practical grinding machine for grinding a plurality of cam blanks on an integral camshaft. A further object of the invention is to provide an improved mechanism for producing a relative feeding movement between the cam blank and the grinding wheel to facilitate grinding the cam blank to a predetermined size and contour. Another object of the invention is to provide an automatic feed controlling mechanism whereby the grinding operation may proceed for a predetermined time interval.

Another object of the invention is to provide a feed control mechanism in which the master cam and master cam roller are relatively moved to control both the contour and sizing of the cam blank. A further object of the invention is to provide an electrically controlled, hydraulically operated feed mechanism relatively to feed a master cam roller to produce the desired and predetermined infeeding movement automatically to size a cam blank. Another object of the invention is to provide a hydraulically actuated feeding mechanism for a master cam roller which is automatically controlled by means of an electrical counting device automatically to separate the master cam and the master cam roller after a predetermined grinding operation has been completed. 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 the possible embodiments of the mechanical features of this invention,

Fig. 1 is a fragmentary front elevation of a cam grinding machine embodying this invention;

Fig. 2 is a fragmentary rear elevation, on an enlarged scale, of the master cam and master cam roller assembly together with their actuating mechanism;

Fig. 3 is a fragmentary cross sectional view, taken approximately on the line 3—3 of Fig. 2, showing the details of the cam feeding mechanism;

Fig. 4 is a fragmentary sectional view, on a reduced scale, taken approximately on the line 4—4 of Fig. 3; and

Fig. 5 is a combined electric wiring diagram and hydraulic piping diagram of the control and actuating mechanism of the machine.

A cam grinding machine has been illustrated in the drawings, having a base 10 which supports a longitudinally traversable work supporting table 11 on a flat way 12 and a V-way 13. The base 10 also supports a rotatable grinding wheel 14 which is mounted on a wheel spindle 15 journalled in bearings (not shown) in a transversely movable wheel slide 16. The wheel slide 16 may be adjusted transversely relative to the base 10 by a wheel feeding mechanism which is old and well known in the grinding art such as, for example, that shown in the prior 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. The wheel feeding mechanism may be actuated either manually or automatically as desired.

In the preferred construction, the wheel slide 16 is provided with a depending nut 19 which meshes with or engages a rotatable cross feed screw 20 which is rotatably supported in bearings (not shown) in the base 10. The feed screw 20 is provided with an integral shaft 21 which extends from the front of the machine base. A gear 22 is mounted on the front end of the shaft 21 and meshes with a small gear or pinion (not shown) which is arranged to be rotated by means of a manually operable feed wheel 23. The feed wheel 23 is provided with a micrometer adjusting mechanism 24 by means of which a stop abutment 25 may be readily adjusted as desired. A pivotally mounted stop pawl 26 cooperates with the stop abutment 25 and serves to limit the approaching movement of the wheel slide 16 to locate it in a predetermined grinding position. In the present cam grinding machine, the mechanism just described for adjusting the grinding wheel 14 transversely is provided merely for adjusting the position of the wheel in setting up the machine for a given grinding operation, to feed the grinding wheel 14 during a truing operation, or to compensate for wear of the grinding wheel 14 during production grinding.

The work supporting table 11 may be traversed or reciprocated longitudinally either automatically or manually relative to the base 10. A manually operable traversing mechanism has been illustrated for traversing the table 11 longitudinally. This mechanism comprises a manually operable rotatable traverse wheel 28 which is rotatably supported on a shaft 29. A gear 30 is mounted on the shaft 29 to rotate with the hand wheel

28. The gear 30 meshes with a large gear 31 which is supported on a rotatable shaft 32. The shaft 32 also supports a gear 33 which is fixedly mounted relative to the gear 31 to rotate therewith. The gear 33 meshes with a rack bar 34 which depends from the under side of the table 11. It will be readily apparent from the foregoing disclosure that any rotary motion of the hand traverse wheel 28 will be transmitted through the gear mechanism above described to produce a longitudinal traversing movement of the rack bar 34 and the table 11. The direction of movement of the rack bar 34 and table 11 is determined by the direction of rotation of the hand wheel 28.

The longitudinally movable work table 11 supports a pivotally mounted rock bar 35. The rock bar 35 is supported in bearings 36 (Fig. 1) and 27 (Fig. 2) each of which is fixedly mounted on the upper surface of the table 11. The rock bar 35 is arranged so that it may be rocked about an axis which is substantially parallel to the axis of rotation of the grinding wheel 14. The rock bar 35 is provided with a rotatable shaft or headstock spindle which, as illustrated in the drawings, may be designated as a master camshaft 38 having a camshaft supporting center 39. The master camshaft 38 is supported in bearings 40 (Fig. 1) and 41 (Fig. 2) which are in turn supported on or formed integral with the rock bar 35. The rock bar 35 also supports a footstock 42 which is provided with a footstock center 43. The headstock center 39 and the footstock center 43 are arranged rotatably to support a camshaft 44 having a plurality of cams 45 to be ground.

In order that the cams 45 on the camshaft 44 may be ground to a predetermined size and contour, it is desirable to provide a plurality of master cams 48 for controlling the rocking movement of the rock bar 35 so as to rock the camshaft 44 being ground toward and from the periphery of the grinding wheel 14 so as to generate a predetermined shape on the cam blanks 45. A plurality of master cams 48 are mounted on the master camshaft 38 in axial alignment with the axis of the camshaft being ground.

A master cam roller 49 is slidably keyed on a rotatable shaft 50 which is rotatably supported in a pair of spaced bearings 51 and 52. The bearings 51 and 52 are carried by a pivotally mounted frame 53 which is pivotally supported on a shaft 54. The shaft 54 is journalled in a frame 55 which is supported in fixed relationship with the table 11.

The master cam roller 49 is preferably indexed automatically as the table 11 is traversed longitudinally automatically to position the master cam roller 49 opposite the master cam 48 which corresponds to the cam 45 being ground on the camshaft 44 to be ground. The details of the master cam roller indexing mechanism have not been illustrated since this feature is not considered to be a part of the present invention. For a detailed disclosure of the automatic shifting mechanism for the master cam roller, reference may be had to the prior U. S. Patent No. 1,783,755 to Trefethen and Belden dated December 2, 1930, and also to the U. S. Patent No. 2,022,178 to Belden and Silven, dated November 26, 1935. The automatic indexing mechanism may comprise a dog bar 60 which is anchored at one end by means of a bracket 61 to the base 10. The dog bar 60 is slidably supported in brackets 62 and 63 which are formed integral with the frame 55 so that as the table 11 and the frame 55 are moved longitudinally during a positioning movement of the camshaft 44, the brackets 62 and 63 will slide along the dog bar 60, thus serving as a support for the dog bar 60. The dog bar 60 is provided with a plurality of adjustable dogs 64 which are arranged to engage a star wheel 65 when the table is traversed longitudinally. The star wheel 65 is supported on a stud 66. The stud 66 also supports a gear 67 which is mounted to rotate with the star wheel 65. The gear 67 meshes with a gear 68 which is rotatably supported on a stud 69. The gear 68 meshes with a gear 70 which is rotatably supported on a stud 71.

A gear 72 is formed integral with the gear 70 and meshes with a rack bar 73. The rack bar 73 is slidably supported in a channel-shaped frame 74 (Fig. 3). A yoke-shaped member 75 is fixedly mounted to the rack bar 73. The yoke-shaped member 75 straddles the master cam roller 49 and is arranged to move the master cam roller 49 longitudinally when the rack bar 73 is moved automatically to position the master cam roller 49 opposite the master cam 48 which corresponds with the cam 45 being ground. The adjustable dogs 64 are positioned along the dog bar 60 in position to correspond with the spacing of the cams 45 on the camshaft 44 so that when the table 11 is traversed longitudinally to position a predetermined cam 45 in operative position opposite the grinding wheel 14, the dogs 64, through the star wheel 65 and the gear train previously described, will index the rack bar 73 longitudinally automatically to index the master cam roller 49 into position opposite a predetermined master cam 48. For details of disclosure of this indexing mechanism not contained herein, reference may be had to the prior U. S. patents above referred to.

A work driving mechanism is provided for rotating the camshaft 44 being ground. As illustrated in the drawings, this mechanism may comprise a driving belt 80 which is driven from any suitable source of power, such as an overhead drive or a motor attached to the machine. The belt 80 drives a pulley 81 which is mounted on the end of a rotatable shaft 82. The shaft 82 is supported by a bracket 83 which is fixed to the upper surface of the table 11. In order to drive the master camshaft 38 and the product camshaft 44 uniformly during the rocking movement of the rock bar, a universal driving connection is provided comprising a universal joint 84 which is connected between the shaft 82 and a connecting shaft 85. The shaft 85 is connected by a second universal joint 86 with the end of the master camshaft 38 uniformly to rotate the same during the rocking movement of the rock bar 35.

It is desirable to provide a yieldable device whereby the master cam 48 may be maintained in operative contact with the master cam follower roller 49 during the rotation of the master camshaft 38 in order to impart the desired oscillatory movement to the rock bar 35 so as to generate a predetermined contour on the cam 45 being ground. The rock bar 35 is provided with an outwardly extending lever or arm 90 (Figs. 3 and 5). A cylinder 91 is supported in a bracket 92 which is in turn supported by the frame 55. A slidably mounted piston 93 is contained within the cylinder 91. A piston rod 94 is connected to the piston 93 at one end and by means of a stud 95 at the other end to the arm 90. A spring 96 contained within the cylinder 91 surrounds the

piston rod 94 and is interposed between the piston 93 and a bushing 97 which is mounted within the lower end of the cylinder 91. The spring 96 is a compression type spring and serves normally to exert a pressure tending to rock the rock bar 35 in a clockwise direction (Figs. 3 and 5) to maintain the master cams 48 in operative engagement with the master cam roller 49. The axis of the master cam roller 49 being relatively stationary, a rotary motion of the master camshaft 38 and master cams 48 produces a rocking or oscillating movement of the rock bar 35 to impart a corresponding oscillating movement to the cam 45 being ground to produce a predetermined contour thereon.

It is desirable to provide a suitable mechanism for separating the master cam 48 and the follower roller 49 when the table 11 is traversed longitudinally to position a new cam 45 in operative position opposite the grinding wheel 14. In the preferred construction, a fluid pressure mechanism is provided comprising a fluid pressure cylinder 100 which is supported on the frame 55. A piston 101 is slidably mounted within the cylinder 100 and is connected to one end of a piston rod 102. The lower end of the piston rod 102 rides on the end of an adjustable stop screw 103 which is carried by the outer end of the arm 90 (Figs. 3 and 5). It will be readily apparent from the foregoing disclosure that when fluid under pressure is admitted to a cylinder chamber 104, the piston 101 is forced downwardly so that the piston rod 102 engaging the screw 103 rocks the lever 90 and the rock bar 35 in a counterclockwise direction into the position illustrated in Fig. 3 until the lever 90 engages a stop screw 99 which serves to restrict the separating movement.

A fluid pressure system is provided for supplying fluid under pressure to the cylinder 100 as well as to a feeding mechanism to be hereinafter described. A reservoir 105 is provided in the base 10 of the machine. Fluid is pumped from the reservoir 105 through a pipe 106 by means of a motor driven fluid pressure pump 107 and passes fluid under pressure through a pipe 108 to a control valve 109. A variable pressure relief valve 110 is connected in the pipe line 108 to return excess fluid under pressure through a pipe 111 to the reservoir 105 in case the pressure within the system increases over the desired and predetermined pressure. The control valve 109 is a piston type control valve comprising a valve stem 112 having valve pistons 113, 114, 115 and 116 formed integrally therewith. The valve stem 112 is normally held in its left-hand end position (Fig. 5) by means of a compression spring 117 which surrounds the left-hand projecting end of the valve stem 112 and is interposed between nuts 118 and a valve head 119. An electric solenoid 120 of the pull type is provided to shift the control valve 109 into its reverse position, that is, toward the right (Fig. 5).

In the position of the valve 109 (Fig. 5), fluid under pressure passing through the pipe 108 enters a valve chamber 121 located between the valve pistons 114 and 115 and passes out through a pipe 122, through an adjustable throttle valve 123, and a pipe 124, into the cylinder chamber 104 to move the piston 101 downwardly into the position illustrated in Fig. 5, thereby rocking the rock bar 35 to move it to an inoperative position, thus separating the master cam 48 from the master cam roller 49 and the product cam 45 from the grinding wheel 14 so as to facilitate a traversing movement of the table 11 to position the next cam opposite the grinding wheel 14. When the solenoid 120 is energized, the valve 109 is shifted into its right-hand position (Fig. 5) so that fluid within the cylinder chamber 104 may exhaust through the pipe 122, through a valve chamber 125 located between the valve pistons 113 and 114, and pass outwardly through a pipe 126, an adjustable throttle valve 127, and a pipe 128, into the reservoir 105. By adjustment of the valve 123, the speed of movement of the rock bar 35 toward and from an operative posiiton may be adjusted as desired. By adjustment ofthe throttle valve 127, the exhaust of fluid from the cylinder chamber 104 may be varied as desired to control the rocking movement of the bar 35 in a counterclockwise direction. When the pipe 122 is open to the exhaust, as above described, the released compression of the spring 96 serves to rock the bar 35 to an operative position and the throttle valve 123 serves to control the speed of exhaust of fluid and thereby to control the speed of movement of the rock bar 35.

In order to grind a cam blank not only to a predetermined contour but also to a predetermined size, it is desirable to provide a feeding mechanism for causing a relative approaching and receding movement between the axis of the cam 45 being ground and the grinding wheel 14. In the preferred form of this invention, I provide a feeding mechanism which causes the master cam roller 49 to approach or recede from the axis of the grinding wheel 14 so as to change the position of the stroke of oscillation of the rock bar 35 to produce either a relative approaching or a receding movement between the cam 45 being ground and the grinding wheel 14.

A feeding mechanism is provided for controlling the transverse feeding movement of the master cam roller 49 so as to impart the desired relative feeding movement between the cam 45 being ground and the grinding wheel 14. This mechanism is preferably a fluid pressure mechanism comprising a hydraulic cylinder 130 which contains a slidably mounted piston 131. A piston rod 132 is connected to the piston 131. The piston rod 132 projects from the right-hand end of the cylinder 130 (Figs. 3 and 5) and is provided at its outer end with a transversely arranged pin or stud 133 which engages slots 134 formed in the upper yoke-shaped end 135 of an upwardly extending arm 136. The arm 136 is preferably formed as an integral part of the oscillatable frame 53 which supports the master cam roller 49 and its supporting shaft 50.

It will be readily apparent from the foregoing disclosure that movement of the piston 131 will be imparted through the lever 136 and the frame 53. Movement of the frame 53 and lever 136 in a clockwise direction (Figs. 3 and 5) is limited by an adjustable stop screw 137, thus limiting the separating movement of the master cam roller 49. The lever 136 and the frame 53 may move from the full line position 136 shown in Figs. 3 and 5 into the broken line position 136a (Fig. 5). The admission of fluid to and the exhaust of fluid from the cylinder 130 is preferably controlled by means of the control valve 109. A pipe 138 is connected between the pipe 122 and a cylinder chamber 139. Similarly a pipe 140 is connected between the valve 109 and a cylinder chamber 141 formed at the left-hand end of the piston 131. The cylinder 130 and piston 131 serve to produce a rapid approaching movement of the master cam roller 49 rapidly to rock the bar 35 to bring the product cam

45 into a grinding position adjacent to the operative surface of the grinding wheel 14.

In the position of the valve 109 (Fig. 5), fluid under pressure from the pump 107 passing through the pipe 108, the valve chamber 121, the pipe 122, the pipe 138, into the cylinder chamber 139, moves the piston 131 toward the left-hand end of the cylinder 130 into the position illustrated in Figs. 3 and 5 to move the rock bar 35 so as to separate the cam 45 being ground from the operative face of the grinding wheel after a grinding operation has been completed. During this movement, fluid within the cylinder chamber 141 is exhausted through the pipe 140, through a valve chamber 142 located between the valve pistons 115 and 116, through a port into a central aperture 143 within the valve stem member 112, and passes outwardly into the valve chamber 125 located between the valve pistons 113 and 114 and out through an exhaust pipe 126 and a throttle valve 127 into the reservoir 105. The speed of movement of the piston 131 in the direction above described, that is, toward the left (Figs. 3 and 5) may be readily controlled by adjusting the throttle valve 127 as desired. A pipe 144 is connected to chambers at each end of the valve 109 and serves as an exhaust pipe to cause any fluid leakage by the valve pistons to drain directly through an unrestricted passage which is always open to return such fluid to the reservoir 105, thus facilitating free movement of the control valve 109.

It is desirable to provide a slow relative approaching movement between the cam 45 being ground and the grinding wheel 14. In the preferred form, a feed regulating mechanism is provided for modifying the rapid approaching movement of the cam 45 and the grinding wheel 14 caused by the piston 131 to obtain a controlled and predetermined relative infeeding movement between the cam 45 and the grinding wheel 14. In the preferred construction, a self-contained dash pot feed regulator is provided, of the type such as that shown in the prior U. S. patent to B. H. Goehring, No. 2,151,660, dated May 21, 1939. This mechanism may comprise a pair of dash pot cylinders 150 and 151 which contain dash pot pistons 152 and 153, respectively. The dash pot pistons 152 and 153 and their respective cylinders 150 and 151 are arranged with their axes parallel to each other and spaced on diametrically opposite sides of an extension 154 of the piston rod 132. The dash pot cylinders 150 and 151 are supported in a casing 155 which is affixed to the end of the cylinder 130. The dash pot pistons 152 and 153 are normally held in a left-hand end position by means of springs 156 and 157, respectively. An adjustable stop screw 158 serves to limit the movement of the dash pot pistons 152 and 153 in a direction toward the left (Fig. 5). A slidably mounted sleeve 159 having an integral flange 160 is slidably supported on the extension 154 of the piston rod 132. The flange 160 is arranged to engage the left-hand end faces of the dash pot pistons 152 and 153, respectively. The stop screw 158 engages the flange 160 and thereby serves to limit not only the movement of the flange 160 in a left-hand direction but also the movements of the dash pot pistons 152 and 153, respectively. An adjustable stop collar 161 is mounted on a screw threaded portion 162 of the piston rod extension 154. An adjustably mounted stop collar 163 is supported on the sleeve 159 and may be adjusted relative thereto by means of a collar 164 which is screw threaded onto a threaded portion 165 of the sleeve 159.

The rapid forward feeding movement of the master cam roller 49 and the product camshaft 44 continues until the collar 161 engages the end of the sleeve 159. Continued movement of the piston rod 132 moves the sleeve 159 and flange 160 toward the right and continued movement serves to move the dash pot pistons 152 and 153 in a direction toward the right. As soon as the dash pot pistons 152 and 153 start moving toward the right, the rapid approaching feed is reduced to a slower predetermined grinding feed due to the fact that fluid confined within the dash pot cylinders 150 and 151 respectively, which are interconnected by a passage 166, exhausts through the passage 167 and a needle valve 168 into a chamber 169 which is connected with a reservoir 170. Fluid may also exhaust through a passage 171 and a pipe 172 through an adjustable throttle valve 173 and a pipe 174 into the chamber 169 and reservoir 170. Either the needle valve 168 or the adjustable throttle valve 173 or both may be used to control the rate of exhaust of fluid from the dash pot cylinders 150 and 151. The slow grinding feed continues until the adjustable stop sleeve 163 engages the end face 175 of the dash pot casing which serves positively to limit the forward feeding movement of the master cam roller 49 and the product camshaft 44 relatively toward the grinding wheel 14 to stop the forward grinding infeed when the cam 45 has been reduced to substantially the predetermined desired size and contour.

When fluid under pressure is reversed to shift the fluid pressure operated piston 131 into the position illustrated in Figs. 3 and 5, the released compression of the springs 156 and 157 serves to move the dash pot pistons 152 and 153, respectively, into the left-hand end position (Fig. 5). During this movement, fluid from the reservoir 170 is drawn through the pipe 174 and a pipe 176 and ball check valve 177 again to refill the dash pot cylinders 150 and 151 ready for the next infeeding movement.

In order to maintain the desired level of fluid within the reservoir 170, a pipe 178 is connected with the pressure pipe line 108 to pass fluid through a valve 179 and a pipe 180 into the chamber 169 and reservoir 170. An overflow pipe 181 serves to return fluid to the reservoir 105 in case the fluid within the reservoir 170 rises above a desired pipe. If desired, the valve 179 may be left slightly open so that the reservoir 170 is at all times maintained with its level up to the aperture adjacent to the end of the pipe 181. In normal use, however, the valve 179 is used merely to replenish the supply of fluid within the reservoir 170 periodically when necessary.

It is desirable to provide a control device whereby the cam 45 being ground may be maintained in its forward feeding position for a predetermined finish grinding operation. This is preferably accomplished by means of an electrical control apparatus comprising an electrical impulse time relay or counter 185, such as, for example, the "Microflex" instantaneous reset counter or relay which is manufactured by the Eagle Signal Corporation of Moline, Illinois. A normally open limit switch 186 is mounted in fixed relationship with the table 11 and is arranged so that its actuating plunger 182 is en-

gaged and actuated each time the rock bar 35 is oscillated by means of an arm 187 which is adjustably supported on the rock bar 35. The relay 185 may be adjusted so that after a predetermined number of electrical impulses, the relay or counter 185 operates to close a circuit to deenergize the solenoid 120, thereby releasing the compression of the spring 117 to shift the control valve 109 toward the left (Fig. 5) which serves to reverse the direction of flow of fluid to the cylinder 130. A push button switch 183 serves as a stop and start switch to render the timer or counter 185 operative at the start of the grinding operation. The switch 183 and the circuit previously described are supplied by power from any suitable source which has for the sake of illustration been indicated by the power line 184.

The operation of this improved cam grinding machine will be readily apparent from the foregoing disclosure. Assuming all of the parts to have been previously adjusted, a camshaft 44 is mounted in operative position on the work supporting centers 39 and 43, the camshaft 44 is started rotating, and the table 11 is traversed longitudinally by means of the hand wheel 28 to position the end cam 45 on the camshaft 44 in operative position opposite the grinding wheel 14. The push button 183 is then closed to energize the solenoid 120 and at the same time render the Microflex instantaneous reset counter 185 operative. The energizing of the solenoid 120 shifts the valve 109 toward the right (Fig. 5) into the reverse position to admit fluid from the pump 107 through the pipe 108, through the valve chamber 121 and the pipe 140, into the cylinder chamber 141, to move the piston 131 toward the right (Fig. 5) to cause a rapid approaching movement of the master cam roller 49 and also of the camshaft 44 to be ground. At the same time, the shifting of the valve 109 serves to open the pipe line 122 to the exhaust so that the released compression of the spring 96 serves to rock the rock bar 35 in a clockwise direction (Figs. 3 and 5), thus forcing the piston 101 upwardly and exhausting fluid from the cylinder chamber 104 through the pipe 124, the valve 123, the pipe 122, the valve chamber 125, and out through the exhaust pipe 126 into the reservoir 105. The speed of movement of the rock bar 35 into an operative position may be controlled by the valve 123. The infeeding movement of the master cam roller 49 continues at a rapid rate until the collar 161 engages the end of the sleeve 159, after which the sleeve 159 starts movement of the dash pot pistons 152 and 153. The movement of the dash pot pistons 152 and 153 sets up a back pressure which reduces the rapid approaching movement to a slow grinding speed. The grinding feed continues until the collar 163 engages the surfaces 175 which stops the infeeding movement of the master cam roller 49 when the work piece is ground to approximately a desired predetermined size. The grinding operation continues, however, allowing the grinding wheel 14 to grind out or finish grind the work.

Each oscillation of the rock bar 35 during the grinding operation serves through the arm 187 to close the limit switch 182 instantaneously, thus imparting an electrical impulse to the Microflex instantaneous reset counter 185. After a predetermined number of oscillations of the rock bar 35, that is, rotations of the master cams and the cam 45 being ground, the time relay operates to break the circuit, thereby deenergizing the relay 120. As soon as the relay 120 is deenergized, the released compression of the spring 117 shifts the valve stem 112 rapidly into the position illustrated in Fig. 5 to reverse the flow of fluid to the cylinder 130 so as to admit fluid into the cylinder chamber 139 to move the piston 131 toward the left (Figs. 3 and 5) to move the master cam roller 49 to an inoperative position. At the same time, fluid is admitted through the pipe 122, through the valve 123 and pipe 124, into the cylinder chamber 104 to cause a downward movement of the piston 101, thus rocking the rock bar 35 in a counterclockwise direction (Figs. 3 and 5) to rock the master camshaft and the product cams 44 being ground to an inoperative position, thus separating the cam 45 which has been ground from the grinding wheel 14 so as to facilitate a traversing movement of the table. The hand wheel 28 may then be rotated to traverse the table 11 longitudinally to position the next cam 45 in operative relation opposite the operative face of the grinding wheel 14. When the table 11 and the next cam 45 have been thus positioned, the push button 183 may again be closed to stop the next grinding cycle, which cycle is repeated as above described until all of the cams on the camshaft have been ground to the desired and predetermined size and contour.

In case it is necessary to compensate for wheel wear, that is, wearing away of the operative face of the grinding wheel 14, this may be accomplished by adjustment of the feed wheel 24 to advance the grinding wheel slide 16 by an amount equal to the wheel wear.

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. In a cam grinding machine having a rotatable grinding wheel, a rock bar, a rotatable camshaft support on said rock bar, means including a master cam and a follower roller to impart an oscillatory movement to the rock bar to generate a predetermined contour on a cam blank, and a feeding mechanism for moving said roller transversely including a hydraulic piston and cylinder operatively connected to impart a comparatively rapid transverse movement to said follower roller to rock said bar and position a cam blank adjacent to the operative face of the grinding wheel, and a hydraulic feed regulator operatively connected with said piston and cylinder to reduce the rapid transverse movement of the follower roller to a slow transverse movement to control the oscillation of the rock bar so as to produce a grinding feed.

2. In a cam grinding machine having a rotatable grinding wheel, a rock bar, a rotatable camshaft on said rock bar, means including a master cam and a follower roller to impart an oscillatory movement to said rock bar to generate a predetermined contour on a cam blank, a pivotally mounted frame to support said follower roller, and means including a fluid pressure piston operatively connected to swing said frame to produce

a transverse movement of the follower roller so as to impart a transverse feeding movement of a cam blank relative to the grinding wheel to grind a cam blank to a predetermined size and contour.

3. In a cam grinding machine having a rotatable grinding wheel, a rock bar, a rotatable camshaft support on said rock bar, means including a master cam and a follower roller to impart an oscillatory movement to the rock bar to generate a predetermined contour on a cam blank, a pivotally mounted frame to support said follower roller, means including a fluid pressure operated piston and cylinder operatively connected to swing said frame to produce a comparatively rapid transverse movement of the follower, and a dash pot piston and cylinder operatively connected therewith to reduce the rapid transverse movement of the roller to a slow grinding feed.

4. In a cam grinding machine having a rotatable grinding wheel, a rock bar, a rotatable camshaft support on said rock bar, a master cam and a follower to impart an oscillatory movement to the rock bar to generate a predetermined contour on a cam blank, means including a fluid pressure piston and cylinder to move said rock bar to separate the master cam from the follower roller, a pivotally mounted frame to support said follower roller, a feeding mechanism including a fluid pressure operated piston and cylinder operatively connected to swing said frame to produce a relative transverse movement of the follower roller to impart a feeding movement to said cam blank, means including a control valve operatively connected to control the admission of fluid to said rock bar cylinder and to said feed cylinder, an electrical time delay relay to control said valve, and means including a switch actuated by and in timed relation with the oscillation of the rock bar automatically through said relay to shift said control valve after a predetermined time interval to admit fluid under pressure to rock the bar to an inoperative position and to admit fluid to said feed cylinder to move the master cam roller transversely to an inoperative position.

5. In a cam grinding machine having a rotatable grinding wheel, a rock bar, a camshaft support on said rock bar, a master cam and a follower to impart an oscillatory movement to the rock bar to generate a predetermined contour on a cam blank, means including a piston and cylinder to move said rock bar to separate the master cam from the follower roller, a pivotally mounted frame to support said follower roller, a feeding mechanism including a piston and cylinder operatively connected to swing said frame to produce a relative transverse movement of the follower to impart a feeding movement to said cam blank, a control valve operatively connected to control the admission of fluid to said rock bar cylinder and to said feed cylinder, a solenoid to move said valve to an operative position, an electrical time delay relay which is operatively connected to deenergize said solenoid after a predetermined time interval, and means including a switch actuated by and in timed relation with the oscillation of the rock bar automatically to control said time delay relay so as to admit fluid under pressure to rock the bar to an inoperative position and to admit fluid to the feed cylinder to move the master cam roller transversely to an inoperative position after a predetermined time interval.

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