

Oct. 22, 1935.

A. P. STEINER ET AL

2,017,927

CAM GRINDING MACHINE

Filed Aug. 7, 1929

6 Sheets-Sheet 1

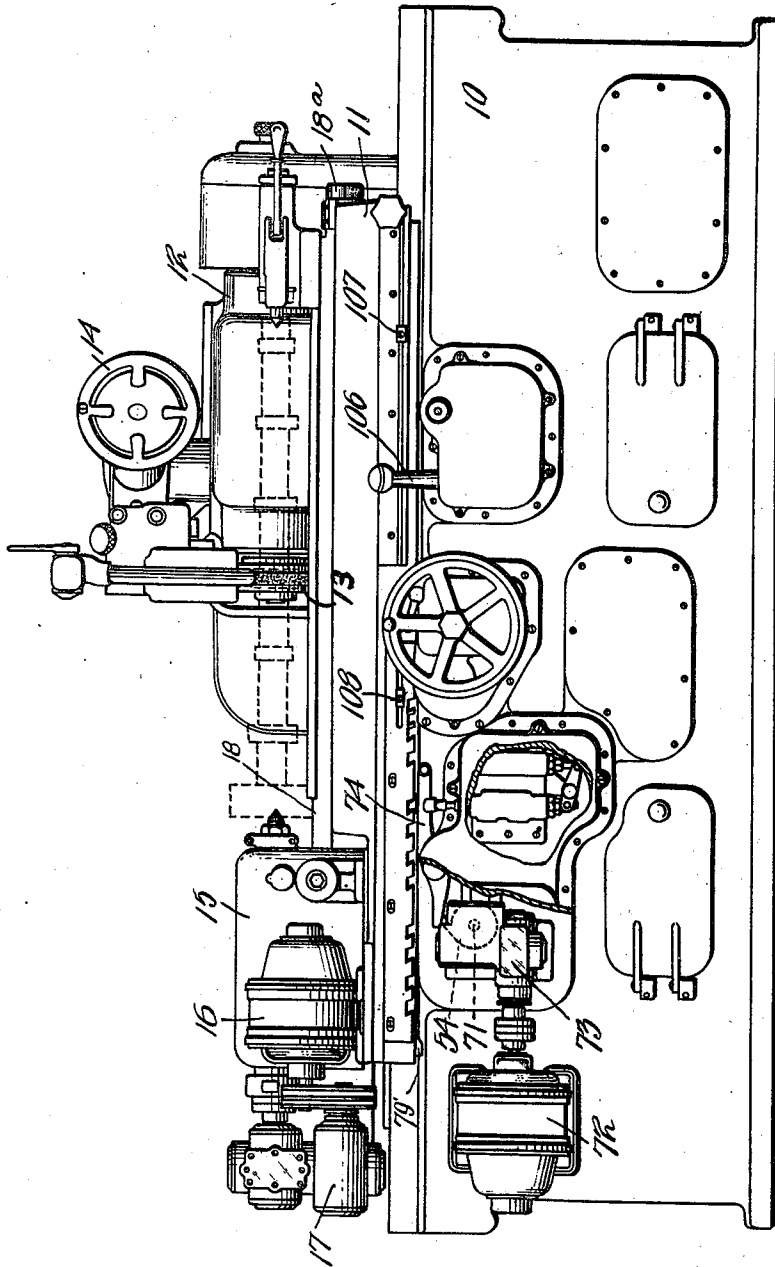


Fig 1

INVENTORS
AMOS P. STEINER
EDGAR P. WINE
CONRAD L. OTT
HAROLD E. BALSIGER
ATTORNEYS.

BY

Amos P. Steiner

Oct. 22, 1935.

A. P. STEINER ET AL

2,017,927

CAM GRINDING MACHINE

Filed Aug. 7, 1929

6 Sheets-Sheet 2

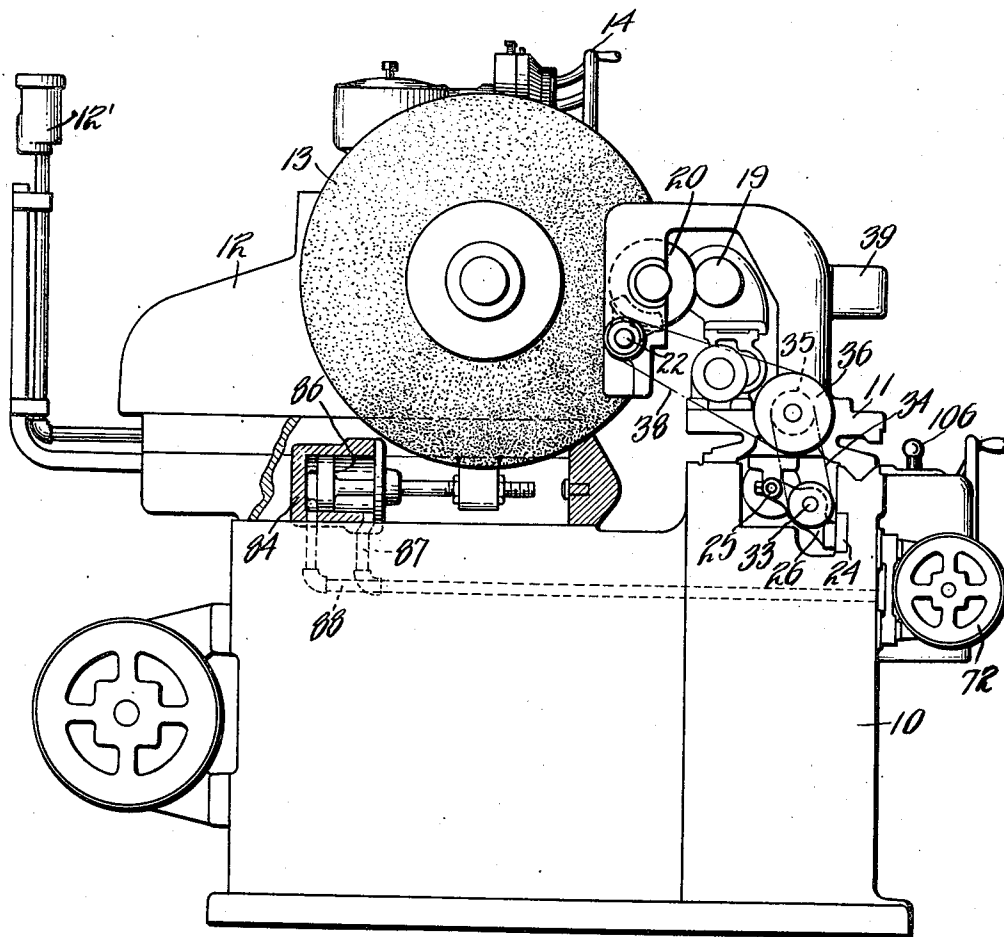


Fig 2

INVENTORS

AMOS P. STEINER

EDGAR P. WINE

CONRAD L. OTT

HAROLD E. BALSIGER

ATTORNEYS.

BY

Harold E. Balsiger

Oct. 22, 1935.

A. P. STEINER ET AL

2,017,927

CAM GRINDING MACHINE

Filed Aug. 7, 1929

6 Sheets-Sheet 3

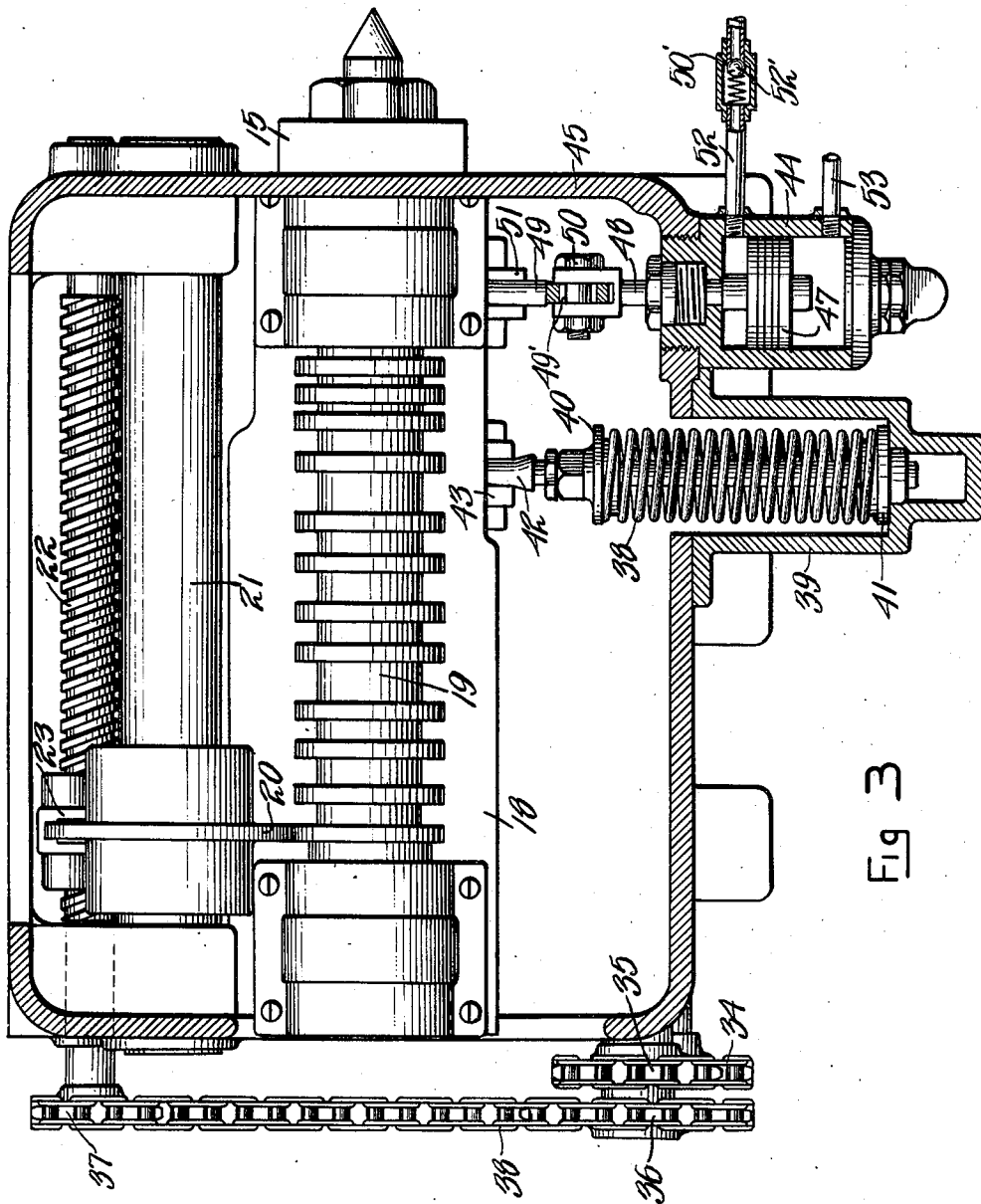


Fig 3

INVENTORS

AMOS P. STEINER

EDGAR P. WINE

CONRAD L. OTT

HAROLD E. BALSIGER

ATTORNEYS.

BY

Edgar P. Wine

Oct. 22, 1935.

A. P. STEINER ET AL

2,017,927

CAM GRINDING MACHINE

Filed Aug. 7, 1929

6 Sheets-Sheet 4

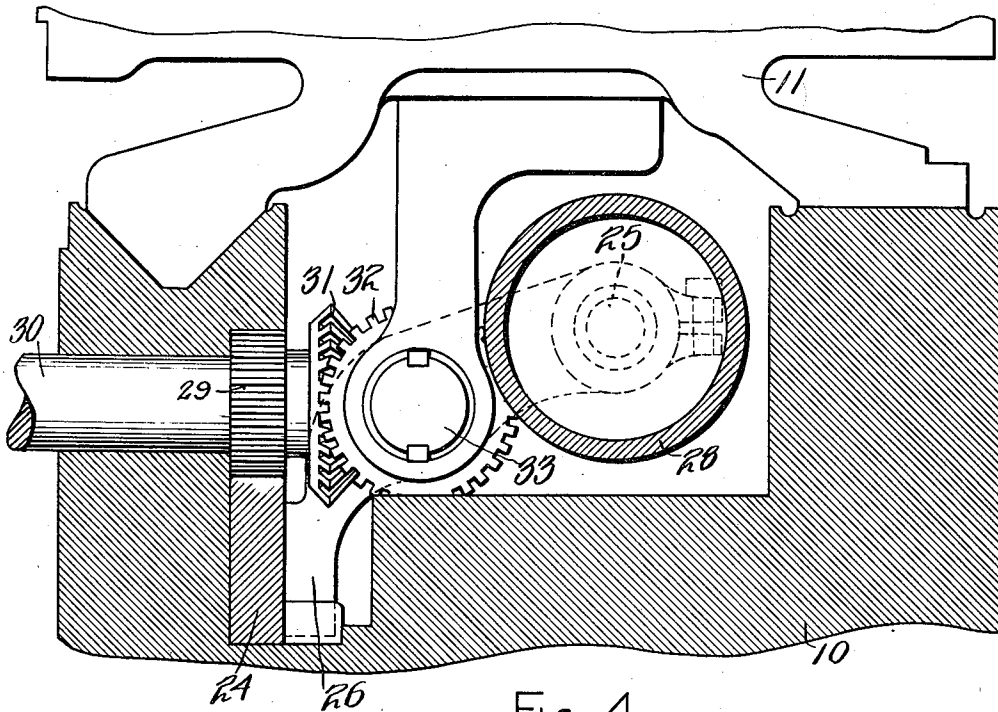


Fig 4

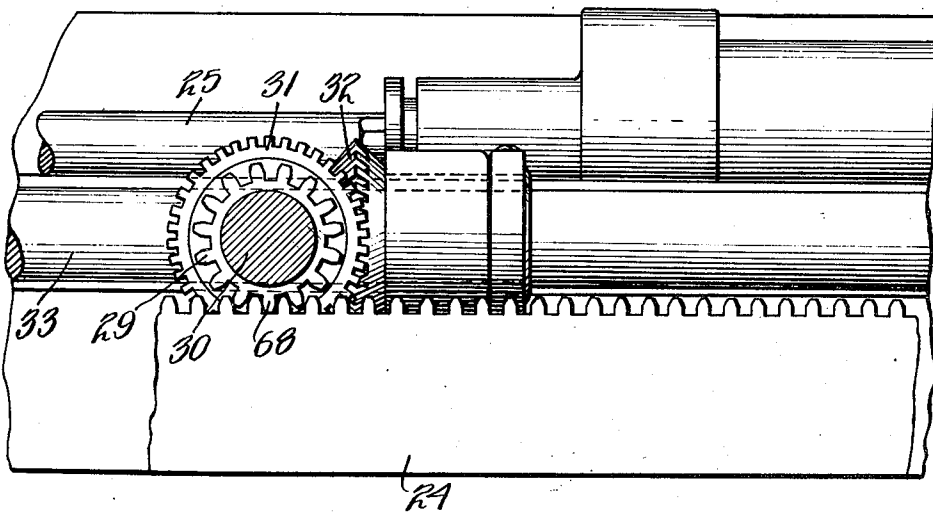


Fig 5

INVENTORS
AMOS P. STEINER
EDGAR P. WINE
BY
CONRAD L. OTT
HAROLD E. BALSIGER
ATTORNEYS.

Edgar P. Wine

Oct. 22, 1935.

A. P. STEINER ET AL

2,017,927

CAM GRINDING MACHINE

Filed Aug. 7, 1929

6 Sheets-Sheet 5

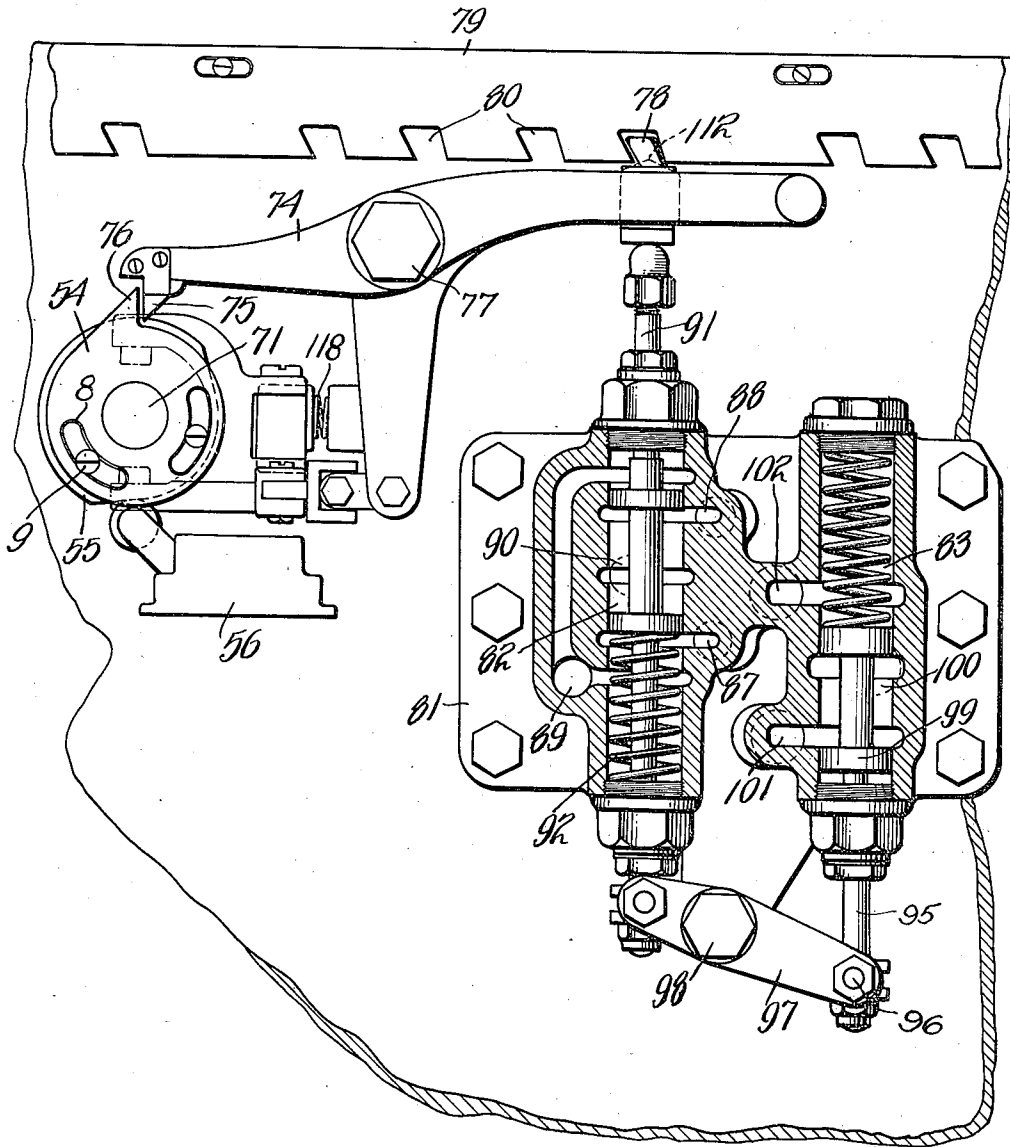


Fig 6

INVENTORS
AMOS P. STEINER
EDGAR P. WINE
CONRAD L. OTT
BY *Edgar P. Wine*
HAROLD E. BALSIGER
ATTORNEYS.

UNITED STATES PATENT OFFICE

2,017,927

CAM GRINDING MACHINE

Amos P. Steiner, Edgar P. Wine, Conrad L. Ott,
and Harold E. Balsiger, Waynesboro, Pa., as-
signors to Landis Tool Company, Waynesboro,
Pa., a corporation of Pennsylvania

Application August 7, 1929, Serial No. 384,068

32 Claims. (Cl. 51—101)

Our invention relates to machines for grinding cam shafts and the prime object of the invention is to provide a machine which will operate automatically to completely grind the cam shaft.

Further objects are to provide new and improved means for indexing the various mechanisms and timing the cycles of operation so as to preserve the synchronism of the mechanisms.

Further objects and advantages will become apparent as the description proceeds.

Referring to the accompanying drawings, which are made a part hereof and on which similar reference characters indicate similar parts,

Figure 1 is a front elevation of the machine,
Figure 2 is an end elevation looking from the left of Figure 1,

Figure 3 is a plan view of the head stock with parts shown in section,

Figure 4 is an end elevation of the driving mechanism for shifting the master cam roller,

Figure 5 is a front elevation of the parts shown in Figure 4,

Figure 6 is a front elevation of the timing cam and the control valve with the latter shown in section,

Figure 7 is a plan view of the timing cam and the control lever,

Figure 8 is a somewhat diagrammatic view of the wiring circuits and fluid conduits by means of which the various mechanisms are hydraulically driven.

In machines for grinding cam shafts as heretofore made the various operations of the machines were controlled by an operator so that it was impossible for one operator to run more than a single machine. With this machine the operator places the work in position in the machine and starts the machine, whereupon the entire cam shaft is ground to size and the machine is automatically stopped when the cam shaft is finished without any further attention on the part of the operator. This enables a single operator to run a number of machines at a considerable saving in expense.

In the drawings reference character 10 indicates the bed of the grinding machine having a work carriage 11, a wheel base 12 in which is mounted a grinding wheel 13. A wheel 14 provides means for manually moving the grinding wheel toward and from the work. The work carriage 11 is provided with a head stock 15. The head stock is driven by a motor 16 through a reduction unit 17. The head stock and tail stock are mounted upon a swinging cradle or rock bar 18 which is suitably pivoted upon the work car-

riage so that the work may have the necessary swinging movement toward and from the grinding wheel to grind the cams. The cradle 18 is pivoted at the right hand end thereof as viewed in Fig. 1 and in Fig. 2, the cradle is shown in end view. Mounted in the head stock 15 is a master cam 19 which is axially aligned with the work, not shown, which work is carried between the head and tail stocks in the usual way. The necessary swinging motion of the work carrying 10 cradle or rock bar is provided by the master cam which is resiliently held against a follower roll 20. The roll 20 is mounted so as to move axially along a shaft 21, its movement being produced by means of a screw 22 and a bifurcated member 23 15 which engages the sides of the cam roller 20 so that rotation of the screw 22 will move the cam follower roll 20 to position it opposite the desired cam on the master cam shaft.

The means for shifting the roller 20 to its positions will now be described: This mechanism consists of a rack 24 slidably mounted in the bed of the machine and attached to a piston rod 25 by means of a bracket 26. The piston rod 25 is connected to a piston 27 in a cylinder 28 25 which piston and cylinder form the motor for reciprocating the work carriage. The rack 24 engages a pinion 29 on a shaft 30 which is mounted in the bed of the machine. The inner end of the shaft 30 carries a bevel gear 31 which 30 meshes with a corresponding bevel gear 32 on a shaft 33. The bevel gear 32 is slidably mounted on the shaft 33 so that the rack 24 and shaft 33 may move with the work carriage 11. The shaft 33 also carries a sprocket which drives a chain 35 34 which forms the driving connection with a sprocket 35. Another sprocket 36 mounted to rotate with sprocket 35 drives a sprocket 37 by means of a sprocket chain 38. Sprocket 37 is mounted on the outer end of the screw 22 by 40 means of which the cam follower roll 20 is moved along the shaft 21. It will be seen from the construction just described that movement of the work carriage 11 to position the work axially of the grinding wheel would also move the cam fol- 45 lower roll to position it opposite the various cams on the master cam shaft. The gearing connection between the rack 24 and screw 22 is such that the cam follower roll is moved through a much shorter distance than the work carriage 50 moves. A spring 38 is mounted in a projection 39 of the head stock cover. This spring is held between two caps 40 and 41 on a pin 42 which is connected to a lug 43 on the swinging cradle 18. The purpose of the spring 38 is to hold the

cam shaft 19 against the cam follower roll 20. A cylinder 44 is also secured to the cover 45 of the head stock. The cylinder 44 carries a piston 47 to which is connected a piston rod 48 which extends without the cover 45. Piston rod 48 is bifurcated to receive a link 49, the piston rod and the link being connected by means of a bolt 50. The end of the link 49 through which the bolt 50 passes is slotted to provide a little lost motion between the link 49 and piston rod 48. The purpose of the slot is to provide lost motion to allow free oscillation of the cradle during grinding operations. The inner end of the link 49 is secured to a lug 51 on the swinging cradle 18. The chambers on the opposite sides of the piston 47 are connected by pressure fluid lines 52 and 53. When pressure fluid is introduced into the cylinder 44 through line 52 the cradle will be withdrawn to separate the master cam from the cam follower roll and also separate the work from the grinding wheel so as to allow the work to be traversed past the grinding wheel. The pipe 52 is provided with a ball check valve 52' around which there is a by-pass passage 50' so that the fluid may freely flow into the cylinder 44 but will have its return flow checked so as to prevent too sudden a return of the master cam shaft against the cam follower roll. This prevents injury to the master cams and to the cam follower roller.

Timing mechanism

The timing mechanism will now be described: This consists primarily of a cam 54 Figure 6 for the hydraulic mechanism and a cam 55 for operating a limit switch 56 which switch is in circuit with the work driving motor. The cam 54 is secured to cam 55 by screws 9 positioned through arcuate slots 8. These slots permit adjustment of cam 54 relative to cam 55 to change the time at which the work drive motor is slowed down. The operation of the limit switch is as follows: The switch 56 controlled by the cam 55 is normally closed. This closes a circuit through lines 57, 58, 59 and coil 60 to energize this coil and close switch at 61; this closes a circuit through the lines 62, 63, 64, resistances 65, line 66, field 67 and line 68. A circuit is also normally closed through line 62, 69, resistance 70, line 66, field 67 and line 68. It will therefore be noticed that when the line 62, 69, etc. operates, the circuit goes through resistance element 70. When the switch 61 is closed current may also pass through a resistance 65 which is in parallel with the resistance 70 when the switch 61 is closed therefore the total resistance between wire 62 and wire 66 is lessened so that a greater amount of current may flow through the field 67. When the switch 61 is open the main motor runs at a certain speed. When the switch 61 is closed the current through the field coil is increased and the motor consequently slows down to a speed suitable for finishing grinding.

The hydraulic mechanism later to be described is controlled by means of cam 54 on a shaft 71. Shaft 71 is driven by a motor 72 through reduction gearing 73. The cam 54 operates a lever 74 on which lever is a cam follower 75 which is engaged by a projection 76 on cam 54. The lever 74 is pivoted at 77 on the bed of the machine. On the end of the lever opposite the cam is an index finger 78 which engages in notches in a spacing bar 79 secured to the work carriage of the machine. The notches 80 in the spacing bar

correspond to the spacing of the cams on the shaft which is to be ground. A valve casing 81 is secured to the front of the base of the machine. This valve casing is bored to receive valves 82 and 83. The valve 82 is a reversing valve which distributes the pressure fluid to the cradle retracting cylinder 44 and also to the wheel base cylinder 84. The valve consists of spaced disks which control valve ports 52 and 53, 87, 88, 89 and 90. A piston rod 91 extends up through the valve casing and is engaged by the end of the lever 74 by which the valve is operated. A spring 92 is positioned beneath the lower disk on the valve and rests at the lower end of the bore which forms the valve body. This spring tending normally to hold the valve disks in elevated position, as shown in Figs. 6 and 8. Pressure fluid is supplied to the valves by means of a pump 93 delivering fluid through a line 90. When the valve 82 is in position shown in Figures 6 and 8 pressure fluid is delivered through the line 90, line 88 to the cylinder 84 to move the wheel base to its forward or grinding position and hold it there. With the valve in the position just described fluid will pass through the line 53 to the cylinder 44 at the rear of the piston 47 to hold the piston in its forward position so that the master cam may be engaged by the cam follower roller during grinding operations. Lost motion is provided by a slot 49' in the link 40, this allows free swinging movement of the cradle without any interference from the piston 47. When the cam 54 has been moved so that the point 76 of the cam raises the point 75 of the lever 74 the opposite end of the lever will be depressed so as to move the valve disks to close the ports 88 and 53 from the pressure line 90 and to open the lines 87 and 52 to pressure line 90. At the same time lines 88 and 53 are connected with the exhaust line 89 so that fluid may now pass from line 90 through line 87 to the forward side of piston 86 to retract the grinding wheel from grinding position and pressure fluid will pass through line 52 to the forward side of piston 47 to retract this piston and to move the master cam from engagement with the cam roller 20 and likewise to move the work to permit the grinding wheel to clear the cams as the work carriage is traversed to move another cam into grinding position. It should be noted that the cam point 76 will rest upon the shoe 75 only for an instant. The lever 74 therefore would tend to drop down and to shift the valve to the position shown in Figures 6 and 8 before the necessary operations of indexing the work could be completed. This would occur but for the fact that the control valve 83 is opened sufficiently just before contact 75 reaches the top of cam 76 to allow the carriage to begin its traverse and so when the cam releases the lever the carriage has moved far enough for the spacing bar 79 to hold the lever 74 down until a new notch comes into position above the finger 78. The spring 92 pressing upon the piston 91 will force the finger 78 into a notch as soon as the work carriage has moved the correct distance to bring a cam opposite the grinding wheel. The work indexing motor is controlled by means of the valve 83. This valve consists of a bore in which a pair of spaced valve disks operate, the disks being connected to a stem 95 which projects out of the casing and is pivotally connected at 96 to a lever 97. The lever 97 is pivoted at 98 to the base of the machine and has one end pivoted to the lower end of the valve stem 91. Movement of the

valve stem 91 therefore, through the pivoted lever mechanism just described will move the valve stem 95 in the opposite direction. This controls the fluid ports as follows: When the valve 99 is in the position shown in Figures 6 and 8 pressure fluid from the pump 93 is delivered through line 100 to the valve chamber and through line 101 to the exhaust line 89. When the valve stem 95 is moved to its uppermost position the valve disks will open communication between pressure line 100 and pressure line 102 to deliver fluid to the reversing valve 103 into either port 104 or 105 depending upon the position of the reversing lever 106. When the reversing lever is to the right of the position shown in Fig. 8 pressure fluid will be delivered through the pipe 104 to the right of the piston 27 to move the work carriage to the left. The reversing lever 106 will be in position to the right of that shown in Figure 8 during the indexing operations on a shaft until the last cam has been ground and the machine has moved far enough to the left for a dog 107 on the work carriage to engage the reversing lever 106 to shift it to the left, but to stop it at the central or neutral position as shown in Figure 8 to stop the carriage. To return the carriage to the right the operator moves the lever 106 to the left at which time pressure fluid from the line 102 will pass through the line 105 to move the work carriage to the right in position for another series of grinding operations on a cam shaft. As the work carriage returns to the right the dog 108 will move the reversing lever 106 to its position as shown in Figure 8 to stop further movement of the work carriage. When the valve is in the position shown in Figure 8 both sides of the cylinder are open to fluid lines 104 and 105 and hence to exhaust fluid line 109 so that the carriage is stopped and held in stationary position even though pressure fluid might be admitted to fluid line 102.

As best shown in Figure 7 there is provided a clutch throw-out mechanism consisting of a bent lever 110 pivoted at 111. At the upper end of this lever is an inverted V-shaped cam block 112 which is engageable by either of two cams, one at each end of the spacing bar 79. Only one cam 79' is shown. The opposite end of the lever acts through a pair of links 113 and 114 to rotate an arm 115 which is pivoted at 116. The opposite end of the arm 115 has a bifurcation to engage a spool 119 to shift a clutch 117 to stop rotation of the timing cam 54 and cam 55. A spring 118 acts normally to hold the lever to keep the two parts of the clutch engaged.

The operation of the machine is as follows: Assuming that all parts of the machine are in a position to start grinding, i. e. the master cam 19 and cam follower shoe 20 are engaged, the wheel base 12 is in rear position and work carriage 11 is at the right extreme of its travel. The operator places a cam shaft in the machine, the lever 74 is depressed because finger 78 is engaging the lower side of the space bar 79 rather than one of the notches 80, the cam 79' on the spacing bar 79 is also engaged in holding the lever 110 depressed to hold the clutch 117 in inoperative position. To start the machine the reversing lever 106 is thrown to the right causing pressure fluid to enter the right hand end of the cylinder 28 and to move the piston 27 and carriage 11 to the left. As soon as the cam block 79' passes over the block 112 it releases the lever 110, the clutch 117 is engaged and timing cams 54 and 55 begin to rotate. The carriage con-

tinues to move to the left until finger 78 enters the first notch 80. This allows the valves to return to normal position in which pressure fluid passes to cylinder 44 to cause master cam 19 and roller 20 to become engaged and fluid also passes to the cylinder 84 to move the wheel base 12 to grinding position. The valve 99 drops to normal or lowermost position and at the same time bypasses pressure fluid to the reservoir instead of through the transverse cylinder. This stops the carriage in position to grind the first cam. During the first part of the grinding operation cam 55 holds the switch 56 in open position. In this position automatic switch 61 is open and circuit through 63 and 64 is broken causing current to pass through 62 and 69 and the resistance 70. This gives a small amount of current through the motor field and thus causes the motor to operate at high speed. As soon as the roller begins to ride the low part of cam 55 the switch 56 is closed, automatic switch 61 is closed and current passes through both resistances 65 and 70 in parallel, allowing a greater amount of current to enter the field 67 and thus reduce the speed of the motor 17. After grinding at a slow speed for a predetermined time cam 54 lifts the lever 74, releases the carriage by withdrawing finger 78 from the notch 80 in the spacing bar 79, shifts the valves to again separate the master cam and cam roller, withdraws grinding wheel and traverses the work carriage to the next cam. Then through roller shifting mechanism previously described roller 20 is shifted to position to engage the master cam corresponding to the cam to be ground. After the last cam has been ground the carriage moves until the dog 107 engages the reversing lever 106 and shifts it to the central position, as shown in Figure 8, thus stopping movement of the carriage.

It will be obvious to those skilled in the art that various changes may be made in our device without departing from the spirit of the invention, and we, therefore, do not limit ourselves to what is shown in the drawings and described in the specification, but only as set forth in the appended claims.

Having thus fully described our said invention, what we claim as new and desire to secure by Letters Patent, is:

1. A machine for grinding cam shafts comprising a base, a work carriage, a grinding wheel, a cradle swingably mounted on the work carriage, a master cam mounted on said cradle, a cam follower roll adapted to engage the master cam to swing the cradle, a motor for indexing the work carriage past the grinding wheel, and means operated by said motor for shifting the cam follower shoe to position it adjacent a cam on the master cam shaft corresponding to cams on a work piece which is being operated on by the grinding wheel and a motor operable independently of any moving parts on the machine for timing indexing of the work carriage, substantially as set forth.

2. In an automatic cam grinding machine having a work carriage, a wheel support and a work cradle, a fluid motor for operating said work carriage and said wheel support, a timing and indexing mechanism comprising a timing cam, a motor operable independently of other mechanism on the machine for driving said cam, a lever operated by said cam, valves operable by said lever to operate the work carriage, work cradle and wheel support, a notched spacing bar on the work carriage, a finger on said lever adapted to

enter said notches, and means whereby said finger may enter said notches without interference to stop the work carriage in grinding position, substantially as set forth.

3. In an automatic cam grinding machine having a grinding wheel support and a grinding wheel mounted thereon, a work cradle and a work carriage, pressure fluid means for operating the work carriage, wheel support and the work cradle, a valve in control of said pressure fluid means, a timing cam for controlling the operation of said valve, means operable independently of other mechanism on the machine for driving said cam and automatic means to disconnect said cam and said driving means at a predetermined point in the operation of the machine, substantially as set forth.

4. In a cam grinding machine, a work carriage, a grinding wheel, a work cradle pivoted on said carriage, a motor driven timing cam, a motor driven independently of other mechanism on the machine for operating said cam and means operated by said timing cam to cause withdrawal of the wheel base and work cradle to inoperative position, substantially as set forth.

5. In a cam grinding machine having a base, a work carriage, a grinding wheel, a work cradle pivoted on said carriage, a timing cam, a motor driven independently of the mechanism on the machine for operating said cam, means operated by said timing cam to cause withdrawal of the wheel and work cradle to inoperative position the same means acting to cause a return of said wheel and said cradle to operative position, substantially as set forth.

6. An automatic cam grinding machine comprising a wheel base, a grinding wheel mounted thereon, a work carriage, a cradle pivotally mounted on said carriage, power means to operate said wheel base, carriage and cradle and a timing and indexing mechanism for controlling the operation of said power means, carriage and cradle, and a motor operable independently of other mechanism on the machine for operating said timing mechanism, substantially as set forth.

7. In a cam grinding machine, a bed, a wheel base, a work carriage, a fluid motor for moving said work carriage transversely of said wheel base, a work supporting cradle pivotally mounted on said carriage, a spacing bar mounted on said carriage, a rotatable timing cam, means for locking the spacing bar in one of several predetermined positions, a valve in control of the carriage traverse motor and a lever actuated by the said cam for releasing the locking means and for operating the said valve to control movement of the wheel base and the work carriage, a motor operable independently of other mechanism on the machine for operating said cam, said spacing bar operating to hold said lever in depressed position until said carriage has moved the work to another grinding position.

8. In a cam grinding machine having a traverse carriage, a motor for traversing said carriage, a bar for locking said carriage in successive predetermined positions, locking means movable into and out of engagement with said bar, means for timing the operation of said locking means, and means operated by a movement of the locking means to release the bar for causing the operation of the traversing motor for moving the carriage.

9. An automatic cam grinding machine having a work carriage index and control mechanism comprising a spacing bar on said carriage, means engaging said spacing bar and adapted to locate

said carriage accurately in several grinding positions, means to withdraw said locating means from said bar at predetermined intervals, and means actuated on withdrawal of said locating means to actuate said carriage, substantially as set forth.

10. An automatic cam grinding machine comprising a traversable work carriage, an oscillating work cradle on said carriage, a grinding wheel, a wheel support, means to provide relative traverse and longitudinal movement between said carriage and said support, a spacing bar on said carriage having portions corresponding to several parts of a work piece, means engaging said spacing bar and adapted to cooperate with said portions, and means actuated on withdrawal of said engaging means to actuate said carriage and to withdraw said wheel support and rock said work cradle to inoperative position, substantially as set forth.

11. An automatic cam grinding machine having a work support, index mechanism for said support, a grinding wheel, a support for said wheel, mechanism to move one of said supports transversely of the other, mechanism to move the other support longitudinally of the first-named support, and means whereby the movements of said supports are controlled by said indexing mechanism.

12. An automatic cam grinding machine having a work support, a wheel support, power means to move said supports relative to each other transversely, and power means to move said supports relative to each other longitudinally, and means to effect said movements at predetermined intervals including a spacing bar mounted one of said supports, and control mechanism cooperating with said spacing bar and controlling the power means imparting longitudinal movement to said supports to stop said longitudinal movement, said control mechanism operating at the same time to cause said transverse movement to bring the wheel and work into grinding contact.

13. An automatic cam grinding machine having a work carriage index and control mechanism comprising a spacing bar on said carriage, means engaging said spacing bar and adapted to locate said carriage accurately in several grinding positions, means to withdraw said locating means from said bar at predetermined intervals, and means actuated on withdrawal of said locating means to actuate said carriage and means actuated on withdrawal of said locating means to move said wheel support to inoperative position, substantially as set forth.

14. An automatic cam grinding machine having a work support, a wheel support, power means to move said supports, means to provide relative transverse and longitudinal movement of said supports at predetermined intervals comprising a spacing bar mounted on one of said supports, an element in control of said power means adapted to cooperate with said spacing bar to stop said longitudinal movement, said element acting also to permit movement of the said wheel support into grinding position, and means actuated on withdrawal of said element to move said wheel support to inoperative position, substantially as set forth.

15. An automatic grinding machine having a work support and a wheel support, power means to provide relative transverse and longitudinal movement between said supports, a spacing bar on one of said supports, notches on said spacing bar, a finger adapted to engage said notches to locate various portions of a work piece in grinding position, means operating with said finger to actu-

ate said power means, and a timing mechanism to actuate said finger, substantially as set forth.

16. An automatic grinding machine having a work support and a wheel support, power means to provide relative transverse and longitudinal movement of said supports, a spacing bar on one of said supports, a finger adapted to engage said spacing bar, control means for said power means adapted to be actuated synchronously with said finger, means to actuate said finger at predetermined intervals to permit movement of said work support, said means acting also to cause movement of said support, substantially as set forth.

17. An automatic grinding machine having a power driven work support and wheel support, control mechanism for said supports comprising a spacing bar on one of said supports, means adapted to cooperate with said spacing bar to locate the support accurately in successive grinding positions, means to withdraw said locating means from said bar at predetermined intervals, means actuated on withdrawal of said locating means to actuate said support, and means to hold said locating means in withdrawn position until said support has moved to the next grinding position, substantially as set forth.

18. An automatic grinding machine having power driven work support and wheel support, indexing and control mechanism for said supports comprising a spacing bar on one of said supports, means adapted to cooperate with said spacing bar to locate the support accurately in successive grinding positions and to cause said other support to move toward and away from said first support, means to withdraw said locating means from said bar at predetermined intervals, means actuated on withdrawal of said locating means to move one of said supports to inoperative position and the other to the next grinding position, means whereby said locating means may return to normal position relative to said spacing bar, and means actuated by said locating means in normal position to stop said part in grinding position and to return said other part to operative position, substantially as set forth.

19. A machine for grinding cam shafts comprising a bed, a work carriage and a wheel base mounted thereon, a grinding wheel rotatably mounted on the wheel base, a work support movably mounted upon the work carriage, a master cam mounted on said work support, a cam follower roll engageable by the master cam, a motor for moving the work carriage relative to the grinding wheel, means for indexing the work carriage to lock it in predetermined positions with respect to the grinding wheel, means operated by movement of the said work carriage for shifting the cam follower roll axially of the master cam and a motor operated independently of the carriage drive motor for timing indexing of the said carriage, substantially as set forth.

20. In a grinding machine, a work carriage, power means for driving said carriage, means automatically operable to start and stop said power means at intervals comprising means to time the movement of the carriage, means to positively lock the carriage in grinding position, and means actuated by said timing means to unlock said carriage and cause said power means to move it to the next position, substantially as set forth.

21. In a grinding machine, a work carriage, a wheel carriage, power means to drive said work

carriage, means automatically operable to start and stop said power means at intervals comprising means to time the movement of the work carriage, means for locking the carriage in grinding position, means actuated by said timing means for unlocking said carriage and permit it to be moved by said power means to the next position, and means controlled by movement of the work carriage for stopping said timing means, substantially as set forth.

22. In a machine for grinding selected portions of a work piece, a wheel base, work carriage and work cradle, means to provide intermittent relative longitudinal and transverse movements of said parts, comprising a spacing bar, mechanism adapted to cooperate with said spacing bar to control the movement of the work carriage, wheel base and work cradle, means actuated by said mechanism in normal position to prevent movement of the work carriage, and to cause said wheel base and work cradle to move to operative position, and means on said spacing bar to hold said mechanism out of normal position after the last portion of the work piece has been ground, substantially as set forth.

23. In a cam grinding machine having a work carriage and a motor for operating said work carriage, a valve in control of said motor, means for locking the work carriage in any one of several predetermined positions, a timing cam for releasing said locking means, a work drive motor, means for slowing down said work drive motor at a predetermined time, operative connection between said timing cam and said speed change mechanism, and means for varying the point at which the change in speed of the work rotating motor occurs, substantially as set forth.

24. In a cam grinding machine of the kind described, a work drive motor, a cam for timing the indexing of a work carriage, means operably connected to said timing means for changing from high speed to low speed work drive, and means for changing the relative duration of fast and slow speed operation of the work drive motor, substantially as set forth.

25. A hydraulically operated cam grinding machine comprising a rotatable grinding wheel, a traversable table, a rock bar thereon rotatably supporting a camshaft in operative relation to the wheel, means including a set of master cams and a follower to rock the bar and determine the cam contour during the grinding operation, a fluid pressure operated mechanism to traverse the table in either direction, a fluid pressure operated mechanism to rock said bar and move the camshaft to an inoperative position, means including a fluid pressure operated mechanism to move the wheel towards and from the work to grind the cams thereon, a fluid pressure system including a valve mechanism connected to each of said fluid pressure operated mechanisms and operating to admit fluid successively thereto whereby to traverse the table and position the cam opposite the wheel, then to move the wheel and grind the cam, and thereafter to lock the bar and move the cam away from the wheel, and a main control cam for actuating said valve mechanism to control the cycle of operations.

26. A hydraulically driven automatic cam grinding machine of the type covered by claim 25 comprising a drive shaft to rotate the main control cam and a clutch arranged to connect said cam with the drive shaft at the start of the grinding cycle and to disconnect it there-

from at the end of the cycle after the camshaft has been ground.

27. A hydraulically driven automatic camshaft grinding machine of the type covered by claim 25 comprising a clutch to rotate the main control cam, and means actuated by the traversing movement of the table to connect said clutch at the start of the cycle and to disconnect it at the end of the cycle of operation.

28. A hydraulically driven cam grinding machine comprising a rotatable grinding wheel, a transversely movable slide therefor, fluid pressure means to move said slide, a longitudinally movable work supporting table, fluid pressure means to traverse said table, a rock bar pivotally mounted on said table and arranged to support a camshaft for movement toward and from the grinding wheel, fluid pressure mechanism to rock said bar to an inoperative position so as to separate the grinding wheel and the camshaft during the traversing movement, a main control valve mechanism arranged to admit fluid successively to said fluid pressure mechanisms, a rotatable control cam which is arranged to actuate said valve mechanism to control the cycle of operation, and a clutch arranged to automatically connect said cam with the drive shaft at the start of the grinding cycle and to disconnect it therefrom at the end of the cycle after the camshaft has been ground.

29. A hydraulically driven automatic camshaft grinding machine of the type covered by claim 25 comprising a clutch to rotate the main control cam, and means including a dog mechanism on the table arranged to connect said clutch at the start of the cycle, to disconnect the clutch during the truing operation and at the end of the grinding cycle.

30. In a grinding machine the combination with a work table having work supporting means thereon, a grinding wheel, a spacing bar fixed

to said work table and having seats therein, locking means engageable with said seats for stopping the table and holding it in fixed position, means controlled by the machine for releasing said locking means, a fluid motor for operating said table, and means operable upon a release of said locking means for controlling pressure fluid to said motor.

31. In a machine of the kind described, a work support, means to mount a work piece rotatably thereon, a wheel support, mechanism to effect relative transverse movement of said supports, mechanism to effect relative longitudinal movement of said supports intermittently to bring the grinding wheel into grinding relation with different portions of the work piece, means for rotating said work, and a control means therefor for rotating the work at a roughening speed and automatically changing the speed of rotation to a finishing speed during the grinding of each portion.

32. In a machine of the kind described, a work support, means to mount a work piece rotatably thereon, a wheel support, mechanism to effect relative transverse movement of said supports, mechanism to effect relative longitudinal movement of said supports, a timing mechanism for intermittently effecting longitudinal movement of said supports to bring said wheel and a series of portions of the work piece into operative grinding relation, means for rotating said work, and a control means operated by said timing mechanism for rotating the work at a roughening speed and automatically changing the speed of rotation to a finishing speed during the grinding of each portion.

CONRAD L. OTT.
AMOS P. STEINER.
HAROLD E. BALSIGER.
EDGAR P. WINE.