Jan. 2, 1940. G. CROMPTON, JR 2,185,837

GRINDING MACHINE

Filed March 16, 1938 5 Sheets-Sheet 1

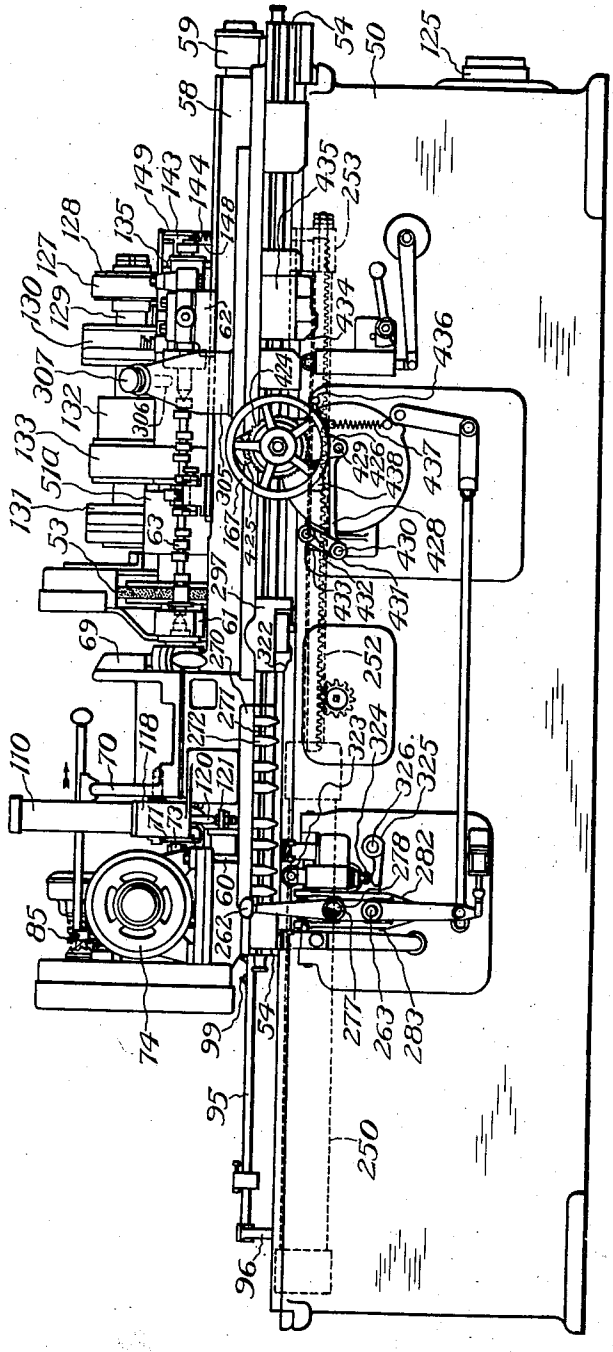


FIG. 1

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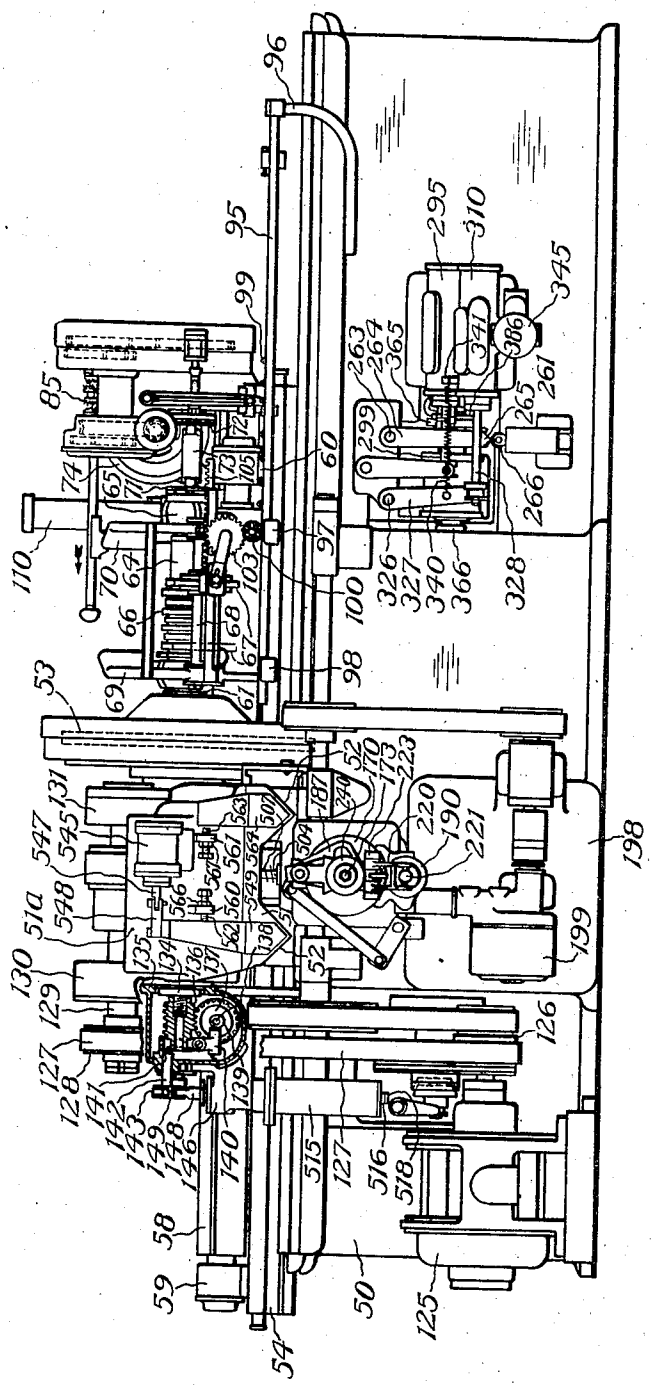


FIG. 2

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GRINDING MACHINE

Filed March 16, 1938 5 Sheets-Sheet 3

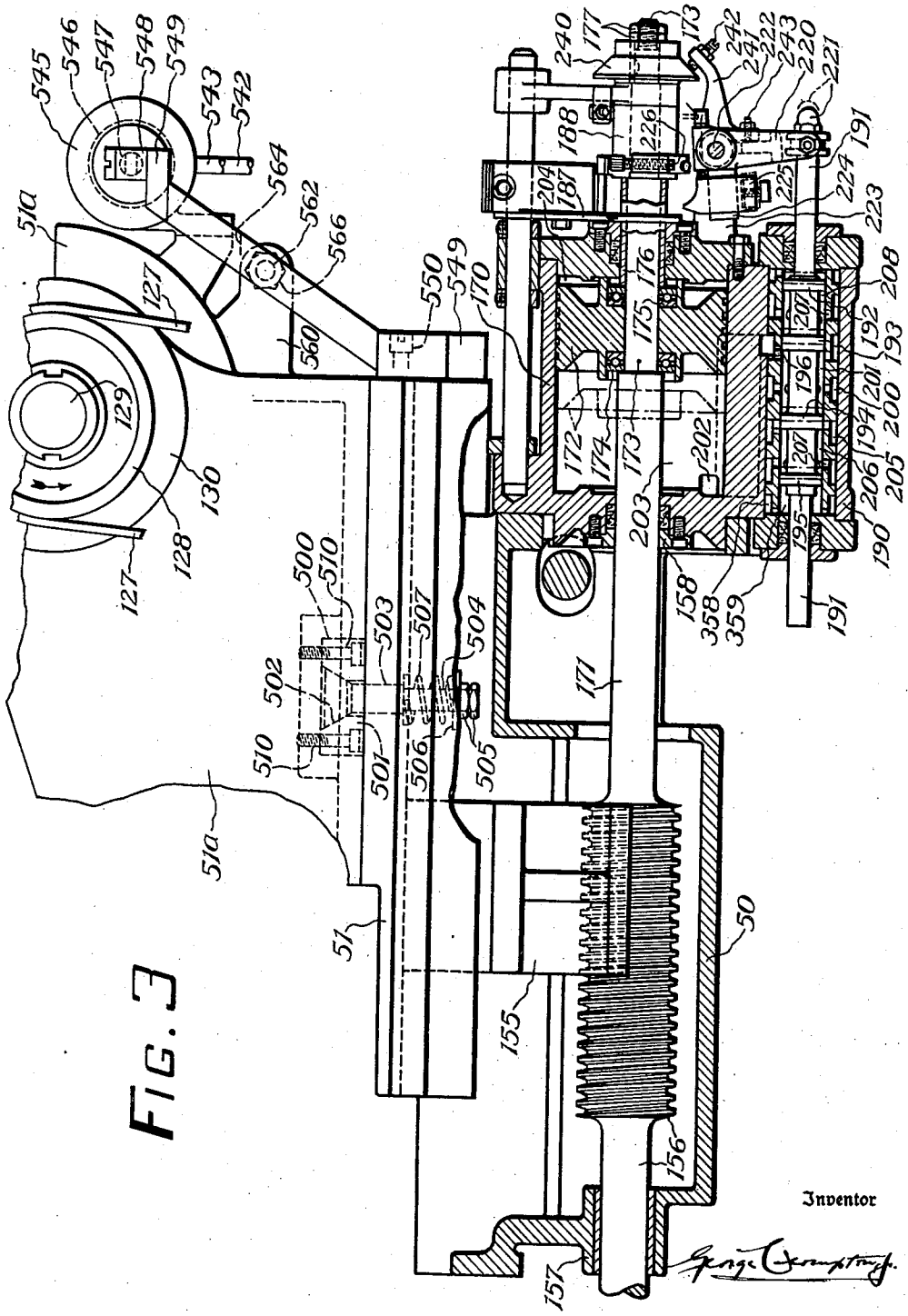


FIG. 3

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GRINDING MACHINE

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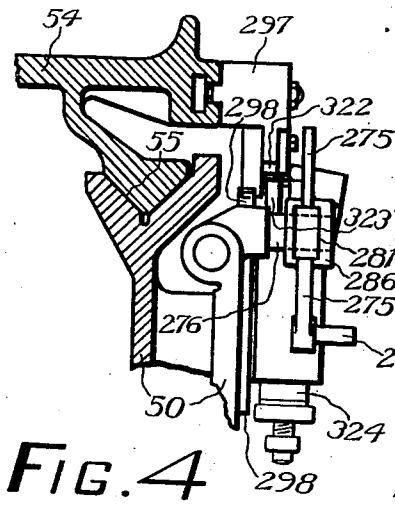


FIG. 4

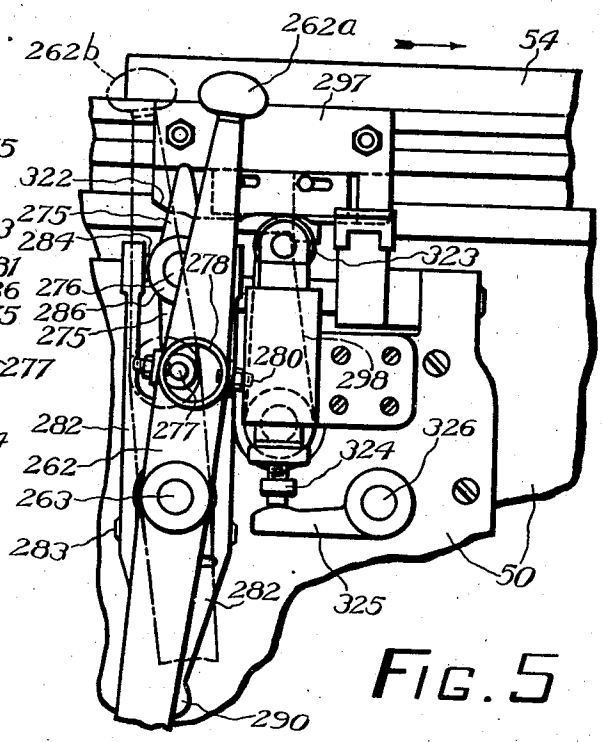


FIG. 5

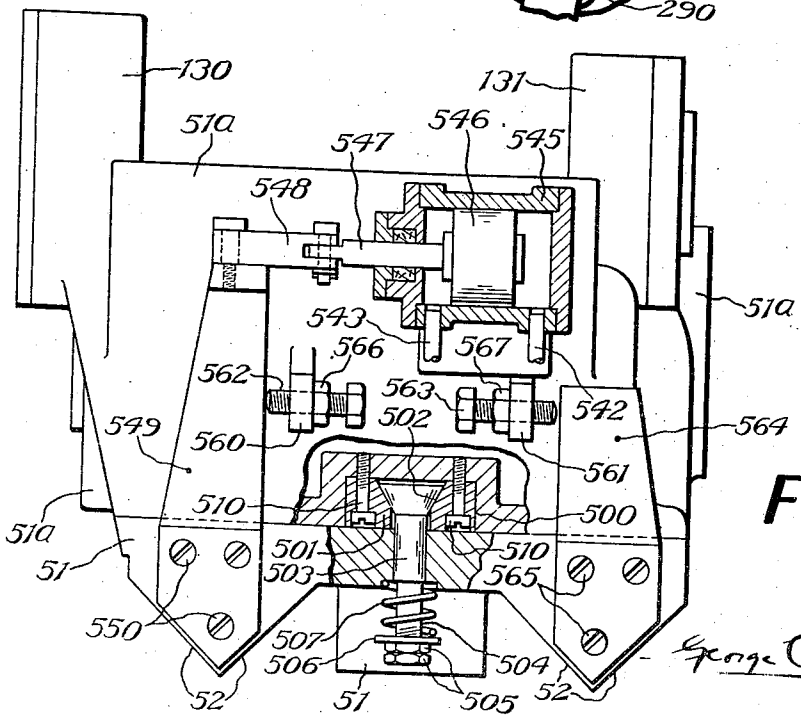


FIG. 6

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GRINDING MACHINE

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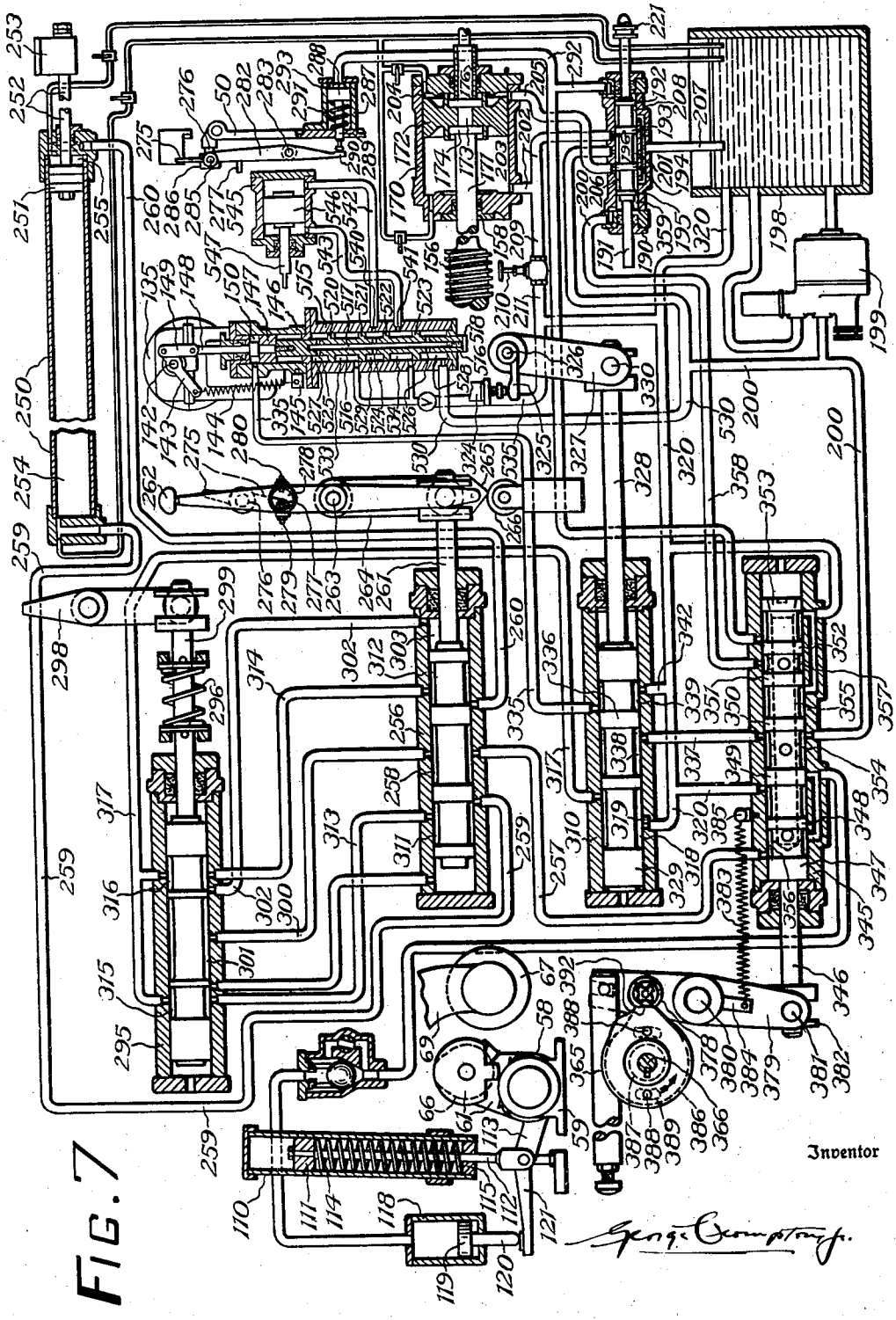


FIG. 7

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Patented Jan. 2, 1940

2,185,837

UNITED STATES PATENT OFFICE

2,185,837

GRINDING MACHINE

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Application March 16, 1938, Serial No. 196,235

7 Claims. (Cl. 51—101)

The invention relates to grinding machines, and with regard to its more specific features to grinding machines adapted to grind a plurality of cams on a camshaft.

One object of the invention is to provide an improved cam grinding machine, for grinding the cams of automotive camshafts, whereby a slight taper may be ground on each cam and adjustments and changes made without procuring a new set of master cams. Another object of the invention is to provide a readily adjustable automatic grinding machine of the type indicated. Another object of the invention is to provide readily controlled apparatus for dressing a grinding wheel for the production of a plurality of tapers on a given work piece of the same dimensions without readjusting the cross slide of the machine. Another object of the invention is to provide a simple and accurate mechanism for dressing a grinding wheel to a frusto-conical shape. Another object of the invention is to provide an automatic machine for the grinding of automotive camshafts to tapered surfaces. 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 many possible embodiments of the mechanical features of this invention,

Figure 1 is a front elevation of a grinding machine to which the invention may be applied;

Figure 2 is a rear elevation of the grinding machine, illustrating certain features of the invention;

Figure 3 is a fragmentary cross sectional view of the cross slide, wheel head and feed screw;

Figure 4 is a vertical sectional view through the table or carriage of the grinding machine, illustrating certain controls;

Figure 5 is a fragmentary elevation of some of the controls on the front of the machine;

Figure 6 is a view, partly in rear elevation and partly in section, of the wheel head-cross slide construction and the fluid pressure mechanism to move the former angularly on the latter;

Figure 7 is a fluid pressure diagram.

For convenience, so far as the parts are the same, I have adopted the same numerals for the several parts as are used in Letters Patent No. 2,022,178.

As conducive to a clearer understanding of the present invention, it is noted that the illustrative embodiment discloses it as an improvement of the hydraulically operated automatic cam grinding machine of U. S. Letters Patent No. 2,022,178 granted November 26, 1935 on application of Albert G. Belden and Herbert A. Silven. The machine of that patent has a work table or carriage upon which is mounted a rock bar upon which the work piece is held by centers, the rock bar being rocked back and forth by the engagement of a master cam roller, which is stationary in the direction of oscillation, with one of the master cams which are mounted upon the rock bar. The grinding wheel is mounted upon the usual cross slide, the spindle of the grinding wheel being journalled in the upper part of the cross slide, sometimes referred to as the wheel head, and there being no provision for movement or adjustment between the wheel head and the cross slide. In fact, these have usually been considered the same part and have been often made as an integral casting.

In the machine of the patent referred to, the table or carriage is automatically moved from station to station for the grinding of the several cams on the automotive product camshaft and, at the completion of a grinding operation, or between rough grinding and finish grinding, the wheel is automatically dressed by a dressing device which consists of a holder secured to the carriage presenting a diamond for contact with the wheel by relative motion of the carriage and wheel.

The dressing apparatus of said patent has certain highly desirable characteristics which I wish to maintain unimpaired. The dressing tool holder is a somewhat massive casting rigidly secured to the work table or carriage which in turn weighs several tons and moves on the main ways of the base. There is thus little chance for vibration or any play or undesired movement of the dressing diamond during the dressing operation.

In the automobile engine as now manufactured, the camshaft is a steel forging, all the cams being integral with the shaft. The cams lift the valves by engagement with tappet rods, the bottoms of which have the shape of disks and may be of hardened steel. Nevertheless it is found that there is a tendency of the cam to wear a groove in the bottom of the tappet rod which eventually interferes with the adjustment of the valves. Accordingly, automotive engineers have recently adopted the improved feature of forming each of the cams with a slight taper which causes the

cams to revolve the tappet rods or the disks, thus distributing the wear.

If automotive camshafts are to be formed with a slight taper, the grinding machine which automatically grinds them should form them with this shape, as subsequent to finsh grinding there is usually only a polishing operation, if any operation, further performed upon the cams. Camshafts with a slight taper have been made on automatic grinding machines of the type disclosed in the aforesaid Patent No. 2,022,178 by providing master cams of different size, decreasing in size from one end of the master camshaft to the other end thereof, and also mounting the rock bar on the table or carriage non-parallel to the ways thereof. This, it will be seen, produces the desired taper camshaft with all the cams on the product shaft of the same size because the disturbance of the relation between the forward position of the grinding wheel and the various cams due to the angular position of the product camshaft on the table or carriage is compensated for by the varying sizes of the master cams.

The forming of master cams for a grinding machine of the type disclosed in said Patent 2,022,178 is in itself an operation requiring considerable care. The product cams will be no more accurate than the master cams which form them. It has been customary to shape a plurality of identical master cams and to key them to the master camshaft in varying angular positions, as required for the operation of the internal combustion engine. The provision of a plurality of these master cams, all of different sizes, greatly increases the expense of operation and maintenance of the machine and, furthermore, the chances of error are thereby greatly increased. In fact, it has been difficult to maintain all the product cams of the same size in accordance with the system just described, in which the master cams are of different size, and it should be noted that tolerances in the grinding of camshafts are fine.

According to the present invention, the machine of the Belden and Silven Patent 2,022,178 or other cam grinding machine is equipped with improved features whereby a single size of master cam may be used and yet the dressing of the wheel may be effected according to said patent, utilizing the massive table to hold the dressing diamond for the attainment of the most accurate results in forming the wheel.

As illustrated in the drawings, the improved automatic cam grinding machine comprises a base **50** which supports a wheel slide **51** for transverse movement thereon on the V-ways **52** which in turn rotatably supports a grinding wheel **53**. The base also supports a longitudinally movable work supporting table **54** which is arranged to slide on a V-way **55**.

Camshaft supporting mechanism

A rock bar **58** is journalled in the bearings **59** and **60** which are rigidly fixed to the table **54** so that bar **58** is free to rock therein. A headstock **61** and footstock **62** are mounted on the rock bar **58** and are provided with centers to rotatably support a camshaft **63**. A master camshaft **64** is supported at one end in the headstock **61** and at the other end in a bearing **65** which is fixed to the rock bar. The master camshaft is provided with a plurality of spaced master cams **66** which correspond with the number of product cams on the camshaft to be ground. A master cam roller **67** is slidably mounted on a shaft **68** which is fixed in bearing brackets **69** and **70** which are in turn fixed to the table of the machine. It will be readily seen from this construction that when the master camshaft **64** is rotated with a master cam in engagement with the roller **67**, a rocking motion will be transmitted to the bar **58** to rock the product camshaft toward and from the periphery of the wheel so as to produce the desired contour thereon.

Work rotation

The master camshaft and product camshafts are preferably rotated by a power drive through universal joints **71** and **72** and the connecting shaft **73**. A motor **74** is preferably provided to rotate these parts through a clutch member **85** together with suitable gearing which need not be herein described.

Automatic indexing master cam roller

The master cam roller **67** is preferably indexed automatically so as to position it in operative relation with successive master cams on the master camshaft to conform with the cams being ground on the product camshaft. This mechanism, as illustrated in the drawings, is substantially the same as that illustrated in the prior patent to C. G. Trefethen et al. No. 1,783,755 dated December 2, 1930. Since this feature does not constitute the subject matter of the claims, it has been illustrated only in outline, as shown in Fig. 2. For further disclosure as to details of this construction, reference may be had to the above-mentioned patent. A dog bar **95** is fixed by a bracket **96** to the base of the machine. The other end of the dog bar **95** is slidably supported in brackets **97** and **98** which are carried by the table **54**. The dog bar **95** is provided with a plurality of adjustable dogs **99** engaged by a star wheel **100**. By suitable gearing including gear **103** the star wheel **100** shifts a rack bar **105**. The rack bar **105** is slidably mounted in the brackets **69** and **70** and is connected to move the master cam roller **67** in an endwise direction. It will be readily appreciated from the foregoing disclosure that when the table **54** is traversed longitudinally, the star wheel will engage the dogs **99** successively which in turn, through the gearing will move the rack bar **105** and index the master cam roller **67** automatically into alignment with the master cam corresponding to the product cam.

Rock bar actuation

The rock bar **58** is normally held under a yieldable tension so that a master cam **66** is held in operative contact with the master cam roller **67**. This tensioning device is similar to that shown in the prior patent above mentioned and preferably comprises a cylinder **110** pivotally supported on the bracket **70**. A piston **111** is slidably mounted within the cylinder **110** and is connected by a piston rod **112** with an arm **113** which is fixedly mounted to the rock bar **58**. A spring **114** is interposed between the piston **111** and a collar **115** in the base of the cylinder **110**. The spring **114** is a compression spring of sufficient strength to hold the master cam **66** in proper contact with the master cam roller **67** during the rotation of the master cam and the rocking of the bar **58**.

A fluid pressure mechanism is provided to rock the bar **58** to an inoperative position automatically before the table is traversed so that the master cam and follower and product cams and

grinding wheel will be separated before the traversing of the table is started. This mechanism may comprise a fluid pressure cylinder 118, having a piston 119 slidably mounted therein. The piston is connected to a piston rod 120 arranged to contact with a projection 121 of the arm 113. When fluid under pressure is admitted to the cylinder 118, piston 119 moves downwardly and rocks the projection 121 and the arm 113 to rock the bar 58 and separate the master cam 66 from the follower roller 67 (Fig. 7). Fluid under pressure is preferably admitted to the cylinder 118 in a definite timed relation to the action of the other mechanisms of the machine.

Grinding wheel drive mechanism

The grinding wheel may be driven from any suitable source of power, such as a main driving motor 125 mounted either on the base of the machine or on the floor adjacent to the base, as illustrated in the drawings. The motor is connected by a pulley 126 and a belt 127 to a pulley 128 on the jack shaft 129 which is rotatably supported in bearings 130 and 131 on the wheel head 51*a*. The shaft 129 is provided with a pulley 132 which is connected by a belt 133 to rotate a grinding wheel spindle 134.

Wheel spindle reciprocating mechanism

The grinding wheel is fed by the straight-in or plunge-cut method. It is, therefore, desirable that a suitable mechanism be provided to reciprocate the grinding wheel axially during the grinding operation. In the machine illustrated in the drawings, a wheel spindle reciprocating device 135 is utilized. This mechanism has not been shown in detail, since it corresponds with the mechanism shown in the prior patent to Belden et al. No. 1,584,717 dated May 18, 1926. This mechanism preferably comprises a worm 136 mounted on the end of the wheel spindle which in turn meshes with a worm gear 137. The worm gear 137 is mounted on a shaft 138 and carries an eccentric 139 arranged to rock a yoked member 140. The yoked member 140 is arranged to be swung out of the path of the eccentric 139 by a cam 141 which is mounted on the end of a shaft 142. To stop the reciprocating motion of the wheel spindle, the operator may rock the shaft 142 and rock the yoked member out of operative contact with the eccentric, thereby stopping the reciprocating movement of the wheel spindle. The control of the wheel spindle reciprocating may be manual but in the preferred construction, it is desirable to provide an automatic control which may be actuated in timed relation with the machine mechanisms. As illustrated in the drawings (Figs. 2 and 7), a lever 143 is mounted on the outer end of the shaft 142 and a spring 144 is interposed between the end of the lever 143 and a stud 145 fixedly mounted on the lower end of a cylinder 146, the tension of the spring 144 normally holding the lever 143 in a position so that the wheel spindle and the grinding wheel are reciprocated. The cylinder 146, which is fixed to the wheel head 51*a*, is provided with a piston 147 connected by a piston rod 148 and link 149 with the lever 143. It will be readily appreciated from this construction, that when fluid is admitted to a chamber 150, it will cause a downward movement of the piston 147 and rock the lever 143 in a clockwise direction to stop the wheel spindle reciprocation. Fluid under pressure is admitted to this cylinder in timed relation with the actuation of the other mechanisms of the machine to stop the wheel spindle reciprocation during the truing of the grinding wheel, as is hereinafter described.

Grinding wheel feeding mechanism

The grinding wheel slide 51 is arranged for a feeding movement to control the movement of the grinding wheel toward and from the work. This mechanism preferably comprises a nut 155 depending from slide 51 and engaging a feed screw 156 which is rotatably mounted in the bearings 157 and 158 in the base 50 of the machine. A hand wheel 167 on the front of the machine is connected to turn the feed screw 156.

In an automatic machine of this type, it is preferable to provide a suitable mechanism for rapidly moving the grinding wheel to and from a grinding position. As illustrated in the drawings, a fluid pressure mechanism is provided having a cylinder 170 which is formed either as an integral part of the base or fixedly mounted therein. The rod 171 which is preferably an extension of the feed screw 156 is aligned with the axis of the cylinder and serves as a piston rod. A piston 172 is slidably mounted within the cylinder 170 and is rotatably supported on a reduced end portion 173 of the piston rod 171. An end thrust bearing 174 is interposed between a shoulder on the rod 171 and one end of the piston 172 and a second end thrust bearing 175 is interposed between the other end of the piston 172 and a sleeve 176 which surrounds the portion 173 of the piston rod 171. The sleeve 176 is held in proper adjustment by means of adjusting nuts 177 on the outer end of the reduced portion 173. By tightening or loosening the nuts 177, the end thrust of the bearings 174 and 175 may be adjusted. It will be readily apparent from this construction that when the piston is moved endwise, it will transmit a feeding movement to the grinding wheel through the rod 171, feed screw 156, half nut 155, to move the wheel slide 51. The feed screw is arranged so that it may be rotated relative to the piston so that the operator, by manual rotation of the feed screw, may readily adjust the position of the grinding wheel relative to the fluid pressure mechanism.

In a feeding mechanism of this type, it is desirable that the grinding wheel be fed to a predetermined positive stop so that for each successive grinding operation, the grinding wheel may be moved to the same extent to grind new pieces of work. To accomplish this result, a gauge block 187 is mounted on the rear of the cylinder 170 and arranged to be engaged by a sleeve 188 on the reduced end portion 173 of the piston rod 171. When the piston moves forward to feed the grinding wheel into the work, the sleeve 188 contacts with the gauge 187 definitely limiting the forward feeding movement of the grinding wheel so that on successive grinds, the wheel may be brought to the same position.

A fluid pressure control valve 190 is provided to regulate the admission of fluid to said cylinder. This valve is preferably of the balanced piston type having a valve stem 191 and a plurality of valve pistons 192, 193, 194, and 195 which are slidably mounted within the valve 190. The ports in the valve are so arranged that fluid from a reservoir 198 is forced by a pump 199 through a conduit 200 into a valve chamber 201. As the valve stem 191 is shifted from one extreme to the other extreme position, the fluid flow may be changed from one side of the piston 172 to the

other to reverse the direction of movement of the wheel slide.

In the preferred construction, it is desirable to connect the valve stem 191 so that when the piston 172 has reached a predetermined position in its stroke, the valve stem 191 is automatically shifted to partially cut off the fluid flow through the valve 190 to the cylinder 170. When the valve 190 is in the position illustrated in Fig. 7, fluid under pressure is forced through a pipe 202 into the cylinder chamber 203 to move the piston 172 toward the right-hand end of the cylinder and thereby cause a rearward movement of the grinding wheel and its supporting slide. During this movement, fluid is exhausted from a cylinder chamber 204, through a pipe 205, a valve chamber 206 and through an exhaust pipe 207 into the reservoir 198.

To obtain a forward feeding movement of the grinding wheel, the valve stem 191 is shifted toward the left, as viewed in Figs. 3 and 7, so that fluid under pressure passes from the valve chamber 201, through the pipe 205 into the cylinder chamber 204, to move the piston 172 and the grinding wheel toward the work. During this movement, fluid is exhausted from the cylinder chamber 203, the pipe 202, through a valve chamber 208 and exhaust pipe 207 into the reservoir.

It is desirable to have a finely adjustable port for regulating the exhaust of fluid from the chamber 203 so as to produce a slow but uniform feed of the grinding wheel into the work during the grinding operation. This is preferably accomplished by an actuating means which moves the valve stem 191 so that the valve piston 193 partially covers a V-port 196 connected with the pipe 202 so that fluid thereafter exhausts at a slower but uniform rate to produce the desired grinding feed of the wheel. If desired, the actuating mechanism may be so adjusted that the valve piston 193 entirely covers the V-port 196 so that fluid thereafter exhausts through a pipe 209, a needle valve 210, and a pipe 211 into the reservoir 198. By manipulation of the needle valve 210, the operator may obtain a desired slow grinding feed. The actuation of the valve stem 191 to obtain a reversal in direction of the grinding wheel movement is preferably obtained by means of a main control valve which is hereinafter described.

Feed control valve actuating mechanism

The feed control valve 190 is preferably actuated in timed relation with the movement of the piston 172 so that the forward feeding movement of the grinding wheel may be rapid until the wheel is about to contact with the surface of the work. This mechanism comprises a rock arm 220 having a yoked end provided with pins engaging the groove of a collar 221 on the outer end of the valve stem 191. The rock arm 220 is pivotally mounted on a stud 222 which is supported in brackets 223 on the base of the machine. The arm 220 has an inwardly extending arm 224 which carries an adjustable dog 225 which is arranged in the path of an adjustable screw 226 on the collar 188 which is carried by the reduced end portion 173 of the piston rod. It is readily apparent from this disclosure that when the rod 173 is moved in a direction toward the left, as viewed in Figs. 3 and 7, to cause an infeeding movement of the grinding wheel, the valve stem 191 is positioned so that both intake and exhaust ports are wide open to permit a rapid approaching movement of the grinding wheel toward the work. This movement continues until the adjustable stop screw 226 strikes the upper end or cam face of the dog 225 so as to rock the arms 224 and 220 and move the valve stem 191 so as to partially cut off the exhaust of fluid to produce a slower but uniform grinding feed of the wheel into the work.

It is desirable to provide a suitable mechanism for shifting the valve stem 191 when the wheel is moving rearwardly to either stop the rearward feeding movement or slow down its movement before the piston 172 engages the end of the cylinder. This is preferably accomplished by means of a collar 240 which serves as a cam to rock a bell crank lever 241 which is mounted on the stud 222 so as to cause a movement of the rock arm 220 and valve stem 191 toward the left. An adjusting screw 242 is located adjacent the outer end of the bell crank lever 241 to permit adjustment of the time when the valve is actuated. A similar adjusting screw 243 is provided at the lower end of the bell crank and is arranged to engage a portion of the rock arm 220 to provide a further adjustment so that the valve stem 191 may be moved a sufficient distance to partially cut off the exhaust of fluid from the pipe 205 or to entirely cut it off so as to either slow down or stop the rearward movement of the grinding wheel.

Table traverse or indexing movement

The work supporting table 54 is traversed or indexed longitudinally and automatically by means of a fluid pressure system comprising a cylinder 250 which is fixed to the base of the machine. A piston 251 is slidably mounted within the cylinder 250 and is connected by a piston rod 252 to a bracket 253 depending from the under side of the table 54. The admission of fluid to either cylinder chamber 254 or 255 is controlled by a valve 256. Fluid from the pump 199 passes through pipe 200, a pipe 257 into a valve chamber 258. A pipe 259 is connected between the valve 256 and the cylinder chamber 254 and a pipe 260 is connected between the valve 256 and the cylinder chamber 255. It will be readily apparent from this disclosure that when the valve 256 is in the position illustrated in Fig. 7, no fluid will be admitted to either of the cylinder chambers and the table will remain stationary. The valve 256 is provided with a valve stem 261 which is operatively connected to a manually operable control lever 262 mounted on a rock shaft 263 by means of a short arm 264. The arm 264 is mounted on the rear end of shaft 263 and has a pin engaging a groove on the valve stem 261. It will be readily apparent from this construction that when the lever 262 is moved in a clockwise direction, the valve stem 261 will be moved toward the left, as viewed in Fig. 7, so as to admit fluid through pipe 259 to the cylinder chamber 254 and cause a movement of the table 54 toward the right (Figs. 1 and 7). Similarly, when the lever 262 is moved in a counterclockwise direction, the valve stem 261 will be moved toward the right so as to pass fluid through the pipe 260 into the cylinder chamber 255 to move the table 54 toward the left.

The lever 262 is normally held in the full line position 262*a* as indicated in Fig. 5 or in the opposite position by means of an arrow point 265 on the lever fixed on the end of the shaft 263 and engaged by a spring pressed roller 266. See Figs. 2 and 7. The lever 262 is in the dotted line position 262*b* (Fig. 5), while the table is indexed

intermittently in a position toward the left. The lever 262 is in the opposite position, to the right, while the table is being indexed intermittently as it moves toward the right. The valve stem 261 is normally in a position to admit fluid either through the pipe 259 or the pipe 260 to the cylinder 250. The admission of fluid through the pipe 257 to the valve 256 is controlled by a main control valve, as will hereinafter be described.

An actuating mechanism is provided for the valve so that movement of the work supporting table 54 operates to close the valve 256 so that when the table is traversed a predetermined distance to position the next cam in front of the grinding wheel, the valve is automatically closed to stop the table against further movement. This is preferably accomplished by means of a dog bar 270 which is adjustably mounted on the front edge of the table. The dog bar 270 is provided with a T-slot 271 in which is a plurality of adjustable dogs 272. The dogs may be adjusted along the bar 270 to conform with the spacing of the cams on the product camshaft. The dog bar, if necessary for any variation in successive camshafts, may be adjusted longitudinally of the table without upsetting the adjustment of the individual dogs.

There is provided a secondary actuating lever for cooperating with the table dogs. As illustrated in Fig. 4, a dog lever 275 is pivotally mounted on a stud 276. The lower end of the dog lever 275 is provided with a projecting pin 277 which rides in a cylindrical aperture 278 in the lever 262. See Figs. 5 and 7.

Assuming the lever 262 is positioned as illustrated in Fig. 1, that is, in a neutral position, the lever 262 is thrown either manually or automatically into position 262b to move the valve stem 261 and admit fluid through pipe 260 into cylinder chamber 255 to start the movement of table 54 in a direction toward the left. This movement traverses the camshaft supporting table 54 to bring the first product cam into operative relation with the grinding wheel. The traversing movement continues until the dog lever 275 is engaged by the first dog 272. The dog lever 275 is rocked, swinging the pin 277 from engagement with a stop screw 279 into engagement with a stop screw 280, both of which are carried by the lever 262, and then swings the lever 262 from position 262b into the full line position illustrated in Fig. 7, with the arrow point 265 depressing the spring pressed roller 266. The parts, however, are adjusted so that the arrow point does not reach the high point on the spring roller, so that the roller is at all times exerting a pressure tending to move the lever either toward the right or toward the left. The swinging of the lever 262 from position 262b into the full line position, as indicated in Fig. 7, moves the valve stem 261 into the position illustrated in Fig. 7, so as to cut off fluid pressure from both of the pipes 259 and 260, thereby stopping the movement of the work carrying table. By adjusting the position of the dogs 272 along the dog bar 270, the stopping position of the table may be adjusted as desired so that the product cams will be positioned successively in operative relation with the grinding wheel.

The dog lever 275 is slidably mounted on the stud 276 so that it may be thrown out of the path of the dogs 272 to permit a further traversing movement of the table. A lever 282 (Figs. 5 and 7) is pivoted on a stud 283 and at its upper end is formed as a yoke having pins 284 and 285 engaging slots 281 in opposite sides of the hub 286 of the lever 275. When the lever 282 is moved clockwise (Fig. 7), the dog lever 275 is moved rearwardly on the stud 276 out of the path of the dog 272 so as to permit a further traversing or indexing movement of the table. This movement is preferably accomplished in timed relationship with the other operating mechanisms of the machine. A fluid pressure cylinder 287 is mounted within the machine base and is provided with a piston 288 having a piston rod 289 engaging an end 290 of the lever 282. A spring 291 which surrounds the piston rod serves to normally retain the piston 288 in its rearward position. Fluid pressure is admitted through a pipe 292 into a cylinder chamber 293 in timed relationship with the other operating mechanism of the machine to rock the lever 282 and thereby slide the dog lever 275 into an inoperative position out of alignment with the dogs 272. This mechanism is preferably controlled by the main control valve, which is hereinafter described, so as to operate automatically in timed relation with the other movements of the machine.

Pilot valve

After the work table has been indexed intermittently for grinding successive cams on a camshaft, it is then desirable to shift the traverse or table index control valve 256 into a reverse position so that the arrow point 265 rides on the opposite side of the axis of the spring pressed roller 266. This is preferably accomplished by means of a pilot valve 295 which is of a balanced piston type valve and normally held in a neutral or inoperative position by means of a spring 296. When the table reaches its end position in its movement towards the left, a depending projection on an adjustable truing dog 297 (Figs. 1 and 5) engages the upper end of a pilot valve lever 298 (Figs. 4 and 7) and rocks it so as to move a valve stem 299, so as to admit fluid which enters through a pipe 300 and a valve chamber 301 into a pipe 302 which passes fluid under pressure into a valve chamber 303 at one end of the traverse of the index control valve 256. This pressure moves the valve stem 261 so that the control lever 262 and arrow point 265 pass over the high point on the roller 266 and shifts the valve 256 into a reverse position so that after truing of the grinding wheel, the table 54 is ready for an intermittent traversing or indexing movement in a direction toward the right, as viewed in Fig. 1.

Wheel truing mechanism

In a machine of this type, it is desirable that the wheel be automatically trued so that the grinding may be accomplished by a freshly trued wheel face. Referring now to the right-hand side of Fig. 1, a bracket 305 is fixedly mounted on the table 54 and carries a truing tool 306 which may be adjusted by a micrometer mechanism 307. After the last cam on the shaft has been ground, the grinding wheel is moved to an extreme rearward position with the piston 172 engaging the rear end of the cylinder (Fig. 3). The table 54 is then given an additional traversing movement to carry the previously adjusted diamond or truing tool 306 across the grinding wheel 53, while it is in its extreme rearward position.

The normal traversing or indexing movement of the table is comparatively rapid to prevent loss of time between successive grinding operations. This table speed is not well suited for a truing operation which requires a very slow, uniform relative traversing movement between the

truing tool and the grinding wheel. To attain a slow feeding movement of the table, a suitable slow speed or throttle valve 310 is provided. When fluid is exhausted from the cylinder 250, through either pipe 259 or 260, it passes through either chamber 311 or 312, pipes 313 or 314 respectively and then through valve chambers 315 or 316 in the pilot valve 295 and through a common exhaust pipe 317 which enters a valve chamber 318 in the slow speed valve 310. A V-port 319 in the valve chamber 318 is connected by a pipe 320 with the reservoir. During the normal traversing or indexing movement of the table, the V-port 319 is wide open, permitting unrestrained exhaust of fluid from the cylinder 250. When the table 54 indexes or traverses from the last cam on the camshaft and moves toward a truing position, a cam 322 (Fig. 1) on the truing dog 297 strikes a roller 323 which is mounted on the upper end of a spring pressed plunger 324. The lower end of the plunger engages a rock arm 325 mounted on the outer end of a rock shaft 326. The other end of the shaft 326 carries a rock arm 327 (Fig. 7) which is connected by a pin 330 to move a valve stem 328 of the slow speed valve 310. When the cam 322 moves the roller 323 downwardly, it rocks the shaft 326 and arm 327 and valve stem 328 moves the valve piston 329 toward the right (Fig. 7) with the V-port 319 partially closed, thereby restricting the exhaust of fluid from the cylinder 250 so as to produce a slow traversing movement of the work table and the diamond or truing tool 306 across the operative face of the grinding wheel 53.

At the same time the slow speed valve moves to throttle the exhaust of fluid to cause a slow truing movement of the table, a pipe 335 is uncovered by movement of a valve piston 336 to admit fluid from a pipe 337 through a valve chamber 338, a pipe 335, into the cylinder chamber 150 to actuate the lever 143 and thereby stop the wheel spindle reciprocation during the truing movement. The table continues its truing movement towards the left until the pilot valve lever 298 engages the truing dog 297 to move the pilot valve from a neutral position and admit fluid under pressure into the chamber 303 of the traverse valve 256 to reverse the direction of travel of the table. The table moves slowly to pass the diamond across the face of the wheel on its return stroke. The slow movement continues until the roller 323 rides up the cam 322 on dog 297 as the table approaches the last cam on the shaft. A spring 340 (Fig. 2) connected between the lever 327 and a stud 341 on the valve casing 310 serves to return the valve stem 328 to its normal position so as to uncover the pipe 335 and allows fluid to exhaust from the cylinder chamber 150 through pipe 335, valve chamber 339, pipe 342 and pipe 320 into the reservoir, thus allowing the spring 144 to start the wheel spindle reciprocation ready for finish grinding the first cam on the return stroke. At the same time, the V-port 319 is uncovered and unrestricted exhaust of fluid from the cylinder 250 starts the table 54 at its normal traversing or indexing speed.

Main control cam and valve

Inasmuch as most of the mechanisms of the machine are controlled by fluid pressure mechanisms, there is provided a main control valve which is so controlled as to admit fluid under pressure successively to the various mechanisms of the machine to produce the desired cycle of movement. As illustrated in the drawings, a main control valve 345 having a valve stem 346 is arranged to control the movement of a hollow valve member having pistons 347, 348, 349, 350, 351, 352 and 353. Fluid under pressure from pump 199 passes through pipe 200 into a valve chamber 354 in the main control valve 345. From this chamber, fluid under pressure passes through the pipe 337 into the chamber 338 in the slow speed or throttle valve 310. Fluid under pressure from the chamber 354 also passes through a central aperture 355 extending longitudinally within the movable main control valve. Fluid from the passage 355 enters the valve chamber 356 and passes out through the pipe 257 into the valve chamber 258 of the traverse or table index control valve. At the same time, fluid under pressure passing through the central aperture 355 passes into a valve chamber 357 and out through pipe 358 into a valve chamber 359 in the feed control valve 190. Fluid under pressure entering the chamber 359 serves to move the feed control valve in a direction toward the right to uncover the pipe 202 so as to cause a rearward feeding movement of the grinding wheel.

Main control cam

In order that the mechanisms may function in proper sequence, there is provided a suitable mechanism for actuating the main control valve 345. In the preferred construction, this mechanism comprises a main control cam 365 which is mounted on the end of a shaft 366 which is journalled in the base of the machine. The shaft 366 may be driven in any suitable manner. Referring to Fig. 7, the main control cam is arranged to transmit its motion to a follower roller 378 on a rock arm 379 which is pivotally mounted on a stud 380. The lower end of the arm 379 is connected by pin 381 with a grooved member 382 on the outer end of the main control valve cam stem 346. A spring 383 interposed between a stud 384 on the arm 379 and a stud 385 on the valve casing serves to hold the follower roller 378 always in engagement with the master or main control cam 365 so that as the cam rotates, the roller will follow the shape of the cam and transmit a corresponding movement to the valve stem 346.

The cam 365 is preferably so shaped that one rotation of the cam moves the main control valve stem 346 through one cycle to operate the various mechanisms of the machine so as to grind one cam and then index the work supporting table to position the next cam in operative relation with the grinding wheel. The table indexing or traversing movement which moves the work supporting table to position the next cam blank in operative relation to the grinding wheel is accomplished by the nose or high point of the cam. On various camshafts, the spacing between the cams varies somewhat and in order to compensate for the varying distance between cams, it is desirable that the noses of the cams be adjustable so that the mechanism may be set for the desired traversing movement of the table without loss of time, as in case a fixed cam were utilized. This is accomplished by providing a secondary cam 386 which is supported on a hub 387 on the cam 365. The cam 386 is connected to the cam member 365 by means of screws 388 which pass through arcuate slots 389 in the cam 386 and are screw threaded into the cam 365. By adjusting the

cam 386 relative to the cam 365, the nose of the cam 386 may be adjusted so that it coincides with the nose 392 of the cam 365 or may be rotated so that it increases the effective length of the nose so that the indexing time between grinding successive cams may be varied as desired.

Mechanical feed of grinding wheel during truing

After the last cam on the shaft has been rough ground, the grinding wheel is moved to an extreme rearward position for truing, that is, with the piston 172 in engagement with the rear end of the cylinder 170 which serves as a stop to limit the rearward movement of the wheel slide as well as to position the grinding wheel for truing. The work table 54 is then reciprocated to traverse the truing tool 306 across the face of the grinding wheel. Before or after this truing movement, it is desirable that the grinding wheel be advanced so that a sufficient amount may be trued off to maintain the wheel face in the same relative position with relation to the mechanisms of the machine. This is preferably accomplished by a pawl and ratchet mechanism, such as shown in Fig. 1. A ratchet wheel 424 is fixedly connected to the hand wheel 167. A pawl 425 is carried by a rock arm 426 which is freely rotatable on the ratchet wheel hub. The lower end of the rock arm 426 is connected to a link 428 by a pin 429. The other end of the link 428 is connected by a pin 430 to a short link 431 which is carried on a stud 432. An arrow point member 433 is fixed on the stud 432 and is engaged by a cam surface 434 on a wheel feeding dog 435. The downward movement of the arrow point 433 rocks the links 431 and 428 and the arm 426 to actuate the pawl 425 and turn ratchet wheel 424 to cause an infeeding movement of the grinding wheel. A stop screw 436 is provided on the arm 426 to limit the movement of the rock arm in a counter-clockwise direction and a spring 437 serves normally to maintain the rock arm 436 in engagement with a fixed abutment 438. The extent of movement of the ratchet pawl 425, and consequently the extent of feeding movement of the grinding wheel may be varied by adjustment of the screw 436.

The machine and mechanism so far described will be found further described in the Letters Patent 2,022,178 hereinbefore referred to. According to the present invention the truing apparatus of the general type hereinbefore disclosed may be used together with the spindle reciprocating mechanism hereinbefore described and a single size of master cams 66 may be utilized and the product camshaft may move on the table parallel to its axis, as is usual. Nevertheless taper cams can be ground retaining all these features.

The cross slide and work head

The machine of the aforesaid Patent 2,022,178 had a massive casting 51 which was both a wheel slide and a wheel head for journalling the spindle 134. As shown in Figures 2, 3 and 6, I split this casting into two parts, viz., the wheel slide 51 and the wheel head 51*a*. The line of division is preferably a horizontal plane, as indicated in these figures. I provide a cylindrical recess 500 in the wheel head 51*a*, in which fits a cylindrical block 501 having a large countersunk bore 502 in the upper part thereof. A conically headed bolt 503 seats in the bore 502 and extends through the wheel slide 51. The bolt 503 has a threaded end 504 upon which are located a pair of nuts 505, a washer 506, and a heavy spring 507. The wheel head 51*a* is thus trunnioned on the slide 51 and lost motion is substantially eliminated. The block 501 may be secured to the wheel head 51*a* by means of screws 510.

Referring now to Figure 2 and also Figure 7, I provide under and attached to the cylinder 146 a valve casing 515. I provide a piston rod 516 which may be attached to the piston rod 148 and is substantially a continuation thereof. A bore 517 extend up the piston rod 516 and is plugged at the lower end by a plug 518. Four integral pistons 520, 521, 522 and 523 are formed on the piston rod 516. There is an opening 524 into the bore 517 between the pistons 521 and 522. There is an opening 525 at the upper side of the piston 520 and an opening 526 at the lower side of the piston 523, both extending into the bore 517. Central chamber 529 is thus connected to end chambers 527 and 528. Chambers 527 and 528 are connected by piping 530 to the main pressure line 200. Chambers 533 and 534, which are on the outside of chamber 529, are connected by piping 535 to the exhaust line 211. Ports 540 and 541 are connected by piping 542 and 543 to the right-hand and left-hand sides, respectively, of a cylinder 545 (see Figure 6). In the cylinder 545 is a piston 546. Both piston and cylinder are of relatively large diameter. The cylinder 545 is rigidly fastened to the back of the wheel head 51*a*. The piston rod 547 is connected to a connecting rod 548 which in turn is connected to a bracket 549 fastened by bolts 550 to the cross slide 51.

When the slow down cam 322 strikes the roller 323, rocking the rock arm 325, turning the shaft 326 and moving the valve stem 328 and the piston 329 to the right, as hereinbefore described admitting fluid to the pipe 335, the piston rod 148, piston 147 and, therefore, also the piston rod 516 are depressed. This occurs whenever dressing of the wheel is about to take place. This opens up the pressure fluid to the pipe 543 leading to the left-hand side of the cylinder 545, moving the cylinder 545 to the left and (relatively) the piston 546 to the right, thus shifting the back of the wheel slide to the left and, therefore, moving the cross slide 51*a* angularly upon the wheel slide 51. Subsequent to the dressing operation the spring 144 moves the piston rod 516 upwardly, admitting fluid to the piping 542 and, therefore, to the right-hand of the cylinder 545, moving the wheel head angularly back to its original position.

I provide a pair of lugs 560 and 561 integral with the back of the wheel head 51*a*, through which extend bolts 562 and 563, the bolt 562 being in a position to engage the bracket 549 and the bolt 563 being in a position to engage a bracket 564 bolted by bolts 565 to the cross slide 51. Adjustment nuts 566 and 567 are provided for adjusting the bolts 562 and 563, the lugs 560 and 561 being internally threaded. These constitute adjustable stops to limit the relative movement of the parts in either direction.

I prefer that the wheel be trued to a truly cylindrical shape and, therefore, adjustments are made so that during truing, the spindle of the grinding wheel is parallel to the axis of the work piece. This produces a truly cylindrical grinding wheel and, therefore, in the subsequent grinding operation, the wheel spindle may reciprocate without any interference. By simply

reversing the pipe connections 542 and 543, I can change the direction of taper upon the product camshafts. For the grinding of automotive camshafts, the desired taper is not great, being of the order of from three to ten minutes of arc. This is so small that no attempt has been made to illustrate the angular displacement of the parts in the elevation drawings.

The angular movement of the wheel head is synchronized with the dressing apparatus so that whenever the wheel is to be dressed, the wheel head is first shifted angularly and before grinding is resumed, the wheel head is shifted back again. By using fluid pressure to shift the wheel head, a powerful force may be exerted which will positively move the wheel head to the desired angular position and maintain accuracy in the grinding and truing operations.

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 various possible embodiments might be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a grinding machine, a carriage mounted on ways, a cross slide mounted on ways to move transverse to the motion of said carriage, a work holder, a grinding wheel head mounted on one of said parts, a spindle in said wheel head, a grinding wheel on said spindle, a dressing device positioned so that movement of the carriage causes relative movement between the dressing device and the grinding wheel, a pivotal mounting for the grinding wheel head perpendicular to the spindle, means to move the carriage for dressing, and means actuated by and in timed relation with said carriage movement automatically to shift the wheel head on the pivotal mounting whereby to grind a plurality of tapers for a given adjustment of the cross slide.

2. In a grinding machine, a base, a work table or carriage mounted on said base for rectilinear movement thereon, a dressing diamond mounted on said table or carriage, a cross slide mounted on said base for rectilinear movement perpendicular to the first named movement, a wheel head mounted on said wheel slide for angular movement, a grinding wheel journalled in said wheel head, and power means actuated in timed relation with said table movement automatically to shift the wheel head angularly whereby to grind a work piece with the wheel head at one angular position and to dress the grinding wheel with the wheel head at another angular position.

3. In a cam grinding machine, a wheel slide, a work table and a rock bar thereon, each of which is operated by a separate fluid motor, a main control valve in control of said motors, a swivel support for said wheel slide, a fluid motor in control thereof, and means including a valve actuated by and in timed relation with said table to control said wheel slide swivel motor.

4. In a cam grinding machine, a rotatable grinding wheel, a transversely movable wheel slide therefor, a longitudinally movable work table, and a rock bar thereon, a swivel support for said wheel slide, each of which is operated by a separate fluid motor, a main control valve in control of said wheel slide and work table and rock bar motors, and means including a control valve actuated by said table to control the wheel slide swivel motor.

5. In a cam grinding machine having a rotatable grinding wheel, a wheel slide therefor, a work table and a rock bar thereon, a swivel support for said wheel slide, each of which is operated by a separate fluid motor, a main control valve in control of the wheel slide and work table and rock bar motors, a slow speed valve, means actuated by said table to operate the slow speed valve to cause a slow traversing movement of said table, and means including a valve which is actuated in timed relation with said slow speed valve automatically to control said swivel motor to position the wheel slide for a truing operation.

6. In a cam grinding machine having a rotatable grinding wheel, a wheel slide therefor, a work able and a rock bar thereon, a swivel support for said wheel slide which is arranged to position said grinding wheel with its axis either parallel to or at an angle relative to said work table, each of which is operated by a separate fluid motor, a main control valve in control of said wheel slide and work table and rock bar motors, a truing tool on said table, and means including a valve actuated by said table automatically to control said swivel motor to position the grinding wheel with its axis parallel to said table for a truing operation and at an angle relative thereto for a grinding operation.

7. In a grinding machine, a work table, a fluid pressure motor for traversing said work table, a cross slide, means for moving said cross slide transversely to the direction of motion of the table, a grinding wheel head, a swivel support for said grinding wheel head on said cross slide, a fluid motor connected to move said grinding wheel head on said swivel support, and means including a valve actuated by and in timed relation with said table to control the angular position of said grinding wheel head on said cross slide and swivel support.

GEORGE CROMPTON, JR.

CERTIFICATE OF CORRECTION.

Patent No. 2,185,837. January 2, 1940.

GEORGE CROMPTON, JR.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 8, second column, line 35, claim 6, for the word "able" read --table--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of October, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)