

Feb. 22, 1938.

C. J. GREEN

2,109,386

CAM GRINDING APPARATUS

Original Filed Jan. 23, 1936 2 Sheets-Sheet 1

Fig. 1

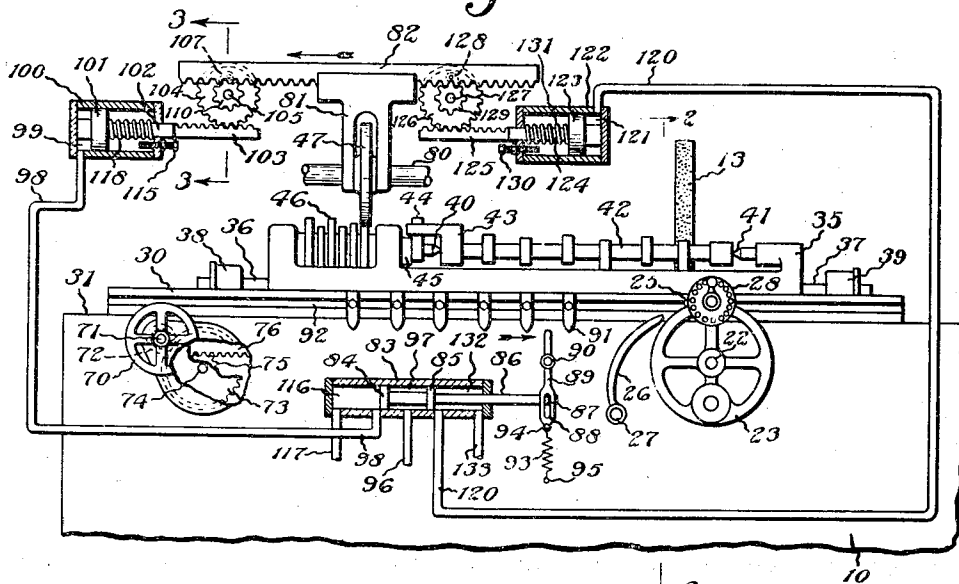


Fig. 3

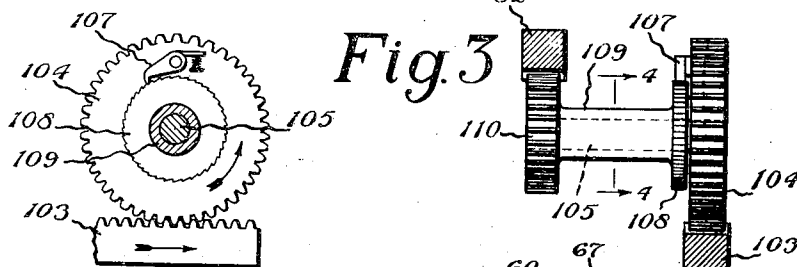


Fig. 4

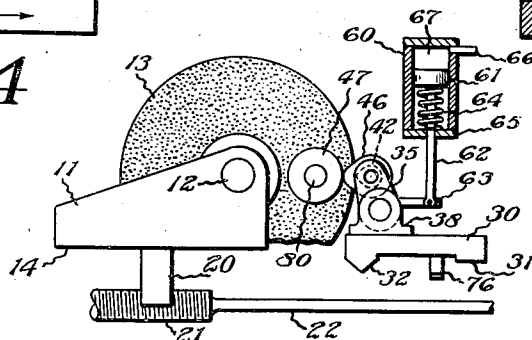


Fig. 2

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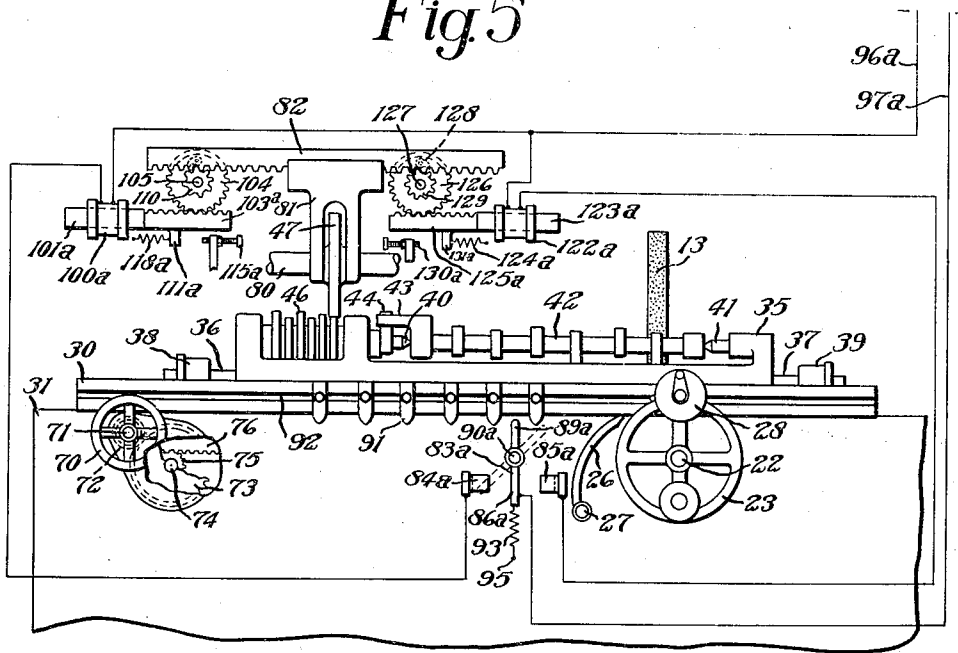
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Fig. 5



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2,109,386

CAM GRINDING APPARATUS

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Continuation of application Serial Nos. 60,477
and 60,478, January 23, 1936. This applica-
tion November 17, 1937, Serial No. 175,100

23 Claims. (Cl. 51—101)

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

One object of the invention is to provide a simple, thoroughly practical cam grinding machine in which the master cam roller is automatically indexed in timed relationship with the relative movement between the camshaft and the grinding wheel. Another object of the invention is to provide an improved indexing mechanism for automatically indexing the master cam roller relative to the master cam.

Another object of the invention is to provide a fluid pressure actuated mechanism for indexing the master cam roller. A further object of the invention is to provide an electrically actuated mechanism for indexing the master cam roller. Other objects will be in part obvious or in part pointed out hereinafter.

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

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

Fig. 1 is a fragmentary front elevation of a cam grinding machine which is partly diagrammatic to show the operation of the mechanism;

Fig. 2 is a fragmentary sectional view, taken approximately on the line 2—2 of Fig. 1, showing the arrangement of the rock bar, master cam and roller and mounting for the grinding wheel;

Fig. 3 is a sectional view, on an enlarged scale, taken approximately on the line 3—3 of Fig. 1;

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

Fig. 5 is a fragmentary front elevation of a modification of the cam grinding apparatus shown in Fig. 1.

A camshaft grinding machine has been illustrated in the drawings of the type shown in the prior patent to Trefethen and Belden No. 1,783,755, dated December 2, 1930. This machine comprises a base 10 which supports a transversely movable wheel slide 11. The wheel slide 11 carries a rotatable wheel spindle 12 which supports a rotatable grinding wheel 13. The wheel slide 11 is provided with suitable ways 14 which mate with corresponding ways on the base 10 to guide the slide so that it may move transversely relative to the base 10.

The wheel 13 and wheel slide 11 are arranged for a transverse feeding movement relative to the base. A feeding mechanism has been illustrated comprising a half nut 20 depending from the wheel slide 11 and meshing with or engaging a rotatable feed screw 21 which is rotatably supported in bearings (not shown) in the base 10. The feed screw 21 is provided with a forwardly extending shaft 22 having a manually operable feed wheel 23 mounted on its outer end. By rotation of the feed wheel 23, the screw 21 may be rotated to cause a forward or rearward feeding movement of the grinding wheel 13. In order positively to stop the forward feeding movement of the grinding wheel when it reaches a predetermined position, an abutment 25 is adjustably mounted on the feed wheel 23 and is arranged to engage a stop pawl 26 which is pivotally supported on a stud 27 mounted on the base 10. A micrometer adjusting mechanism 28 is carried by the feed wheel 23 and is arranged precisely to adjust the position of the abutment 25 relative to the feed wheel 23. The micrometer adjusting mechanism 28 has not been illustrated in the present case since it is not considered to be part of the present invention. This adjustment is substantially identical to the adjustment shown and described in detail in the expired U. S. Patent to Norton No. 762,838, dated June 14, 1904.

A longitudinally movable table 30 is arranged to slide longitudinally on a flat way 31 and a V-way 32 which mate with correspondingly shaped ways on the base 10 of the machine. The table 30 is arranged to support a pivotally mounted rock bar 35 which is provided with trunnions 36 and 37 at opposite ends thereof. The trunnions 36 and 37 are supported in bearings 38 and 39, respectively, which are fixed on the upper surface of the table 30. The rock bar 35 is provided with a headstock center 40 and a footstock center 41 which serve rotatably to support a camshaft 42 to be ground. A driving dog 43 is mounted on the end of the camshaft 42 and is arranged to be driven by a driving plate 44 carried by the headstock spindle.

In the construction illustrated, the headstock spindle 45 serves as a support for a plurality of master cams 46 which are arranged to be engaged by a rotatable master cam roller 47. The master cam roller 47 is rotatably supported by brackets which are fixed to the table 30 so that when the master cams 46 are rotated in engagement with the rotatable master cam follower 47, a rocking motion will be transmitted to the rock bar 35 so as to oscillate the camshaft 42 toward

and from the operative face of the grinding wheel 13 so as to generate a predetermined contour on the cam being ground.

The headstock spindle 45 may be rotated in the manner shown in the prior patent to Trefethen et al. No. 1,783,755, to which reference may be had for details of disclosure.

A fluid pressure cylinder 60 is fixedly supported by the table 30 and is provided with a piston 61 having a piston rod 62 engaging a projecting arm 63 of the rock bar 35. A spring 64 within the lower chamber of the cylinder 60 surrounds the piston rod 62 and is interposed between the piston 61 and a cylinder head 65 and serves to rock the rock bar 35 in a counterclockwise direction, as indicated in Fig. 2, so as to maintain the master cam 46 in operative relation with the master cam roller 47.

The table 30 may be traversed longitudinally to index the camshaft 40 so as to position successive cam blanks to be ground in operative relation with the grinding wheel 13 either manually or by power. For the sake of simplicity of illustration, a manually operable traverse mechanism has been illustrated in the drawings comprising a manually operable traverse wheel 70 which is mounted on a rotatable shaft 71, the inner end of which supports a gear 72. The gear 72 meshes with a large gear 73 mounted on a rotatable shaft 74. The shaft 74 carries a gear 75 mounted on its inner end which meshes with a rack bar 76 depending from the table 30.

After a cam on the shaft 42 has been ground to a predetermined size and contour, it is desirable to index the table 30 longitudinally to present a new cam blank in operative relation with the grinding wheel 13. After a cam blank has been ground to size, it is first necessary to turn the feed wheel 23 in a clockwise direction to separate the wheel 13 from the cam blank being ground. This rearward movement of the wheel serves to admit fluid under pressure through a pipe 66 into a cylinder chamber 67 so as to rock the rock bar 35 in a clockwise direction, as illustrated in Fig. 2, to separate the master cams 46 from the roller 47 and to separate the camshaft 42 from the grinding wheel 13. Details of the mechanism for admitting fluid through the pipe 66 have not been illustrated in the present case, since this is not considered part of the present invention. For details of disclosure of this feature, reference may be had to the prior patent to Trefethen and Belden No. 1,783,755, dated December 2, 1930.

In order to attain the main object of the present invention, namely to provide an automatic indexing mechanism for the master cam roller 47, it is desirable to provide a suitable mechanism which operates in timed relationship with the table movement, so that when the table is indexed to present a new cam blank into operative relation with the grinding wheel 13, the master cam roller 47 will automatically index into operative position with relation to the master cam corresponding to the cam blank to be ground. In the preferred construction, a fluid pressure mechanism is provided for automatically indexing the master cam roller longitudinally in timed relationship with the relative traversing movement between the grinding wheel and the camshaft being ground.

The master cam roller 47 is slidable longitudinally on a rotatable shaft 80 which is supported in bearings (not shown). A yoke 81 straddles the master cam roller 47 and is ar-

ranged to move the roller longitudinally to index the same into operative relation with successive master cams 46. The yoke 81 is carried by a slidably mounted rack bar 82 which is arranged to be indexed longitudinally by means of a fluid pressure mechanism to be hereinafter described which operates in timed relation with the longitudinal indexing movement of the work table 30.

A valve 83 is mounted on the base of the machine and is arranged to control the admission of fluid to cause the desired indexing movement. The valve 83 is preferably of the balanced piston type, comprising valve pistons 84 and 85 which are formed integral with a valve stem 86. The valve stem 86 is provided with a pin 87 which rides in an elongated slot 88 in a control lever 89. The control lever 89 is pivotally mounted on a stud 90 on the base 10 and its upper end is arranged in the path of a plurality of adjustable dogs 91 which are adjustably supported in a T-slot 92 in the table 30. One end of a spring 93 is attached to a stud 94 on the lower end of the lever 89 and the other end is attached to a stud 95 on the base 10 of the machine. The spring 93 serves to hold the lever normally in a vertical or neutral position so that the valve pistons 84 and 85 are in the position illustrated in Fig. 1.

Fluid under pressure is supplied from any suitable source, such as a pump (not shown) within the base of the machine which forces fluid under pressure through a pipe 96 into a valve chamber 97 between the valve pistons 84 and 85. Assuming the table 30 to be traveling in the direction of the arrow, as shown in Fig. 1, by means of rotation of the traverse wheel 70, this motion continues until the second dog 91 strikes the upper end of the lever 89 and rocks the lever in a clockwise direction which causes the valve stem 86 to move toward the left, as viewed in Fig. 1, so as to uncover a pipe 98 and admit fluid under pressure from the valve chamber 97 through the pipe 98 into a cylinder chamber 99 within a fluid pressure cylinder 100. The cylinder 100 contains a slidably mounted piston 101 having a piston rod 102, the outer end of which is formed as a rack bar 103 which meshes with a gear 104. The gear 104 is rotatably mounted on a shaft 105. In order that the rotary motion of the gear 104 may transmit an intermittent motion to the rack bar 82, a ratchet pawl 107 is mounted on the gear 104. The ratchet pawl 107 is arranged to cooperate with a ratchet wheel 108 formed integral with a sleeve 109 which is rotatably supported on the shaft 105. The other end of the sleeve 109 is provided with a gear 110 which meshes with the rack bar 82. When the table 30 is moved manually, as above described, it admits fluid under pressure to the cylinder chamber 99 and moves the piston 101 toward the right, as viewed in Fig. 1, causing the rack bar 103 to rotate the gear 104 in a counterclockwise direction. This motion serves through the pawl 107 to rotate the ratchet wheel 108, the sleeve 109, and the gear 110 in a counterclockwise direction to cause the rack bar 82 to move toward the left, as viewed in Fig. 1, so as to index the master cam roller 47 into operative engagement with the next master cam.

In order to limit the indexing motion of the master cam roller so that the roller moves only to a sufficient distance to bring it into operative relation with the next master cam, an adjustable stop screw 115 is provided in the right-hand end of the cylinder 100 to limit the movement of the piston 101 so as to cause the desired index-

ing movement. When the table 30 has been traversed to a predetermined extent, the dog 91 passes over the end of the lever 89, releasing the tension of the spring 93 which serves again to move the valve stem 86 toward the right, as viewed in Fig. 1, to return the valve pistons 84 and 85 to the positions illustrated in Fig. 1. This movement allows the fluid within the cylinder chamber 99 to exhaust through pipe 98, into valve chamber 116 and out through a pipe 117 into the reservoir. A spring 118 surrounds the piston rod 102 and is interposed between the piston 101 and the right-hand cylinder head so that when the fluid pressure is cut off from the pipe 98, the released tension of the spring 118 serves to aid in quickly exhausting fluid from the cylinder chamber 99. This movement causes the rack bar 103 to move toward the left, as viewed in Fig. 1, causing a clockwise movement of the gear 104, and due to the arrangement of the ratchet pawl 107 causes the pawl to ride idly over the teeth of the ratchet wheel 108 so that it is ready for the next indexing movement.

When the table 30 is moved toward the left, as viewed in Fig. 1, the dogs 91 striking the upper end of the lever 89 serve to rock the lever in a counterclockwise direction, moving the valve stem 86 toward the right, as viewed in Fig. 1, so that the valve pistons 84 and 85 move toward the right and uncover a pipe 120 so that fluid under pressure passing from the pipe 96 into the valve chamber 97 passes through pipe 120 into a cylinder chamber 121 within a cylinder 122. The cylinder 122 is provided with a piston 123 having a piston rod 124 the outer end of which is formed as a rack bar 125 meshing with a gear 126 and rotatably supported on a shaft 127. The gear 126 carries a pivotally mounted ratchet pawl 128 which is arranged to engage a ratchet wheel 108 (not shown) which corresponds with the ratchet wheel 108. The ratchet wheel is carried by a sleeve which is rotatably supported on the shaft 127. The sleeve carries a gear 129 meshing with the rack bar 128. When fluid under pressure is admitted to the cylinder chamber 121, it causes the piston 123 and piston rod 124 to move toward the left, as viewed in Fig. 1, causing a corresponding movement to the rack bar 125 to rotate the gear 126 in a clockwise direction (Fig. 1) which serves through the ratchet pawl 128 to cause the gear 129 to be rotated in a clockwise direction to move the rack bar 82 toward the right, as viewed in Fig. 1, so as to index the master cam roller into operative relation with successive master cams when the table is being indexed toward the left, as viewed in Fig. 1.

An adjustable stop screw 130 is provided in the left-hand end of the cylinder 122 which serves to limit the movement of the piston 123 toward the left and thereby adjustably limit the extent of indexing movement transmitted to the master cam follower roller 47. A spring 131 surrounds the piston rod 124 and is interposed between the piston 123 and the cylinder head to aid in exhausting fluid from the cylinder chamber 121 when the reverse or control valve stem 86 moves into a neutral position, as illustrated in Fig. 1, exhausting fluid through a valve chamber 132 and through a pipe 133 into the reservoir. During the return movement of the piston 123 toward the right, as viewed in Fig. 1, the rack bar causes the gear 126 to move in a counterclockwise direction and the ratchet pawl 128 rides idly over the teeth of the ratchet wheel so that the

parts are in position for the next indexing movement of the table.

An electrically actuated master cam roller shifting or indexing mechanism has been illustrated in the modification shown in Fig. 5. Many of the parts shown in the modification (Fig. 5) are identical with the corresponding parts shown in Figs. 1 to 4 inclusive and consequently have been indicated by the same reference numerals. An electrical switch 83a is mounted on the front of the machine base and is arranged to control an electrical apparatus for causing an indexing movement of the master cam roller 47. The switch 83a is preferably a single pole, double throw knife switch comprising a pair of contact members 84a and 85a. The movable part of the switch 83a comprises a knife arm 86a which is pivotally mounted on a stud 90a on the base 10. Suitable insulation is provided for the parts of the switch, which is common practice in the art. A spring 93 is interposed between the lower end of the arm 86a and the insulated stud 95 on the base of the machine which serves normally to hold the knife arm 86a in an open or central position. The upper part 89a of the arm 86a is arranged in the path of a plurality of adjustable dogs 91 which are adjustably supported in a T-slot 92 on the front edge of the table 30. Electrical energy is supplied from any suitable source of power and in the present case has been indicated by the power leads 96a and 97a. The power line 97a is connected to the knife arm 86a.

Assuming the table 30 to be traveling in the direction of the arrow (Fig. 5), by means of rotation of the manually operable traverse wheel 70, the traversing movement continues until the second dog 91 strikes the upper end of the lever 89a and rocks the lever in a clockwise direction which swings the knife arm 86a so as to engage the contact member 84a, as indicated in dotted lines in Fig. 1, thereby closing a circuit to energize a solenoid 100a which causes the rod 101a to move toward the right, as viewed in Fig. 1, against the tension of a spring 118a. One end of the rod 101a is formed as a rack bar 103a meshing with a gear 104 rotatably supported on a shaft 105. The gear 104 carries a ratchet pawl 107 which is arranged to engage the ratchet wheel 108. The ratchet wheel 108 is formed integral with the sleeve 109 which is rotatably supported on the shaft 105. The other end of the sleeve 109 carries a gear 110 meshing with the rack bar 82. When the solenoid 100a is energized to cause the rack bar 103a to move toward the right, as viewed in Fig. 1, it causes the gear 104 to move in a counterclockwise direction, and as the ratchet pawl 107 engages the teeth of the ratchet wheel 108, causes the gear 110 to rotate in a counterclockwise direction to move the rack bar 82 in a direction toward the left, as viewed in Fig. 5, to index the master cam roller 47 toward the left into operative relation with the next master cam 46.

In order adjustably to limit the extent of the indexing movement, an adjusting screw 115a is mounted on the frame of the machine and is arranged in the path of a downwardly projecting lug 111a carried by the rack bar 103a so that the extent of movement of the rack bar 103a toward the right (Fig. 5) may be readily adjusted to index the master cam roller to a predetermined extent. After the dog 91 passes over the top of the lever 89a, the released tension of the spring 93 serves to swing the switch knife arm 86a into

the full line position (Fig. 5), thereby breaking the circuit and deenergizing the solenoid 100a. The released tension of the spring 118a then causes the rack bar 103a to move toward the left (Fig. 5), causing the gear 104 to move in a clockwise direction while the ratchet pawl 107 slides idly over the ratchet wheel 108 to return the parts to their initial position.

Similarly, when the table 30 is traversed or indexed toward the left (Fig. 5), the lever 89a is moved in a counterclockwise direction so that when a dog 91 strikes the lever 89a, it serves to rock the knife arm 86a into engagement with the contact member 85a so as to energize a solenoid 122a and cause a rod 123a to move toward the left (Fig. 5). The left-hand end of the rod 123a is formed as a rack bar 125a meshing with a gear 126. The gear 126 carries a ratchet pawl 128 which is arranged to cooperate with a ratchet wheel similar to the ratchet wheel 108 shown in Figs. 3 and 4. The gear 126 is rotatably supported on a shaft 127. The shaft 127 also supports a gear 129 which meshes with the rack bar 82. When the solenoid 122a is energized, the rod 123a and rack bar 125a are moved toward the left (Fig. 5) against the tension of a spring 124a to cause the gear 126 to move in a clockwise direction so that the pawl 128 will rotate the ratchet wheel and the gear 129 in a clockwise direction to cause the rack bar 82 to move toward the right, as viewed in Fig. 5, to index the master cam roller toward the right on successive longitudinal indexing movements of the table 30 into operative relation with successive master cams. An adjusting screw 130a is provided to limit the movement of the rack bar 125a and cooperates with a lug 131a depending from the rack bar 125a so that the extent of indexing movement of the rack bar 82 may be readily adjusted. The operation of this machine is readily apparent from the foregoing disclosure. The camshaft 42 to be ground is mounted in position on the headstock center 40 and the footstock center 41 and the master cams 46 and camshaft 42 are rotated. The table 30 is then traversed longitudinally by means of the manually operable traverse wheel 70 to position the first cam in operative relation with the grinding wheel 13. The feed wheel 23 is then rotated in a counterclockwise direction (Fig. 1) to cause an infedding movement of the grinding wheel to grind the cam blank to the required size and contour while the camshaft 42 and its supporting rock bar 35 are rocked toward and from the grinding wheel 13 by means of the master cams 46 and the rotatable master cam roller 47. After the first cam blank has been ground, the feed wheel 23 is turned in a clockwise direction to separate the grinding wheel from the cam blank being ground. This movement serves also to admit fluid under pressure to the cylinder chamber 67 to rock the rock bar 35 to an inoperative position, in accordance with the disclosure in the Trefethen et al. Patent No. 1,783,755. The table 30 is then traversed longitudinally by rotation of the traverse wheel 70 to position the next cam blank into operative relation with the grinding wheel 13. During this traversing movement of the table 30, a dog 91 strikes the upper end of the lever 89 and shifts the valve stem 86 either toward the right or toward the left, depending on the direction of traverse, which admits fluid under pressure either through the pipe 98 or 120 into either the cylinder chamber 99 or 121 to cause a longitudinal indexing movement of the rack bar 82.

and the master cam roller 47 to position the master cam roller 47 in operative relation with the next master cam corresponding with the cam blank to be ground. This cycle of operation is repeated until all of the cams on a camshaft have been ground to a predetermined contour and size.

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 as shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

This case is a continuation of my prior copending U. S. applications Serial No. 60,477 and Serial No. 60,478 both of which were filed on January 23, 1936.

I claim:—

1. A cam grinding machine having a longitudinally movable table, means to traverse said table, a rotatable master camshaft, a cam follower movable longitudinally relative to said shaft, means for shifting said follower comprising a fluid pressure piston and cylinder, and means to control the admission of fluid to said cylinder.

2. A cam grinding machine having a longitudinally movable table, means to traverse said table, a rotatable master camshaft, a cam follower movable longitudinally relative to said shaft, means for shifting said follower comprising a fluid pressure piston and cylinder, and a fluid pressure system including a control valve which is actuated by movement of said table whereby the follower is moved in timed relationship with the table movement.

3. A cam grinding machine having a longitudinally movable table, means to traverse said table, a rotatable master camshaft, a cam follower movable longitudinally relative to said shaft, means to move said follower comprising a fluid pressure piston and cylinder, a rack and gear mechanism interposed between the piston and the follower, and a fluid pressure system including a control valve, and means including adjustable dogs on said table to actuate said valve so as to index the cam follower automatically in timed relation with the table movement.

4. A cam grinding apparatus comprising a longitudinally movable table, means to traverse said table longitudinally, a pivotally mounted camshaft support on said table, a master camshaft aligned with said camshaft support, a master cam follower roller movable in a path longitudinally relative to the axis of said shaft, a gear mechanism for moving the follower, a fluid pressure piston and cylinder mechanism to actuate said gear mechanism, and a fluid pressure system including a control valve which is actuated in timed relation with the table movement automatically to index the master cam roller.

5. A cam grinding apparatus comprising a longitudinally movable table, means to traverse said table, a pivotally mounted camshaft support on said table, a master camshaft aligned with said camshaft support, a master cam follower roller movable in a path longitudinally relative to the axis of said shaft, means including a rack and gear mechanism for moving the follower, a fluid pressure piston and cylinder mechanism to

actuate said gear mechanism, and a fluid pressure system including a control valve which is actuated in timed relation with the table movement automatically to index the master cam roller in timed relationship with the table movement so that the master cam roller is automatically positioned in operative relation with the master cam corresponding to the cam being ground.

6. A cam grinding apparatus comprising a longitudinally movable table, a rock bar pivotally mounted on said table, a camshaft support on said rock bar, a master camshaft arranged in axial alignment with said camshaft support, a plurality of master cams carried by said shaft, a movable master cam follower roller cooperating with said cams, means including a rack and gear mechanism to index the master cam roller, a fluid pressure piston and cylinder operatively connected to actuate said rack and gear mechanism to index the master cam roller in one direction, a second rack and gear mechanism arranged to move said follower in the opposite direction, a second fluid pressure piston and cylinder operatively connected to actuate said rack and gear mechanism to index the master cam roller in the opposite direction, and a control valve which is actuated in timed relation with the table movement automatically to index the master cam roller in either direction in timed relation with the table movement.

7. A cam grinding apparatus of the type having a longitudinally movable table, means to traverse the table longitudinally, a rock bar pivotally mounted on said table, a camshaft support on said rock bar, a master camshaft rotatably mounted on said rock bar and arranged in axial alignment with the camshaft support, a master cam follower roller movable in a path parallel to the axis of said master camshaft, a rack and gear mechanism arranged to shift the follower in either direction, a fluid pressure mechanism including a piston and cylinder to actuate said rack and gear mechanism to index the master cam roller in either direction, a plurality of adjustable dogs on said table, and a control valve actuated by said dogs to control the admission of fluid to said piston and cylinder automatically to index the master cam roller in either direction in timed relationship with the table movement.

8. A cam grinding apparatus of the type having a longitudinally movable table, a rock bar pivotally mounted on said table, a rotatable camshaft support on said rock bar, a master camshaft rotatably supported on said rock bar and arranged in axial alignment with the camshaft support, a plurality of master cams supported on said shaft, a master cam follower roller cooperating with said master cams and movable in a path parallel to the axis of said master camshaft, means including a rack and gear mechanism to index the follower roller in either direction comprising a fluid pressure piston and cylinder, a pawl and ratchet mechanism actuated by said piston and cylinder to rotate the gear mechanism to index the master cam roller in one direction, and a control valve actuated in timed relation with the table movement to admit fluid under pressure automatically to index the master cam roller.

9. A cam grinding apparatus of the type having a longitudinally movable table, a pivotally mounted rock bar on said table, a rotatable camshaft support thereon, a master camshaft rotatably supported thereon and arranged in axial

alignment with the camshaft support, a master cam follower roller which is movable in a path parallel to the axis of the master camshaft, means to index said follower roller comprising a rack and gear mechanism, a pawl and ratchet mechanism arranged to turn said gear mechanism, a fluid pressure piston and cylinder operatively connected to actuate said pawl and ratchet mechanism to index the master cam roller in one direction, and a control valve actuated in timed relation with the table movement to control the admission of fluid to said cylinder to index the master cam roller automatically in timed relationship with the table movement.

10. A cam grinding apparatus of the type having a longitudinally movable work table, a pivotally mounted rock bar on said table, a rotatable camshaft support on said rock bar, a rotatable master camshaft arranged in axial alignment with said camshaft support, a rotatable master cam follower roller movable in a path parallel to the axis of the master camshaft, means including a rack and gear mechanism to move said follower roller, a fluid pressure actuated pawl and ratchet mechanism to actuate said gear and rack mechanism to move the follower roller in one direction, a second fluid pressure actuated pawl and ratchet mechanism which is operatively connected to said rack and gear mechanism so as to move the follower roller in the opposite direction, and a fluid pressure control valve to control the admission of fluid to both of said fluid pressure actuated mechanisms automatically to index the master cam roller in timed relation with the table movement.

11. A cam grinding apparatus of the type having a longitudinally movable work table, a pivotally mounted rock bar on said table, a rotatable camshaft support on said rock bar, a rotatable master camshaft arranged in axial alignment with said camshaft support, a rotatable master cam follower roller movable in a path parallel to the axis of the master camshaft, means including a rack and gear mechanism to move said follower roller, a fluid pressure actuated pawl and ratchet mechanism to actuate said gear and rack mechanism to move the follower roller in one direction, a second fluid pressure actuated pawl and ratchet mechanism which is operatively connected to said rack and gear mechanism so as to move the follower roller in the opposite direction, and a fluid pressure control valve actuated in timed relation with the table movement to control the admission of fluid to both of said fluid pressure actuated mechanisms automatically to index the master cam roller in timed relation with the table movement.

12. A cam grinding machine having a longitudinally movable table, a rotatable master camshaft thereon, a cam follower movable longitudinally relative to said shaft, means including a rack and gear mechanism to move said follower, means to actuate said rack and gear mechanism, a control mechanism to actuate said means, and means including adjustable dogs on said table to actuate said control mechanism so as to index the cam follower automatically in timed relation with the longitudinal movement of the table.

13. A cam grinding apparatus comprising a longitudinally movable table, a rock bar pivotally mounted on said table, a camshaft supported on said rock bar, a master camshaft arranged in axial alignment with said camshaft support, a plurality of master cams carried by said shaft, a movable master cam follower roller cooperating

with said cams, means including a rack and gear mechanism to index the master cam roller, actuating means operatively connected to operate said rack and gear mechanism to index the master cam roller in one direction, a second rack and gear mechanism arranged to move the follower in the opposite direction, a second actuating mechanism operatively connected to actuate said second rack and gear mechanism to index the master cam roller in the opposite direction, and means including a control device which is actuated in timed relation with the table movement automatically to index the master cam roller in either direction in timed relation with the table movement.

14. A cam grinding apparatus of the type having a longitudinally movable table, a rock bar pivotally mounted on said table, a rotatable camshaft support on said rock bar, a master camshaft rotatably supported on said rock bar and arranged in axial alignment with the camshaft support, a plurality of master cams supported on said shaft, a master cam follower roller cooperating with the master cam and movable in a path parallel to the axis of the master camshaft, means including a rack and gear mechanism to index the follower roller in either direction, means including a pawl and ratchet mechanism to actuate said rack and gear mechanism to index the master cam roller in one direction, and a control device actuated in timed relation with the table movement to control said solenoid automatically to index the master cam roller.

15. A cam grinding apparatus of the type having a longitudinally movable table, a pivotally mounted rock bar on said table, a rotatable camshaft support thereon, a master camshaft rotatably supported thereon and arranged in axial alignment with the camshaft support, a master cam follower roller which is movable in a path parallel to the axis of the master camshaft, means to index the follower roller comprising a rack and gear mechanism, a pawl and ratchet mechanism arranged to turn said gear mechanism, means operatively connected to actuate said pawl and ratchet mechanism to index the master cam roller, and a control device actuated in timed relation with the table movement to control said pawl actuating means so as to index the master cam roller automatically in timed relation with the table movement.

16. A cam grinding apparatus of the type having a longitudinally movable table, a pivotally mounted rock bar on said table, a rotatable camshaft support on said rock bar, a rotatable master camshaft arranged in axial alignment with said camshaft support, a rotatable master cam follower roller movable in a path parallel to the axis of the master camshaft, means including a rack and gear mechanism to move the follower roller, a pawl and ratchet mechanism to actuate said rack and gear mechanism to move the follower roller in one direction, a second pawl and ratchet mechanism to actuate said rack and gear mechanism to move the follower roller in the opposite direction, and a control mechanism actuated in timed relation with the table movement to control and actuate both of said pawl and ratchet mechanisms automatically to index the master cam roller in either direction in timed relation with the table movement.

17. A cam grinding apparatus comprising a longitudinally movable table, a pivotally mounted camshaft support on said table, a master camshaft aligned with said camshaft support, a mas-

ter cam follower roller movable in a path longitudinally relative to the axis of said shaft, a gear mechanism to move said follower, a solenoid to actuate said gear mechanism, and an electrical circuit including a control switch which is actuated in timed relation with the table movement automatically to index the master cam roller.

18. A cam grinding apparatus comprising a longitudinally movable table, a pivotally mounted camshaft support on said table, a master camshaft aligned with said camshaft support, a master cam follower roller movable in a path longitudinally relative to the axis of said shaft, means including a rack and gear mechanism for moving the follower, an electrical apparatus including a solenoid to actuate said rack and gear mechanism, and an electrical circuit including a control switch which is actuated in timed relation with the table movement automatically to index the master cam roller in timed relationship with the table movement so that the master cam roller is automatically positioned in operative relation with the master cam corresponding to the cam being ground.

19. A cam grinding apparatus comprising a longitudinally movable table, a rock bar pivotally mounted on said table, a camshaft support on said rock bar, a master camshaft arranged in axial alignment with said camshaft support, a plurality of master cams carried by said shaft, a movable master cam follower roller cooperating with said cams, means including a rack and gear mechanism to index the master cam roller, electrical apparatus including a solenoid operatively connected to actuate said rack and gear mechanism to index the master cam roller in one direction, a second rack and gear mechanism arranged to move said follower in the opposite direction, a second solenoid operatively connected to actuate said second rack and gear mechanism to index the master cam roller in the opposite direction, and an electrical circuit including a control switch which is actuated in timed relation with the table movement automatically to index the master cam roller in either direction in timed relation with the table movement.

20. A cam grinding apparatus of the type having a longitudinally movable table, a rock bar pivotally mounted on said table, a camshaft support on said rock bar, a master camshaft rotatably mounted on said rock bar and arranged in axial alignment with the camshaft support, a master cam follower roller movable in a path parallel to the axis of said master camshaft, a rack and gear mechanism arranged to shift the follower in either direction, electrical mechanism including a solenoid to actuate said rack and gear mechanism to index the master cam roller in either direction, a plurality of adjustable dogs on said table, and a control switch actuated by said dogs to control the electrical circuit automatically to index the master cam roller in either direction in timed relationship with the table movement.

21. A cam grinding apparatus of the type having a longitudinally movable table, a rock bar pivotally mounted on said table, a rotatable camshaft support on said rock bar, a master camshaft rotatably supported on said rock bar and arranged in axial alignment with the camshaft support, a plurality of master cams supported on said shaft, a master cam follower roller cooperating with the master cam and movable in a path parallel to the axis of said master camshaft, means including a rack and gear mech-

anism to index the follower roller in either direction comprising an electric solenoid, a pawl and ratchet mechanism actuated by the solenoid to actuate the rack and gear mechanism to index the master cam roller in one direction, and a control switch actuated in timed relation with the table movement to control said solenoid automatically to index the master cam roller.

22. A cam grinding apparatus of the type having a longitudinally movable table, a pivotally mounted rock bar on said table, a rotatable camshaft support thereon, a master camshaft rotatably supported thereon and arranged in axial alignment with the camshaft support, a master cam follower roller which is movable in a path parallel to the axis of the master camshaft, means to index the follower roller comprising a rack and gear mechanism, a pawl and ratchet mechanism arranged to turn said gear mechanism, an electrical solenoid operatively connected to actuate said pawl and ratchet mechanism to index the master cam roller in one direction, and a control switch actuated in timed relationship with the table movement to control said solenoid to index the master cam roller automat-

ically in timed relationship with the table movement.

23. A cam grinding apparatus of the type having a longitudinally movable work table, a pivotally mounted rock bar on said table, a rotatable camshaft support on said rock bar, a rotatable master camshaft arranged in axial alignment with said camshaft support, a rotatable master cam follower roller movable in a path parallel to the axis of the master camshaft, means including a rack and gear mechanism to move the follower roller, an electrically actuated pawl and ratchet mechanism to actuate said gear and rack mechanism to move the follower roller in one direction, a second electrically actuated pawl and ratchet mechanism which is operatively connected to said rack and gear mechanism so as to move the follower roller in the opposite direction, and an electrical control switch actuated in timed relation with the table movement to control both of said electrically actuated pawl and ratchet mechanisms automatically to index the master cam roller in timed relation with the table movement.

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