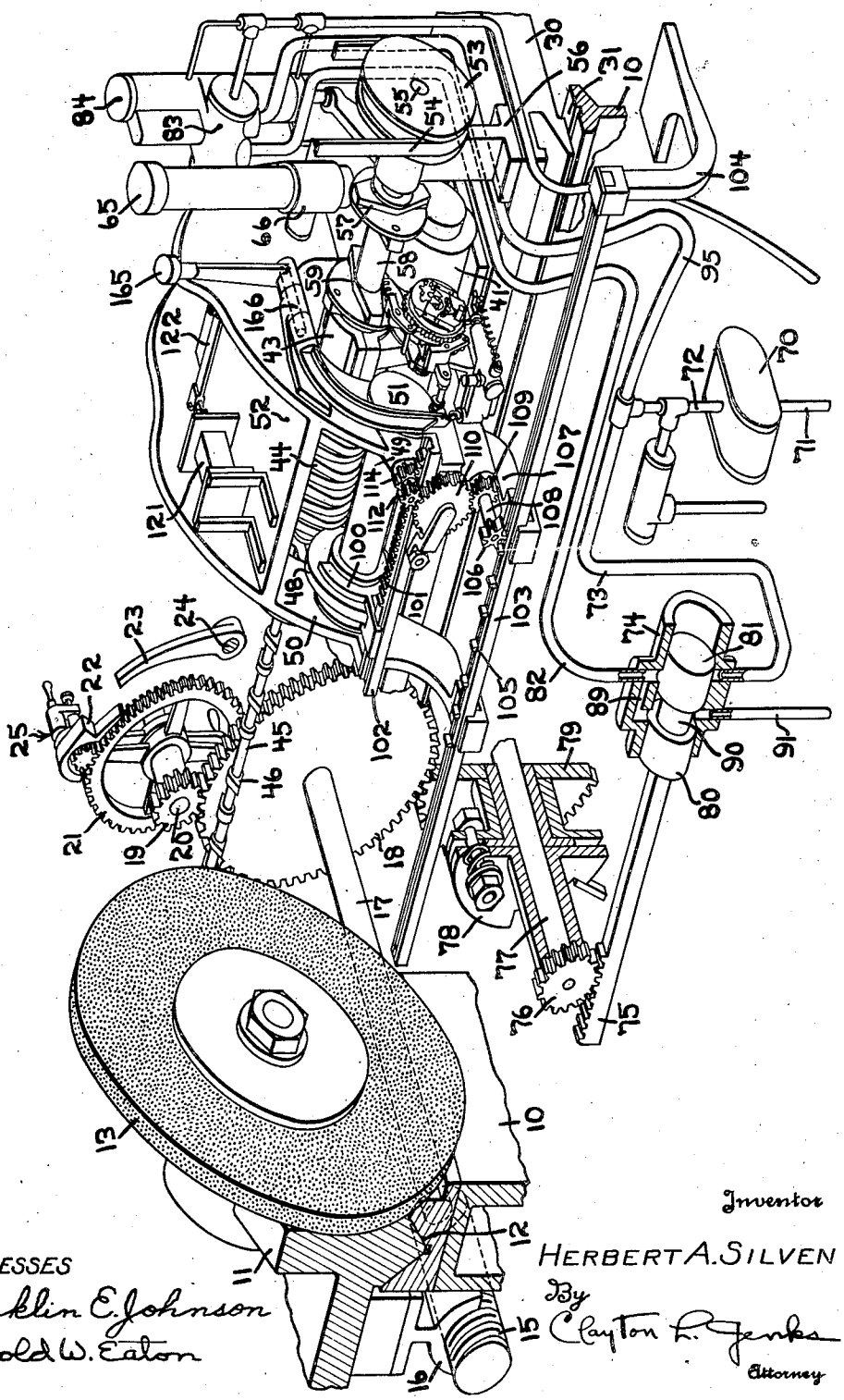
April 27, 1937. H. A. SILVEN 2,078,462

CAM GRINDING MACHINE

Filed March 27, 1935 5 Sheets-Sheet 1

FIG. 1



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CAM GRINDING MACHINE

Filed March 27, 1935 5 Sheets-Sheet 2

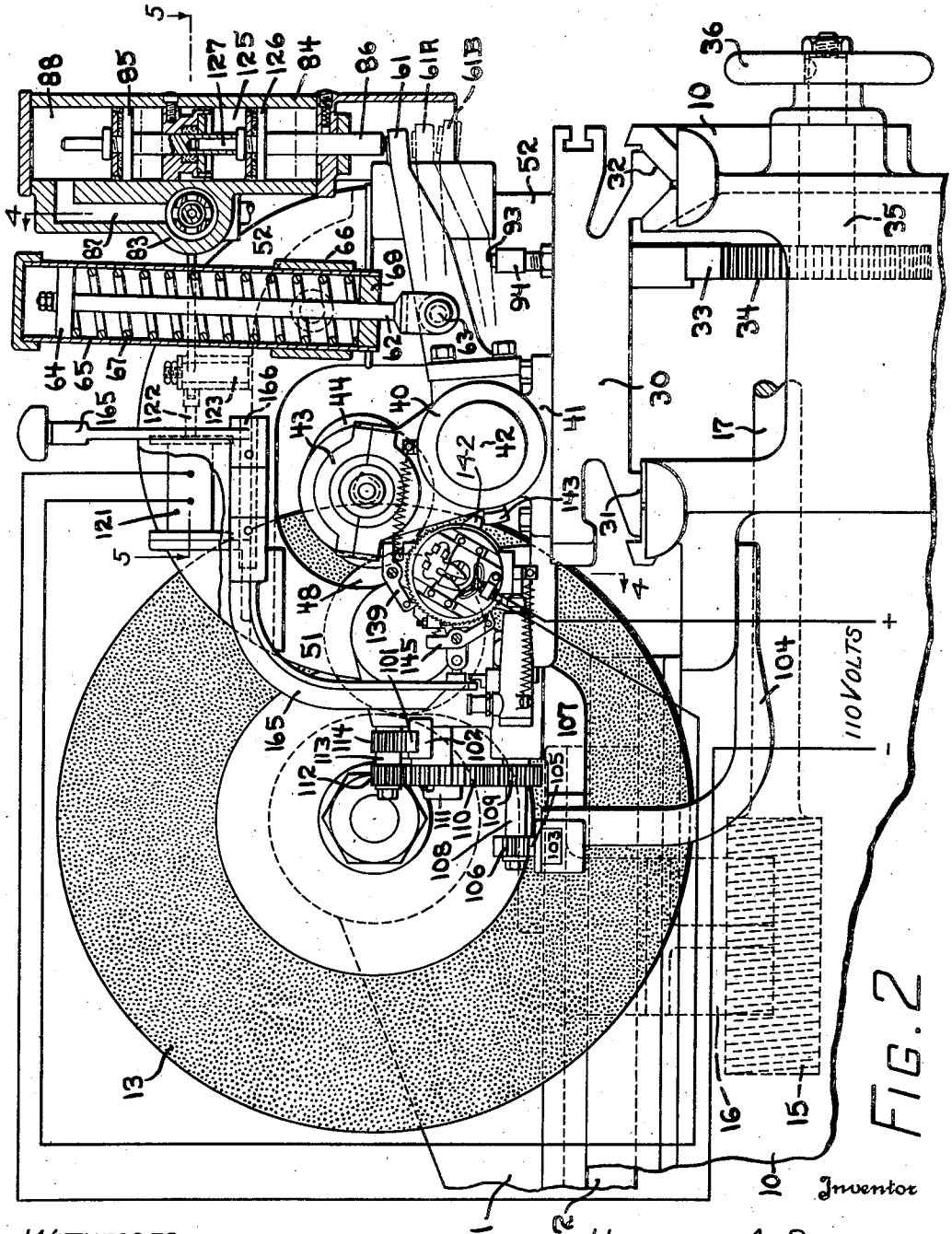


FIG. 2

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CAM GRINDING MACHINE

Filed March 27, 1935 5 Sheets-Sheet 3

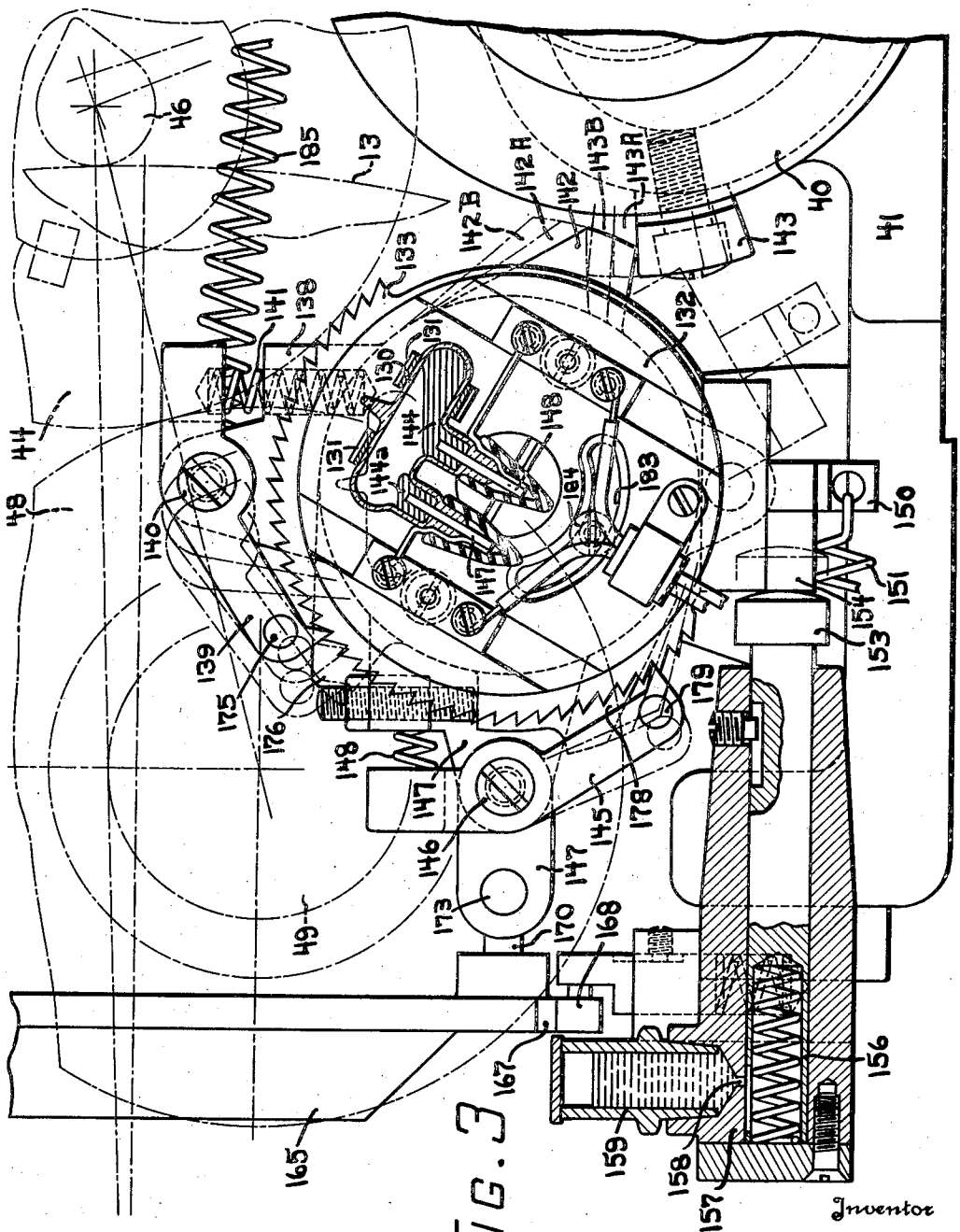


FIG. 3

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CAM GRINDING MACHINE

Filed March 27, 1935 5 Sheets-Sheet 4

FIG. 8

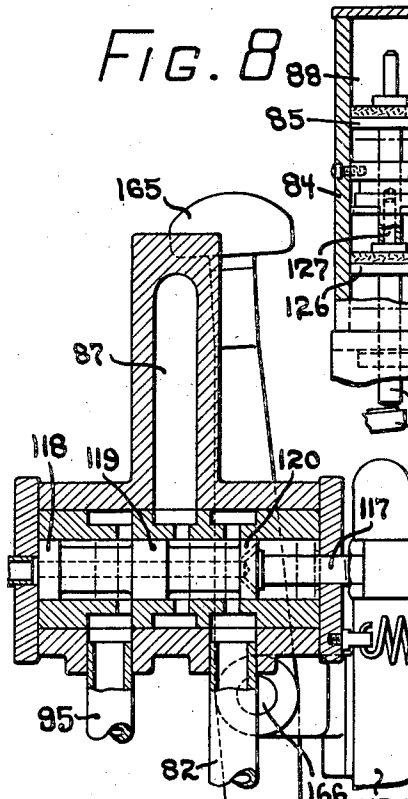


FIG. 5

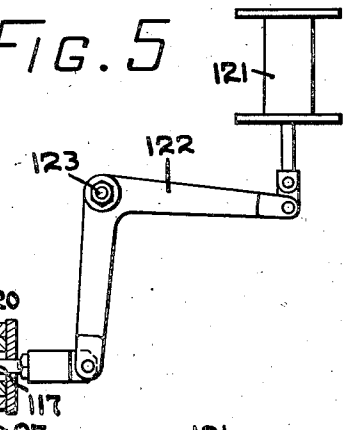


FIG. 4

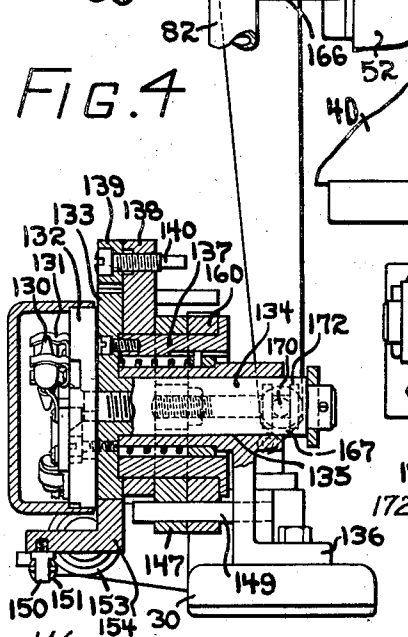


FIG. 6

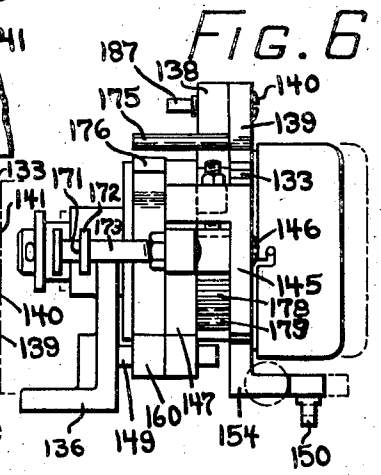
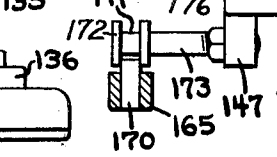


FIG. 7



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CAM GRINDING MACHINE

Filed March 27, 1935 5 Sheets-Sheet 5

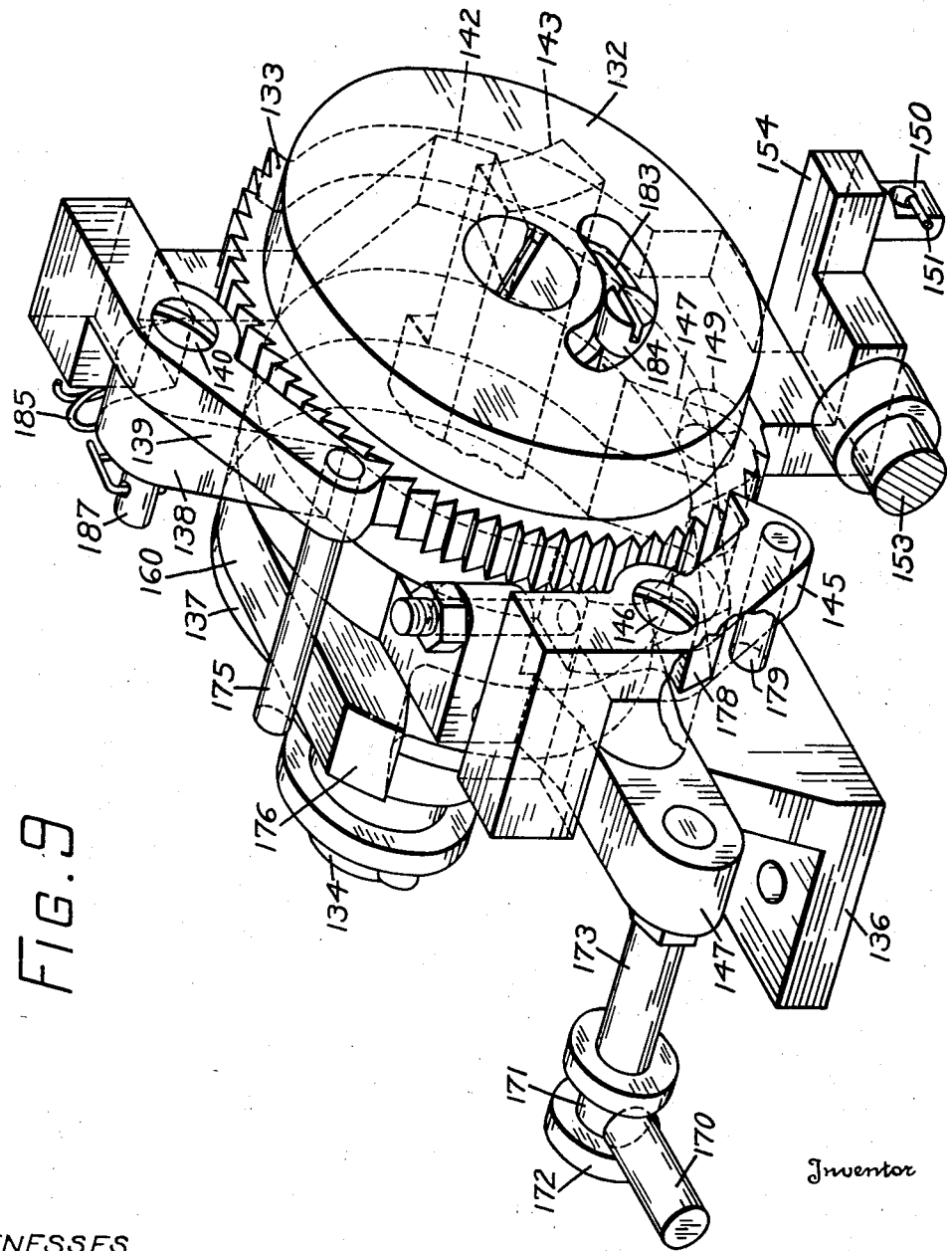


FIG. 9

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Patented Apr. 27, 1937 2,078,462

UNITED STATES PATENT OFFICE

2,078,462

CAM GRINDING MACHINE

Herbert A. Silven, Worcester, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application March 27, 1935, Serial No. 13,289

19 Claims. (Cl. 51—101)

This invention relates to grinding machines, and more particularly to an improvement in cam grinding apparatus.

Heretofore, in the grinding of camshafts, it has been found necessary to grind the cam while feeding the wheel into the work and then allowing the grinding wheel to remain in operative engagement with the work during a finish grinding or dying-out period in order that the cam may be finished to the required size. The die-out period, if the wheel is allowed to entirely grind out, requires considerable time and results in impairing the efficiency of the grinding machine. Attempts have been made to eliminate the die-out period or to reduce it to a minimum, but such a grinding operation without a die-out cut results in a reentrant curve being produced on the periphery of the cam due to the curvature of the wheel at the point where the wheel and the cam separate from each other after grinding. While the reentrant curve is, in many cases, not wholly detrimental to the action of the cam, it does, however, leave a distinct mark on the cam and is of sufficient consequence to cause the rejection of a camshaft at the automobile plants in mass production, since the cam must be finished, according to the automotive specifications, to a surface having a predetermined contour and finish.

It has been found by experimentation that if the cam being ground and the grinding wheel can be separated when the nose of the cam is in contact with the wheel, the reentrant curve produced will be substantially eliminated. It has been the practice in manually controlled machines to attempt to manually separate the cam from the wheel or vice versa when in the above-mentioned predetermined position, that is, when the high point or nose of the cam is in operative engagement with the periphery of the grinding wheel. Such a manual operation, however, requires a highly skilled operator and necessitates a loss of time in grinding cams due to the fact that the operator must reduce the cam to the required size and then separate the cam and the wheel when the cam is in the desired position.

It is the primary object of this invention to provide an automatic lifting device which serves to automatically separate the work being ground from the grinding wheel when a predetermined portion of the work periphery is in contact with the wheel.

It is another object of this invention to provide an automatic nose lifting device which serves to automatically separate the cam being ground from the grinding wheel when a predetermined portion of the cam, such as the nose or the high point of the cam, is in contact with the wheel.

It is a further object of this invention to provide an electro-hydraulic mechanism for automatically separating the cam and the grinding wheel when the nose of the cam is in operative engagement with the wheel. Other objects will be apparent from the foregoing disclosure.

One embodiment of this invention has been illustrated in the drawings, in which like reference numerals indicate like parts:

Fig. 1 is a fragmentary perspective view of a cam grinding machine embodying this invention;

Fig. 2 is a fragmentary end elevation, on an enlarged scale, of the improved cam grinding machine having parts broken away and shown in section to more clearly show the operation of the mechanism;

Fig. 3 is a fragmentary end view, on an enlarged scale, of the nose lifting control device;

Fig. 4 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 4—4 of Fig. 2;

Fig. 5 is a fragmentary plan view partly in section, on a reduced scale, taken approximately on the line 5—5 of Fig. 4;

Fig. 6 is a fragmentary rear elevation of the nose lifting control switch and its operating parts;

Fig. 7 is a fragmentary top plan view of the parts shown in Fig. 6;

Fig. 8 is a vertical section through the rock bar actuating cylinder; and

Fig. 9 is a perspective view, on an enlarged scale, of the nose lifting control switch and its operating parts.

Broadly, this invention comprises a machine for grinding successive cams on an integral camshaft, such as are used in the modern automobile, in which the grinding wheel and the camshaft are moved transversely relative to each other to grind the cam blank to a predetermined size and contour and in which the grinding wheel and camshaft are moved longitudinally relative to each other to position successive cams in operative relation with the grinding wheel. This machine is provided with an automatically actuated mechanism for separating the cam blank and grinding wheel only when a predetermined portion of the cam, namely, the nose or high point of the cam, is in operative contact with the periphery of the grinding wheel when the cam has been ground to a predetermined shape and size.

Grinding wheel feed

A grinding machine embodying this invention

has been illustrated in the drawings, in which a base 10 supports a transversely movable wheel slide 11 mounted on the V-way 12 and flat way (not shown). The wheel slide 11 carries a rotatable grinding wheel 13. The grinding wheel slide 11 may be moved transversely relative to the base 10 by any suitable mechanism, such as a rotatable cross feed screw 15, which is supported in bearings (not shown) in the base. A half nut 16 depending from wheel slide 11 engages the threaded portion of feed screw 15. A reduced projection 17 of the feed screw 15 carries a gear 18 meshing with a pinion 19 on a shaft 20 which in turn supports a manually rotatable feed wheel 21. The feed wheel 21 is provided with an adjustable abutment 22 arranged to engage a stop pawl 23 which is pivotally mounted by means of a stud 24 on the base 10. The feed wheel 21 is provided with the usual micrometer adjusting mechanism 25 which serves to adjust the abutment 22 relative to the feed wheel 21 so as to precisely adjust the stopping point of the infeeding movement of the grinding wheel to permit accurately sizing the work piece being ground. This feed mechanism is substantially the same as that shown in the prior U. S. Norton Patent No. 762,838 dated June 14, 1904 and the U. S. patent to Trefethen et al. No. 1,783,755 dated November 2, 1930, to which reference may be had for further details of disclosure not shown in the present drawings.

Longitudinal table traverse

A longitudinally movable table 30 is slidably mounted on the usual flat way 31 and V-way 32 and is arranged to be moved longitudinally relative to base 10. The table 30 may be traversed longitudinally either manually or automatically, as desired, but for the sake of simplicity of illustration, a manual operable traverse mechanism has been illustrated comprising a rack bar 33 depending from the under side of table 30. The rack bar 33 meshes with a gear 34 mounted on a rotatable shaft 35 which is rotatably supported in the base 10. The outer end of the shaft 35 carries a manually operable traverse wheel 36 which may be rotated in either direction to traverse table 30 relative to base 10 and grinding wheel 13.

Rock bar and master cams

In order that a cam may be accurately ground to a predetermined contour, it is necessary to provide a secondary transverse movement between the wheel and cam blank during the grinding operation in order that the desired contour may be produced on the cam. This movement may be accomplished by imparting a relative transverse movement between the wheel and cam blank but for the sake of simplicity of illustration, the conventional type of cam grinding apparatus has been illustrated, comprising a rock bar 40 which is pivotally supported on the table 30 by means of brackets 41 so that the bar 40 is free to rock about its axis 42. The rock bar 40 carries at one end a headstock portion 43 which rotatably supports a master camshaft having a plurality of master cams 44. The rock bar also supports a product camshaft 45, having a plurality of cams 46 formed integrally therewith, in axial alignment with master cams 44. The master cams and product shaft are supported in the well-known manner employed in camshaft grinding machines, such as, for example, as shown in the patent to Trefethen et al. No. 1,783,755 dated December 2, 1930. Since the mountings of the master cams and the product camshaft do not constitute an essential part of the present invention, only an indication of this support has been made in the present case. For further details of mounting of these parts, reference may be had to the prior patent to Trefethen et al.

In order that a relative transverse movement may be provided to produce the predetermined contour on the cam 46 being ground, it is desirable to rock the bar with a predetermined controlled movement so that the desired relative motion may be produced between the grinding wheel and the cam being ground to produce a predetermined contour on the cam. A master cam follower roller 48 is slidably keyed to and supported on a rotatable shaft 49 which is journaled in brackets 50 and 51 on a headstock frame 52 which is fixed to the table 30.

The master camshaft may be driven by any suitable means, such as a pulley 53 (Fig. 1) which is driven by a belt 54 from an overhead source of power or, if desired, a motor driven unit may be provided by replacing the pulley 53 with an electric motor. The pulley 53 is mounted on the outer end of a shaft 55 which is journaled in a bracket 56 fixedly mounted on table 30. The shaft 55 is connected by a flexible or universal joint 57 to rotate a shaft 58 which is in turn connected by a flexible or universal joint 59 with the master camshaft carrying the master cams 44. By rotation of the pulley 53, a rotary motion is transmitted to the master cams 44 and also to the product camshaft 45 which, due to the mounting and arrangement of the parts, serves to cause a rocking of the rock bar 40 as the master cams 44 rotate to cause a predetermined transverse movement between the cam being ground and the operative face of the grinding wheel so as to generate a predetermined contour on the cam.

Rock bar-pressure device

In order that the master cams 44 may be maintained in operative engagement with the follower roller 48 during the normal grinding operation, a yieldable means is provided to exert a pressure on the rock bar and maintain the master cams 44 in the desired contact with the roller 48. As illustrated in the drawings, a lever arm 61 (Fig. 2) is rigidly fixed to rock bar 40. A connecting rod 62 is pivotally connected by a stud 63 on lever 61. The upper end of rod 63 is provided with a collar 64 which is freely slidable within a cylinder casing 65 which is supported on headstock frame 52 by means of a bracket 66. A spring 67 surrounds the rod 62 and is contained within the cylinder 65. The spring 67 is interposed between the movable collar 64 and a collar 68 which is fixed to the lower end of cylinder 65 so that the compression of spring 67 tends to move the arm 61 and rock bar 40 in a counterclockwise direction, as viewed in Figs. 1 and 2, so as to maintain the master cams 44 in operative engagement with the master cam roller 48 during the normal grinding operation.

Rock bar—automatic separation

It is desirable to provide a suitable automatically actuated mechanism to rock the bar 40 in a clockwise direction so as to separate the master cams 44 from the roller 48 and also to separate the cams 46 from the grinding wheel 13. This is preferably accomplished by a fluid pressure

operated mechanism, such as that shown in the prior patent to Trefethen, et al. No. 1,783,755 dated December 2, 1930, to which reference may be had for details of disclosure not found in the present application. The fluid pressure mechanism may comprise a pump 70 (Fig. 1) within the base 10 which is adapted to draw fluid from a reservoir (not shown) through a pipe 71, a pipe 72 and a pipe 73 to a control valve 74. A rack bar 75, formed on the projecting end of the stem of control valve 74 and meshing with a gear 76 on a shaft 77, is operatively connected through a lost motion friction device 78 with a gear 79 which meshes with the feed screw gear 18 so that when the feed wheel 21 is turned to cause a reverse or rearward feed of the wheel, the gearing and friction device cause the rack 75 to move toward the right, as viewed in Fig. 1, shifting valve pistons 80 and 81 also toward the right so as to allow fluid under pressure to pass from pipe 73 through a valve chamber 90 into a pipe 82. The pipe 82 is in turn operatively connected to a control valve 83 which is mounted on the side of a fluid pressure cylinder 84. The cylinder 84 is supported on the headstock bracket 52. A piston 85 is slidably mounted within the cylinder 84 and serves to move a piston rod 86 which buts against the outer end of the lever 61. When fluid under pressure is admitted through pipe 82, valve 83, it passes through a passage 87 into a cylinder chamber 88 to cause a downward movement of piston 85, rod 86, so as to rock the lever 61 and rock bar 40 in a clockwise direction to separate the master cams 44 from the roller 48 and the camshaft 45 from the grinding wheel 13. The valve pistons and ports of valve 83 are so arranged that in any position of valve 83, there is a free passage for fluid between the pipe 82, passage 87 and cylinder chamber 88. When the grinding operation is started, the rotation of feed wheel 21, to cause an infeed, serves to shift valve 74 towards the left so that the pistons 80 and 81 are in the full line position (Fig. 1). This movement serves to cut off fluid pressure and opens a passage 89 to allow fluid to exhaust from the cylinder chamber 88 through passage 87, valve 83, a pipe 82, a passage 89, through valve chamber 90 and out through a pipe 91 into the reservoir, thus allowing free exhaust of fluid. The clockwise rocking of the bar 40 and lever 61 into an inoperative position is limited by an adjustable stop screw 93 carried by a bracket 94 which is fixed to the headstock frame 52. The above described mechanism serves to rock the bar 40 to an inoperative position when the wheel feed is operated to cause a rearward movement of the grinding wheel and also to return the rock bar 40 to an operative position when the wheel feed mechanism is rotated to cause an infeeding of the grinding wheel.

Nose lifting device

In order to attain the main object of this invention, it is desirable to provide a mechanism, such as is hereinafter termed a "nose-lifting device", for automatically separating the product cams 46 from the grinding wheel 13, only when the cam is in a predetermined rotative position, such as when the nose or high point of the cam is in operative contact with the wheel. To accomplish this result, a mechanism is provided which is preferably operated automatically in timed relation with the rocking of the bar 40. While a master cam 44 is rotating through one complete turn, the bar rocks toward and from the work once as controlled by the shape of the master cam. By utilizing the rocking of the bar, it is possible to automatically cause a separation of the master cam 44 and the follower roller 48 as well as the product cam 46 and the grinding wheel 13 when the high point of the master cam is in engagement with the surface of the master cam roller and the high point of the product cam 46 is in engagement with the grinding wheel.

The valve 83 is provided with a valve stem 117 and valve pistons 118, 119 and 120. The valve 83 is preferably automatically actuated, such as by means of a solenoid 121 which is connected by a bell crank lever 122 pivotally mounted on a stud 123 to move valve 83 in one direction, and a spring 124 is connected to move valve 83 in the opposite direction. When the solenoid 121 is energized, the bell crank 122 is moved in a counterclockwise direction (Fig. 5) to shift the valve stem 117 toward the right (Fig. 5). This movement serves to allow fluid under pressure from pump 70 to pass through a pipe 95 and the valve 83 through a passage 96 into a cylinder chamber 125 to cause a downward movement of a piston 126 so as to rock the lever 61 into position 61*a* and also to rock bar 40 in a clockwise direction to separate the product cam from the grinding wheel. The piston rod 86 is preferably formed in two parts which are loosely connected by a telescopic connection 127 which permits independent operation of pistons 85 and 126. The piston 126 is operated first by means of an electric control device hereinafter described to rock the lever 61 from the full line position (Fig. 2) into broken line position 61*a* after the cam has been ground to a predetermined extent and when the nose or high point of the cam is in operative engagement with the grinding wheel. The piston 85, which is connected through rod 86, is actuated when the wheel feed is reversed to move the grinding wheel to an inoperative position and serves to cause a further downward movement of piston rod 86 to move lever 61 from the broken line position 61*a* into position 61*b* and to rock bar 40 into an inoperative position. When the bar 40 is in an inoperative position, the master cams and follower roller are sufficiently separated to permit indexing of the master cam follower roller relative to the master cams and indexing of the camshaft being ground relative to the operative face of the grinding wheel.

Nose lifting device—electric control

In order that the valve may be actuated in the proper timed relation with the cam being ground, an electrically operated device is provided to energize solenoid 121 when a predetermined portion of the master cam, namely, the high point or nose of the cam, is in operative contact with the grinding wheel. Such a mechanism may comprise a mercury tube switch 130 which is secured in clips 131 on a rotatable plate 132. The plate 132 is preferably made of an insulating material. The plate 132 is adjustably carried by a ratchet wheel 133 which is in turn mounted on the outer end of a rotatable stud 134. The stud 134 is supported in an aperture 135 in a bracket 136 which is fixed to the table 30. A sleeve 137 is fixedly connected with the ratchet plate 133 and adapted to be rotated therewith.

A rotatable pawl carrying plate 138 is rotatably supported on a sleeve 137. The plate 138 carries a pawl 139 which is pivoted on a stud 140 and is arranged to be held in engagement with

the teeth of the ratchet wheel by means of a spring 141 interposed between the end of the pawl 139 and a portion of the plate 138. A projection 142 of plate 138 is arranged in the path of a lug 143 which is fixedly mounted to the rock bar 40 so that when the rock bar is rocked to carry the work piece toward and from the grinding wheel to generate the predetermined contour on the cam blank, the lug 143 engaging the projection 142 rocks between full line position (Fig. 3) and position 143a which serves to actuate the pawl plate 138 and the ratchet pawl 139 to cause an intermittent rotary motion of the ratchet wheel 133. It will be readily apparent that the intermittent rotation of the ratchet wheel 133 in a counterclockwise direction (Fig. 3) serves to tip the mercury switch 130, in a counterclockwise direction, through a sufficient distance so that a column of mercury 144 joins with a column of mercury 144a to close the circuit between terminals 147 and 148. The closing of the circuit serves to energize the solenoid 121 and thereby shift the valve 83 to admit fluid under pressure into cylinder chamber 125 to rock the bar 40 in a clockwise direction so as to remove the cam from operative engagement with the grinding wheel when a predetermined portion of the cam, namely, the nose or high point of the cam, is in operative engagement with the wheel. A safety pawl 145 is pivotally mounted on a stud 146 which is in turn supported on a non-rotatable plate 147. The pawl 145 is maintained in operative engagement with the ratchet wheel 133 by means of a spring 148. The plate 147 is held stationary by a pin 149 so that the pawl 145, therefore, serves as a safety pawl to prevent the ratchet wheel 133 from turning in a clockwise direction during its normal movement.

The ratchet plate 133 which supports the mercury switch 130 is provided with a projecting lug 150 which is connected by a spring 151 with a stud 152 and serves to exert a pressure tending to maintain the pawl plate 138 so that projection 142 remains in operative contact with lug 143 on rock bar 40.

During the grinding operation on a cam blank, the rock bar is oscillated so that lug 143 moves between full line position (Fig. 3) and dotted line position 143a. During this movement, the projection 142 of the pawl carrying plate 138 is oscillated to move the pawl 139 over the teeth of ratchet wheel 133. This movement continues until the mercury switch 130 has rocked so that mercury 144 contacts with mercury 144a to energize solenoid 121. This serves to actuate valve 83 and cause a further rocking movement of bar 40 to swing the rock bar to an inoperative position. Then, the feed wheel 21 is rotated to move the grinding wheel rearwardly. This movement of the feed wheel shifts valve 74 and admits fluid pressure to cylinder chamber 88 to rock lever 61 from position 61a to 61b. At the same time, the projection 142 of pawl carrying plate 138 is rocked into position 142b. This movement serves to cause a pin 175 of pawl 139 to ride up over a cam 176 on a fixed plate 160 so as to withdraw the pawl 139 from engagement with the ratchet teeth 133. The cam 176 is formed on plate 160 which is held against rotation by a pin 149 (Fig. 6). This same rocking movement of the projection 142 into position 142b also serves to cause a cam surface 178 formed on pawl carrying plate 138 to move and engage pin 179 on the safety pawl 145 so as to rock the pawl 145 out of engagement with the ratchet wheel 133.

As soon as the pawls 139 and 145 have been withdrawn from engagement with the teeth of the ratchet wheel 133, the released tension of a spring 185 interposed between a stud 186 on the pawl carrying plate 138 and a stud 187 on the rock bar supporting bracket 41 serves to rapidly move the pawl carrying plate 138 in a clockwise direction so as to return it to its initial or starting position.

This return movement of the pawl carrying plate 138 is rapid, and it is desirable to provide a suitable cushioning device to prevent shocks and vibrations when the plate reaches its normal position.

In the preferred construction, as illustrated in the drawings, a spring pressed plunger 153 engages a projecting portion 154 of the ratchet plate 133 and serves to prevent any shocks or vibrations as the plate is moved by the rock bar. In order to further cushion the motion of the spring pressed plunger 153, the other end of the plunger 153 is arranged to serve as a dash pot piston 156 which is slidably mounted within a dash pot cylinder 157. When the dash pot piston 156 moves toward the left, as viewed in Fig. 3, fluid within the dash pot piston is forced outwardly through a port 158 into a reservoir 159.

Nose lifting device—operative or inoperative

In setting up the machine or for certain grinding operations, it is desirable that a control means be provided so that the nose lifting device may be readily rendered operative or inoperative, as desired. As illustrated in the drawings, a manually operable lever 165 is pivotally mounted on a stud 166 which is fixed to the headstock frame 52. The lower end of the lever is provided with an arrow point 167 which is arranged to engage a spring-pressed roller 168 which serves to maintain the lever 165 in one of two positions. In the position illustrated in Fig. 4, the nose lifting device is operative. When it is desired to render the device inoperative, the lever 165 is manually moved in a clockwise direction (Fig. 4) which serves to move the lower end of the lever toward the left, as viewed in Fig. 4. The lower end of the lever 165 is provided with a pin 170 which engages a groove 171 in a spool 172 mounted on the end of a rod 173 which is fixed to the non-rotatable plate 147. Shifting the lever 165 in a clockwise direction (Fig. 4) serves to cause a movement of plate 147, the ratchet 133, pawls 139 and 145 together with the mercury switch 130 and its mounting plate 132 towards the left until the projection 142 of the pawl plate 138 is out of the path of the lug 143 on rock bar 140. When the projection 142 is moved out of the path of the lug 143, the nose lifting device is rendered inoperative and the machine may be operated manually or automatically without the operation of the nose lifting device, if desired.

Automatic indexing—master cam roller

In order that successive cams on the shaft 45 may be accurately ground to the desired size and shape and in the proper timed relation with the shaft 45, it is necessary to employ a plurality of master cams, one for each cam 46 on the product camshaft 45. In grinding successive cams, it is necessary that the master cam roller 48 be shifted longitudinally into operative relation with the master cam corresponding with the product cam on the shaft 45 to be ground. In the preferred construction, an automatically operable mechanism, which is actuated in timed

relation with the table traverse movement, so that when the work table 30 is traversed longitudinally to position a product cam 46 in operative relation with the grinding wheel 13, the master cam roller 48 will likewise be automatically shifted longitudinally into operative relation with the corresponding master cam 44, is provided. The mechanism illustrated in the present drawings is identical with that shown in the prior patent to Trefethen, et al. No. 1,783,755 dated December 2, 1930, to which reference may be had for a complete disclosure, if desired.

As illustrated in the drawings (Figs. 1 and 2), a slidably mounted yoke 100 is adapted to engage opposite sides of the master cam roller 48. The yoke 100 is fixed to the end of a rack bar 101 which is arranged to slide longitudinally in a guiding member 102. A dog supporting bar 103 is fixedly mounted by means of a bracket 104 to the base 10. The bar 103 is provided with a plurality of adjustable dogs 105 which are adjustably arranged on the bar so as to correspond with the spacing of cams 46 on the product shaft 45. A star wheel 106 is rotatably supported on a bracket 107 which in the present illustration is a depending portion of bracket 51. The star wheel 106 is mounted on the end of a shaft 108. The star wheel 106 is arranged in the path of the dogs 105 so that when the table 30 is traversed longitudinally, engagement of the dogs 105 serves to cause a partial rotation of the star wheel 106. The shaft 108 carries a gear 109 which in turn meshes with a gear 110 mounted on a stud 111. The gear 110 in turn meshes with a pinion 112 mounted on a stud 113. The stud 113 also carries a pinion 114 which is integral with pinion 112. It will be readily apparent from the illustration and description that when the table 30 is traversed longitudinally to position the product camshaft 45, the dogs 105 engaging the star wheel 106 cause an indexing movement of the master cam roller 48 by means of the gear 109, gear 110, pinion 112, pinion 114, rack 101 and yoke 100. It will be thus seen that when the table 30 is moved in either direction, the dogs serve to automatically index the roller 48 longitudinally so that when any cam 46 on the camshaft 45 is brought into operative relation with the grinding wheel 13, the master cam roller 48 is located in proper relation with the corresponding master cam 44.

While the present invention has been described as applied to a manually operable cam grinding machine, I do not desire to be so limited in interpreting the scope of the invention. My invention is equally applicable to an automatic cam grinding machine of the type shown in the U. S. Patents Nos. 1,840,088 and 1,945,588 and the copending application Serial No. 605,707.

The operation of this device will be readily apparent from the foregoing disclosure. In setting up the machine, the stop abutment 22 of the feed mechanism is adjusted to properly size the cams 46. The dogs 105 are adjusted to index the master cam roller 44 in proper timed relation with the cams 46 so that when the table traverses, the master cam roller 48 is moved into operative relation with the master cam 44 corresponding with the cam 46 to be ground. The plate 132, carrying the mercury switch 130, is then adjusted relative to the ratchet wheel 133 by means of an adjusting screw 184 which is threaded into the ratchet plate 133 and passes through an arcuate slot 183 in the plate 132. This arrangement permits a fine adjustment of the mercury switch 130 so that the cam being ground may be rotated and rocked a predetermined number of rotations before the mercury switch becomes operative to energize solenoid 121 and shift the valve 83 and admit fluid under pressure to cylinder chamber 125 to cause a separation of the master cam 44 and follower 48 and a corresponding separation of the product cam 46 and grinding wheel 13 when any predetermined portion, such as the high point or nose of the cam 46, is in engagement with the grinding wheel 13. Successive cams may then be ground and the cam withdrawn from the grinding wheel when the high point or nose of the cam is in operative engagement with the wheel.

Having thus described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. A cam grinding machine comprising a rotatable grinding wheel and a rotatable work support which are movable longitudinally and transversely relative to each other to successively grind a plurality of cams on an integral camshaft, means to cause a relative transverse movement between said wheel and work support to grind successive cams to a predetermined size, means to traverse said work support and wheel longitudinally relative to each other to position the wheel and cam blanks, means to cause a relative movement between the wheel and work to grind successive cams to a predetermined contour, mechanism to separate the grinding wheel and camshaft, and a timing mechanism actuated in timed relation with the rotation of the work support automatically to actuate said mechanism to separate the wheel and cam being ground when a predetermined point of the cam is in engagement with the wheel after a predetermined grinding operation has been completed.

2. A cam grinding machine comprising a rotatable grinding wheel and a rotatable work support which are movable longitudinally and transversely relative to each other to successively grind a plurality of cams on an integral camshaft, means to cause a relative transverse movement between said wheel and work support to grind successive cams to a predetermined size, means to traverse said work support and wheel longitudinally relative to each other to position the wheel and cam blank, means including a plurality of master cams and a follower to cause a relative transverse movement between the wheel and work to grind successive cams to a predetermined contour, mechanism to relatively move the grinding wheel and camshaft to an inoperative position and a nose lifting device actuated in timed relation with said transverse movement to automatically control said mechanism and separate the wheel and cam being ground when a predetermined point of the cam is in operative engagement with the wheel after a predetermined grinding operation has been completed.

3. A cam grinding machine having a rotatable grinding wheel and a rotatable work support which are movable longitudinally and transversely relative to each other, means to cause a transverse movement between the wheel and work support to grind successive cam blanks to a predetermined size and contour, means to cause a relative longitudinal movement between the wheel and work support to position successive cams in operative relation with the grinding wheel, and electrically controlled means to cause a separat-

ing movement between the wheel and cam blank when the high point or nose of the cam is in operative contact with the periphery of the grinding wheel after the cam blank has been ground to a predetermined size.

4. A cam grinding machine comprising a rotatable grinding wheel and a rotatable work support which are movable longitudinally and transversely relative to each other, means to cause a relative transverse movement between the wheel and work support to grind a cam blank to a predetermined size and contour, means to cause a relative longitudinal movement between the wheel and work support to position successive cams in operative relation with the grinding wheel, and automatically actuated electrically controlled fluid pressure mechanism actuated in timed relation with the rotation of the work support to cause a separating movement between the wheel and work support when the high point or nose of the cam is in a predetermined position relative to the grinding wheel after the cam has been ground to a predetermined size and contour.

5. A cam grinding machine comprising a rotatable grinding wheel and a rotatable work support which are movable longitudinally and transversely relative to each other to successively grind a plurality of cams on an integral camshaft, means to cause a relative transverse movement between the wheel and work support to grind successive cams to a predetermined size, means to traverse said work support and wheel longitudinally relative to each other to position the wheel and cam blank, means including a plurality of master cams and a follower to cause a relative transverse movement between the wheel and work to grind successive cams to a predetermined contour, and automatically actuated fluid pressure mechanism to separate the wheel and work support, and means actuated by and in timed relation with said transverse movement to control said fluid pressure mechanism so as to cause a separating movement between the wheel and work support when the high point or nose of the master cam is in a predetermined rotary position relative to the grinding wheel after the cam has been ground to a predetermined size and contour.

6. A cam grinding machine comprising a rotatable grinding wheel and a rotatable work support which are movable longitudinally and transversely relative to each other to successively grind a plurality of cams on an integral camshaft, means to cause a relative transverse movement between the wheel and work support to grind successive cams to a predetermined size, means to traverse said work support and wheel longitudinally relative to each other to position the wheel and cam blanks, means including a plurality of master cams and a follower to cause a relative transverse movement between the wheel and work to grind successive cams to a predetermined contour, and electrically controlled means to automatically separate the wheel and cam blank when the high point or nose of the cam is in operative engagement with the periphery of the wheel after the cam blank has been ground to a predetermined size and contour.

7. A cam grinding machine having a rotatable grinding wheel and a rotatable work support which are movable transversely and longitudinally relative to each other, means to cause a relative transverse movement between the wheel and work support to grind a cam blank to a predetermined size and contour, means to relatively traverse said wheel and work support longitudinally to position successive cam blanks in operative relation with the grinding wheel, separating mechanism to separate the wheel and cam being ground, automatically actuated timing mechanism which is actuated in timed relation with the rotation of the work support to automatically separate the wheel and cam being ground when the cam is in a predetermined rotative position relative to the grinding wheel after it has reached a predetermined size and contour, and means to render said last mentioned means inoperative when desired.

8. A cam grinding machine comprising a rotatable grinding wheel and a rotatable work support which are movable longitudinally and transversely relative to each other to successively grind a plurality of cams on an integral camshaft, means to cause a relative transverse movement between the wheel and work support to grind successive cams to a predetermined size, means to traverse the work support and wheel longitudinally relative to each other to position the wheel and cam blank, means including a plurality of master cams and a follower to cause a predetermined transverse movement between the wheel and work to grind successive cams to a predetermined contour, separating means to separate the grinding wheel and cam being ground, automatically actuated timing mechanism which is actuated in timed relation with said transverse movement to automatically actuate said separating means to separate the wheel and cam being ground when a predetermined point of the cam is in engagement with the wheel after a predetermined grinding operation has been completed, and manually operable means to render said lifting device inoperative when desired.

9. A cam grinding machine comprising a rotatable grinding wheel and a table which are movable longitudinally and transversely relative to each other to successively grind a plurality of cams on an integral camshaft, means to cause a relative transverse feeding movement between the wheel and work support to grind successive cams to a predetermined size, a work support pivotally mounted on said table, a rotatable camshaft support thereon, means including a plurality of master cams and a follower to rock said work support and cause a relative approaching and receding movement between the grinding wheel and cam blanks to grind the cam blanks to a predetermined contour, means to rock said support to an inoperative position, and automatically actuated mechanism which serves to separate the cam being ground and the grinding wheel when the cam blank is in a predetermined rotative position relative to the grinding wheel.

10. A cam grinding machine comprising a rotatable grinding wheel and a table which are movable longitudinally and transversely relative to each other to successively grind a plurality of cams on an integral camshaft, means to cause a relative transverse feeding movement between the wheel and work support to grind successive cams to a predetermined size, a work support pivotally mounted on said table, a rotatable camshaft support thereon, means including a plurality of master cams and a follower to rock said work support and cause a relative aproaching and receding movement between the grinding wheel and cam blanks to grind the cam blanks to a predetermined contour, means to rock said support to an inoperative position, and automatically ac-

tuated mechanism which serves to separate the the cam being ground and the grinding wheel when the high point or nose of the cam is in operative engagement with the grinding wheel.

11. A cam grinding machine having a rotatable grinding wheel, a transversely movable slide to support said wheel, a longitudinally movable table, a work support pivotally mounted on said table and arranged to rotatably support a camshaft having a plurality of integral cams thereon, means to cause a transverse movement of the grinding wheel relative to said support to grind successive cam blanks to a predetermined size, means to cause a relative longitudinal traversing movement between the wheel and camshaft to position successive cams in operative relation with the wheel, means including a plurality of master cams and a follower to cause a rocking movement of said work support to grind successive cams to predetermined contours, means including a fluid pressure cylinder operatively connected to rock said support to an inoperative position, and automatically actuated mechanism to separate the grinding wheel and cam blanks when the high point or nose of the cam is in operative contact with the grinding wheel.

12. A cam grinding machine comprising a rotatable grinding wheel a transversely movable slide to support said wheel, a longitudinally movable table, and rotatable work support pivotally mounted on said table and arranged to rotatably support a camshaft having a plurality of cams formed integrally therewith, means to cause a relative transverse movement of the grinding wheel slide to grind successive cams to a predetermined size, means to traverse said table longitudinally to position successive cams in operative relation with said grinding wheel, means including a plurality of master cams and a follower operatively arranged to cause a rocking movement of said support to grind successive cams to a predetermined contour, means including a fluid pressure piston and cylinder operatively connected to rock said support to an inoperative position, and electrically actuated means to control said fluid pressure system so as to separate the cam being ground and the grinding wheel only when the high point or nose of the cam is in operative contact with the grinding wheel.

13. A cam grinding machine comprising a rotatable grinding wheel, a transversely movable slide to support said wheel, a longitudinally movable table, a rotatable work support pivotally mounted on said table and arranged to rotatably support a camshaft having a plurality of cams formed integrally therewith, means to cause a relative transverse movement of the grinding wheel slide to grind successive cams to a predetermined size, means to traverse said table longitudinally to position successive cams in operative relation with said grinding wheel, means including a plurality of master cams and a follower operatively arranged to cause a rocking movement of said support to grind successive cams to a predetermined contour, means including a fluid pressure piston and cylinder operatively connected to rock said support to an inoperative position, and electrically actuated means operated in timed relation with the rocking of said support to control said fluid pressure system so as to separate the cam being ground and the grinding wheel only when the high point or nose of the cam is in operative contact with the grinding wheel.

14. A cam grinding machine comprising a rotatable grinding wheel, a transversely movable slide to support said wheel, a longitudinally movable table, a pivotally mounted work support on said table arranged to rotatably support a camshaft having a plurality of cams formed integrally therewith, means to traverse said table longitudinally to position successive cams in operative relation with the grinding wheel, means to cause a relative transverse movement between the grinding wheel and work support to grind successive cams to a predetermined size, means including a plurality of master cams and a follower arranged to cause a transverse movement between the wheel and work support so as to grind successive cams to a predetermined contour, means including a fluid pressure piston and cylinder operatively connected to rock said work support and separate the camshaft and the grinding wheel, a valve arranged to control the admission of fluid to said cylinder, and electrically actuated means operated in timed relation with the rocking of said support to actuate said valve and cause a separation of the cam being ground and the grinding wheel only when the nose of the cam being ground is in operative contact with the periphery of the grinding wheel.

15. A cam grinding machine comprising a rotatable grinding wheel, a transversely movable slide to support said wheel, a longitudinally movable table, a pivotally mounted work support on said table arranged to rotatably support a camshaft having a plurality of cams formed integrally therewith, means to traverse said table longitudinally to position successive cams in operative relation with the grinding wheel, means to cause a relative transverse movement between the grinding wheel and work support to grind successive cams to a predetermined size, means including a plurality of master cams and a follower arranged to cause a transverse movement between the wheel and work support so as to grind successive cams to a predetermined contour, means including a fluid pressure piston and cylinder operatively connected to rock said work support and separate the camshaft and the grinding wheel, a valve arranged to control the admission of fluid to said cylinder, a solenoid operatively connected to actuate said valve, and electrically actuated means operated in timed relation with the rocking of said support to energize said solenoid and actuate said valve to cause a separation of the cam being ground and the grinding wheel only when the nose or high point of the cam being ground is in operative contact with the periphery of the grinding wheel.

16. A cam grinding machine comprising a rotatable grinding wheel, a transversely movable slide to support said wheel, a longitudinally movable table, a pivotally mounted work support on said table arranged to rotatably support a camshaft having a plurality of cams formed integrally therewith, means to traverse said table longitudinally to position successive cams in operative relation with the grinding wheel, means to cause a relative transverse movement between the grinding wheel and the work support to grind successive cams to a predetermined size, means including a plurality of master cams and a follower arranged to cause a transverse movement between the wheel and work support so as to grind successive cams to a predetermined contour, means including a fluid pressure piston and cylinder operatively connected to rock said work support and separate the camshaft and the grinding

wheel, a valve arranged to control the admission of fluid to said cylinder, a solenoid operatively connected to actuate said valve, an electric switch operatively connected with said solenoid, and means operated in timed relation with the rocking of said support to actuate said switch and cause a separation of the cam being ground and the grinding wheel only when the nose of the cam being ground is in operative contact with the periphery of the wheel.

17. A cam grinding machine comprising a rotatable grinding wheel, a transversely movable slide to support said wheel, a longitudinally movable table, a pivotally mounted work support on said table arranged to rotatably support a camshaft having a plurality of cams formed integrally therewith, means to traverse said table longitudinally to position successive cams in operative relation with the grinding wheel, means to cause a relative transverse movement between the grinding wheel and work support to grind successive cams to a predetermined size, means including a plurality of master cams and a follower arranged to cause a transverse movement between the wheel and work support so as to grind successive cams to a predetermined contour, means including a fluid pressure piston and cylinder operatively connected to rock said work support and separate the camshaft and the grinding wheel, a valve arranged to control the admission of fluid to said cylinder, a solenoid operatively connected to actuate said valve, a mercury tube switch operatively connected with said solenoid, a pivotally mounted support for said switch, and means operated in timed relation with the rocking of said support to intermittently rock said switch and cause a separation of the cam being ground and the grinding wheel only when the nose of the cam being ground is in operative contact with the periphery of the wheel.

18. In a cam grinding machine having a pivotally mounted camshaft support and master cams and a follower to control the rocking movement of said support, a control device including an electric switch, means including a pawl and ratchet mechanism to actuate said switch, means actuated by the rocking movement of said camshaft support intermittently to index said ratchet wheel to actuate said switch, and an electrically controlled mechanism operated when the switch is actuated to cause a separation of the master cam follower when the high point of the cam being ground is in engagement with the wheel.

19. In a cam grinding machine having a pivotally mounted camshaft support and master cams and a follower to control the rocking movement of said support, a control device including an electric switch, means including a pawl and ratchet to actuate said switch, connections between said camshaft support and pawl to actuate the same in timed relation with the rocking of said support, and an electrically controlled mechanism operated by said switch to rock said support to an inoperative position after a predetermined grinding operation has been completed.

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