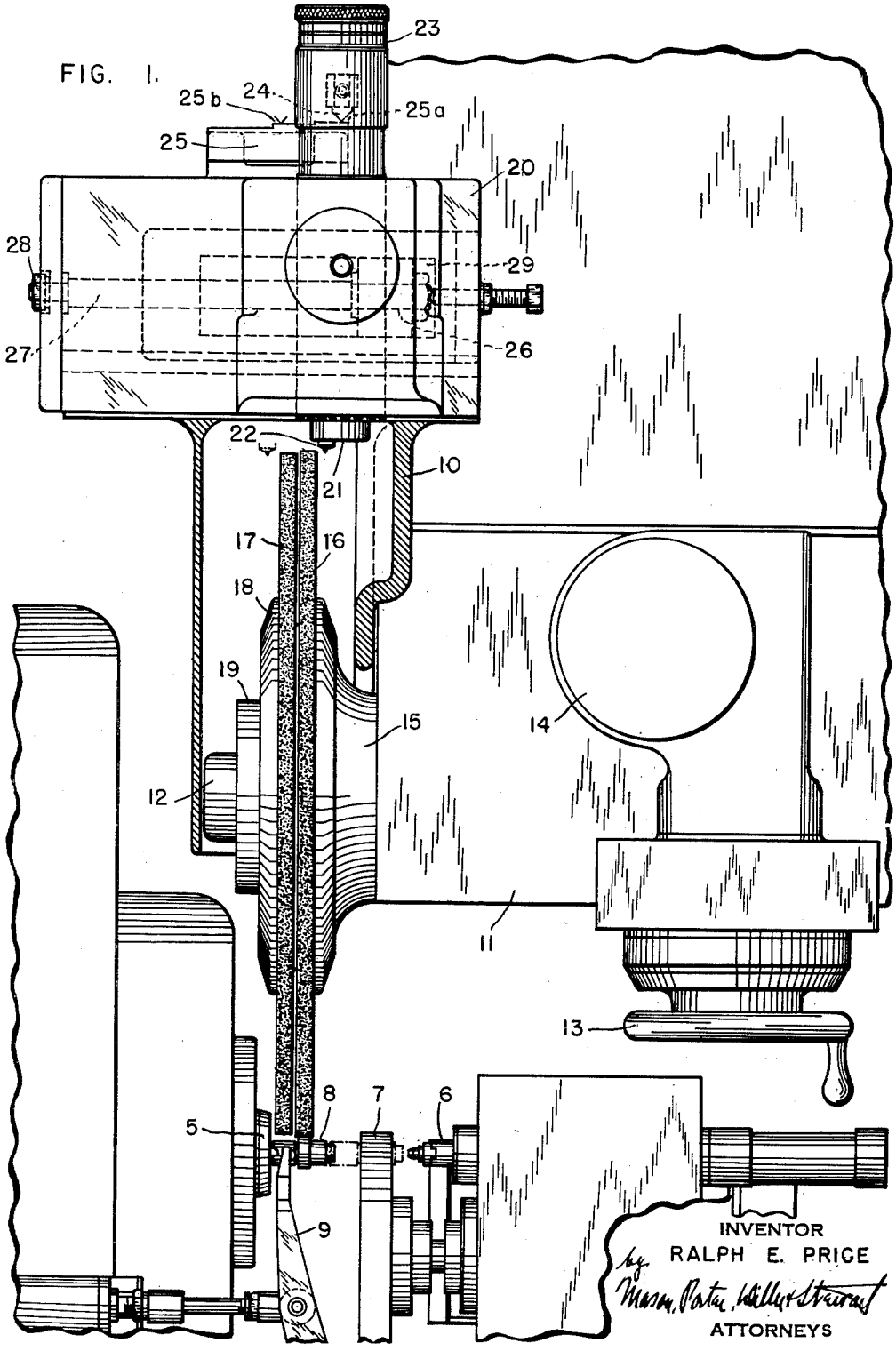
Feb. 6, 1962 R. E. PRICE 3,019,562

GRINDING MACHINE WITH DUAL PURPOSE GRINDING WHEELS

Filed Dec. 3, 1959 2 Sheets-Sheet 1

FIG. 1.



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2 Sheets-Sheet 2

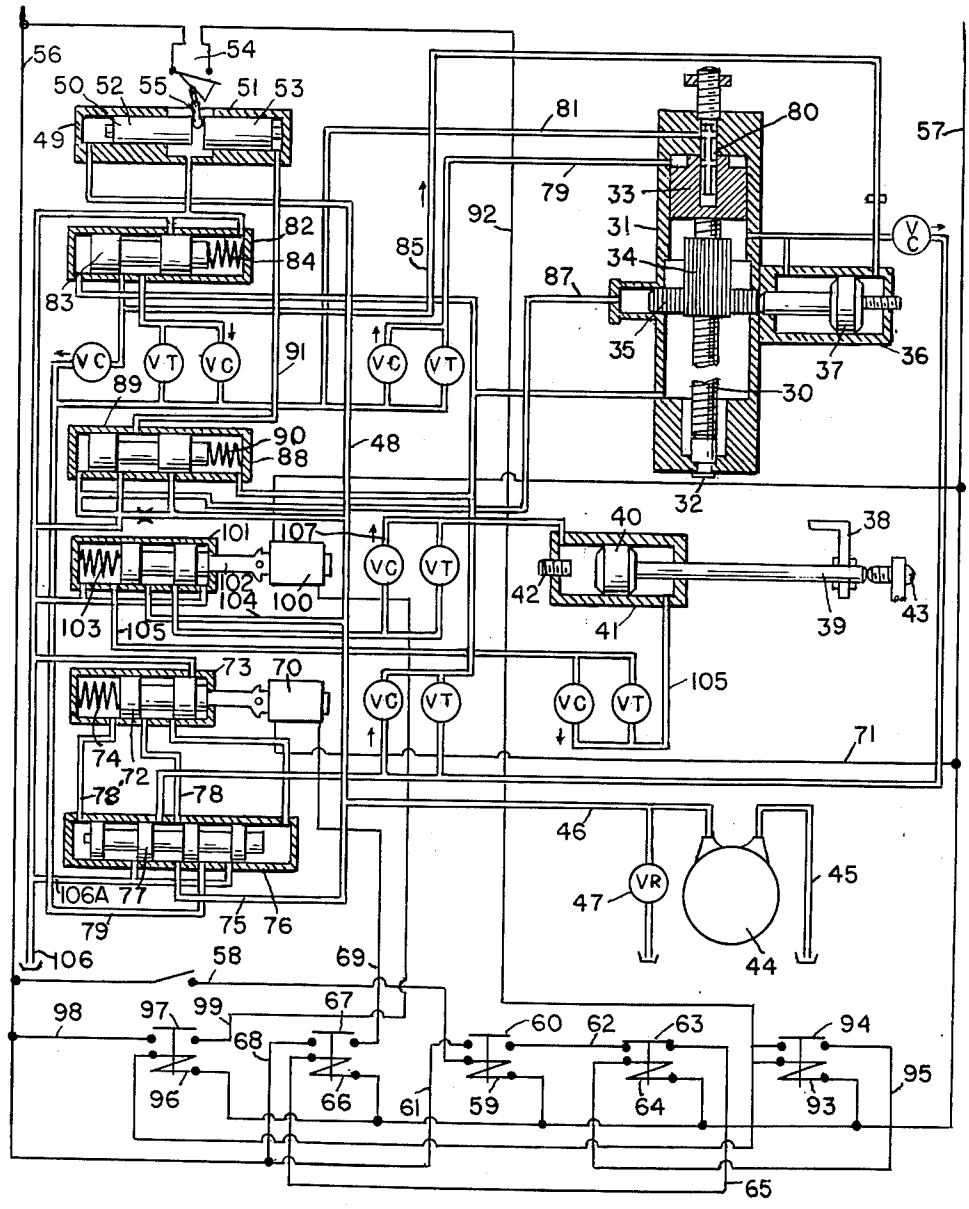


FIG. 2.

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GRINDING MACHINE WITH DUAL PURPOSE GRINDING WHEELS

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The following specification relates to an invention in grinding machines for cams and the like having dual grinding wheels. More particularly, the invention resides in effecting a coarse plunge grinding followed by a fine finish grinding of the workpiece by separate successive operations particularly adapted to the results sought.

It is the usual practice in the rotary grinding of small workpieces to follow a coarse preliminary grinding step with a fine grinding or finishing steps. Both steps are accomplished by successive advance or infeeding of a grinding wheel. In each step, the wheel is given an advance against the work. The actual grinding must of course be varied to accomplish the two different results.

The present invention is based upon following a plunge grinding in which the coarse grinding wheel is fed in toward the workpiece with a finish grinding by means of a second wheel which is caused to traverse the workpiece without any further feeding of the grinding wheel inwardly.

A still further object of the invention is to provide timed retraction of both grinding wheels and reversal of the traverse movement to reset them for the next grinding cycle.

The above and other objects of the invention will be evident from the following description of the preferred form of the invention as illustrated by way of example on the accompanying drawings in which:

FIGURE 1 is a plan view of the improved grinding machine and

FIGURE 2 is a diagrammatic representation of the operating features thereof.

Briefly stated, the invention consists in the arrangement on a single rotary shaft, of two grinding wheels for successive operation on a rotated workpiece. The grinding wheel of lesser diameter is of coarser abrasive. It is advanced against the rotated workpiece by a plunging operation until brought to a stop at the conclusion of the removal of the greater part of the excess metal. No further advance is given the wheels. The finish grinding is accomplished by a traversing movement. This brings the grinding wheel of greater diameter axially against the workpiece, so that the latter is given its final grinding to size and finished surface by means of the finer abrasive in the second wheel. Since there is no advance of the wheel against the workpiece in the finish operation, this operation terminates in a sparkout dwell at the termination of the lateral traverse of the larger wheel. Thereafter the wheels are both retracted from the workpiece and traversed to bring the coarser grinding wheel of lesser diameter in position for the next grinding cycle.

As need arises, the two grinding wheels are dressed by a single dressing tool moved across the face of the wheels successively and adjusted to restore the initial difference in radii of the two wheels.

FIGURE 1 illustrates the rotary grinding machine having the usual headstock 5. Opposite this is the footstock 6. A carrier 7, or loader for the workpieces, moves transversely into and out of position between the headstock and the footstock. The workpiece 8 is delivered from the carrier to a central position on the chuck of the headstock 5.

At the conclusion of the two-stage grinding operation, the workpiece is ejected by a fluid-operated ejector 9.

A grinding wheel base 10 is located opposite the footstock 6 and carries a grinding wheel slide 11, adapted for longitudinal or infeeding toward the work.

A grinding wheel shaft 12 is revolubly mounted in the slide 11 and driven by a motor of the usual type, not illustrated.

The slide can be advanced or adjusted in its approach to the work by means of a handwheel 13 operating through a vertical feed shaft, located within the housing 14 as shown in U.S. Patent No. 2,313,479. The wheel slide is advanced during the plunge-grinding operation by the usual means, not illustrated. The adjustment through the handwheel is effective to compensate for necessary wear of the grinding wheels. The shaft 12 carries an inner hub 15 against which a fine grinding wheel 16 is held.

A second smaller grinding wheel 17 of relatively coarser abrasive is held against the wheel 16 by means of an outer hub 18. The hubs 15 and 18 together with the grinding wheels 16 and 17 are clamped firmly in position on the shaft 12 by means of a nut or collar 19. In the simplest form the wheels 16 and 17 of different grit may be cemented together to provide, in effect, a single wheel. However it is preferred to assemble them on the shaft 12 with a thin intervening spacing disk, not shown, of metal or fibrous material.

A dresser slide 20 is mounted on the base 10 for lateral or traversing movement. It has a dresser bar 21 with a dressing tool 22 projecting from the front. The bar and tool can be adjusted longitudinally of its bearing by an adjusting knob 23.

The bar 21 carries an index point 24 which travels over a profile bar 25. This bar has a stepped rear face 25*a*, 25*b*, which maintains the desired difference in position called for by the desired different diameters of the two wheels 16 and 17.

The dresser slide 20 is caused to traverse the grinding wheels by operation of a piston 26 having a piston rod 27 anchored at 28 to the base 10. Fluid pressure within the cylinder 29 surrounding the piston 26 will cause the diamond tool 22 to follow the desired path across the edges of the grinding wheels, and thus restore their surfaces and relative positions.

The wheel slide 11 is given a rapid forward feeding movement of coarse grinding by means of the feed screw 30 shown on FIGURE 2 and operating in well known manner through the vertical feed shaft. The feed screw is carried as a piston rod in a piston cylinder 31. One end of the cylinder 31 carries a positive stop 32 limiting the advance movement of the feed screw 30. The head 33 of the piston is slidably fitted in the opposite end of the cylinder.

The feed screw has a gear 34 with extended teeth.

Transversely of the gear 34 and in engagement with it, is a piston rod 35 with rack teeth formed on a portion of said rod. This piston rod extends transversely of the cylinder 31 and projects into a cylinder 36, where it carries a piston head 37.

By movement of the piston head 37, the piston rod 35 will cause the gear 34 to rotate and thus give a slow rotation to the feed screw 30. In this way the rapid feed carried out by the piston 33 can be followed by a slow feed through the piston rod 35 and gear 34.

In this manner the wheel slide 11 is caused to advance inwardly with the grinding wheel 17 in position opposite the workpiece 8. As the wheel advances, it is brought to its limit of movement by engagement of the rapid feed piston rod 30 with the fixed stop 32. This represents the maximum pre-set advance of the wheel 17 for coarse plunge grinding. The final operation of the rapid feed screw is of course dependent upon the extent of travel of the slow feed rack 35.

The subsequent finish grinding by means of the grinding wheel 16 with its finer abrasive, is a traverse of the wheel slide 11 to cause the grinding wheel 17 to clear the workpiece, and the larger wheel 16 to traverse the workpiece. This is accomplished by providing a depending bracket 38 on the slide 11. This slide is clamped to a piston rod 39. The piston head 40 travels in a cylinder 41. The extent of travel is limited by the stop 42 in the inner end of the cylinder 41 and a fixed stop 43 on the base. When the piston head 40 engages the stop 42, the grinding wheel 16 will be opposite the workpiece 8, as shown in FIGURE 1. In this limiting position the wheel 16 will rotate for a short period to provide a spark-out during which there will be no infeeding or traverse of the wheel.

The movements of the pistons 33, 37 and 40 are produced by fluid pressure supplied from a pump 44. This pump is operated by a motor not shown. The pump has intake 45 and a pressure discharge 46. A relief valve 47 is provided in the discharge pipe 46.

Operation of the grinding wheels is contingent upon the development of pressure in pipe 46. This is accomplished by delivery from the pressure pipe 46 to a manifold 48 which runs to a piston cylinder 49. The piston cylinder is double-ended, with a small cylinder 50 on the left and a larger cylinder 51 on the right.

Cylinder 50 carries a free piston 52, while a second free piston 53 of larger diameter is carried in the large cylinder 51.

An operating switch 54 is provided with an arm 55 extending into the paths of the pistons 52 and 53. By means of the switch 54, current from the main feed lines 56, 57, is led to clutch relay 93 and control relay 96.

As long as fluid pressure is delivered by the pump 44, the free piston 52 will be held in its right-hand position, as shown in FIGURE 2, subject only to a greater pressure that may at certain times be exerted in the opposite direction by the free piston 53.

With the circuit open through operating switch 54, it is then possible to initiate the feeding movements for the grinding wheels.

These movements are put in operation by means of a starting switch 58 leading from the main feed line 56.

This completes the circuit through the coil of relay 59. The contact 60 of the relay closes the circuit between branch 61 of line 56 through conductor 62 and normally closed contact 63 of a timer relay 64. Current through the closed contact passes by conductor 65 to the coil of relay 66. This closes contact 67 of relay 66. Current is thus drawn from branch 68 of line conductor 56 and delivered by line 69 to the coil of the solenoid 70. This circuit is completed through line 71 to main feed line 57.

Solenoid 70 is connected by a link to a piston valve 72 in cylinder 73. Piston valve 72 is urged to the right and toward solenoid 70 by means of a spring 74 in the left side of the cylinder 73.

Fluid pressure through branch 75 of manifold 48 is directed to a cylinder 76. A spool valve 77 is freely movable in the cylinder 76. Pressure from the valve between the two inner ribs is directed through the cylinder 76 by means of pipe 78 to a mid-point in cylinder 73. Since the piston valve 72 is held in its left position when solenoid 70 is energized, this pressure is then directed by pipe 78' to the left end of cylinder 76. This causes the spool valve 77 to move to the right, uncovering pipe 79 leading to the head end of cylinder 31 to effect a rapid advance of the piston 33 and the grinding wheel toward grinding position. The rapid feed movement is stopped by engagement of the feed screw 30 with the stop 32.

Cylinder 82 has a spool valve 83 held normally to the left by means of a spring 84. During the rapid feed movement of piston 33, exhaust fluid from the rod end of cylinder 31 is directed against the left end of valve 83 to hold said valve to the right. In this position, fluid from line 79 is prevented from passing through line 85 to the head end of slow feed cylinder 36. When piston 33 stops in forward position, exhaust pressure drops and spring 84 shifts valve 83 to the left. In this position fluid pressure from the pipe 79 passes through the center opening of the spool valve 83 and thence by means of pipe 85 to the head end of the slow feed cylinder 36. This causes the piston 37 to move to the left and rotate the feed screw 30, advancing the smaller coarse grinding wheel 17 against the work.

When the slow feed piston rod 35 reaches the end of its stroke, it shuts off the discharge of fluid under pressure through the slow feed jet.

The left end of slow feed jet valve cylinder 88 is connected to the pipe 87 from the slow feed jet. Cylinder 88 contains a slidable spool valve 89, normally held in the left-hand position by spring 90.

When the fluid discharge from the slow feed jet supplied by line 87 is cut off, the pressure in pipe 87 acts on the extreme left end of the cylinder 88, and causes the spool valve 89 to move to the right against the pressure of the spring 90. This shifts the pilot valve to the right. One result is that the pressure fluid is then directed through pipe 91 to the right end of the limit switch operating cylinder 49.

Since the left end 50 of the cylinder 49 is smaller than the right end 51 and is under constant pump pressure, the operating pistons 52 and 53 are normally held in the right-hand position, with the limit switch 54 open.

When the slow feed has reached the limit of its inward movement, pressure in the pipe 91 is applied to the right-hand end of cylinder 49. The piston 53 is moved to the left and closes switch 54.

Current from switch 54 passes by conductor 92 to the coil of timer clutch relay 93. This closes contact 94 from the conductor 95. Conductor 95 leads to the coil of timer relay 64. The effect of this is to open contact 63 after a predetermined interval. This interval begins at the end of the slow feed and lasts until sometime after the end of the traverse movement.

Current from conductor 92 is at the same time led to the coil of relay 96. This closes contact 97. Contact 97 is connected by conductor 98 with the main feed line 56. The contact 97 is also connected by conductor 99 to traverse solenoid 100.

A traverse valve is formed by cylinder 101, having a piston valve 102 linked to the solenoid 100. The valve 102 is held normally in its right-hand position by a spring 103. The mid-point of cylinder 101 is connected by pipe 104 to the pressure line 48. When the solenoid 100 is actuated, it moves the traverse valve 102 to the left, directing the incoming pressure fluid from pipe 104 to pipe 105. Pipe 105 leads from the valve cylinder 101 to right-hand end of the traverse cylinder 41.

Pressure applied thus to the right end of the traverse cylinder 41 moves the piston 39 to the left, causing the bracket 38 and the wheel slide 11 to move the finish grinding wheel 16 across the workpiece.

The traverse movement continues until the piston head 40 strikes the stop 42.

At this point the grinding wheel sparks out on the workpiece.

After a predetermined time, the timer relay 64 which was energized at the same time as the traverse valve solenoid 100, "times open" after permitting the wheel support to rest for a short interval during the end of the traverse movement and during the spark-out.

When contact 63 is thus opened, relay 66 is de-energized and its contact 67 opens to de-energize the infeed valve solenoid 70. Spring 74 then shifts valve 72 to the right, directing fluid under pressure to the right-hand end of the infeed reversing valve cylinder 76, which thus moves the valve 77 to the left.

In this position the reversing valve 77 directs fluid under pressure to the rod end of the rapid feed cylinder 31. When the rapid feed piston 33 is retracted, it permits

fluid under pressure to enter into the rod end of the slow feed cylinder **36** and retracts piston **37** to the right.

At the same time, infeed reversing valve **77** directs exhaust pressure from the head end of cylinder **31** to exhaust lines **106A** and **106**.

When the slow feed piston **37** is re-set, fluid is free to discharge through the slow feed jet pipe **87**, thus reducing the pressure at the left end of the slow feed jet pilot valve **89**. This valve is moved to the left by the spring **90** to connect the right-hand end of the limit switch operating cylinder with exhaust.

The constant pressure at the other end of the operating cylinder **49** then shifts the piston **52** to the right and opens switch **54**.

Opening switch **54** de-energizes and re-sets the clutch relay **93**, the timer relay **64**, and de-energizes relay **96**, which controls the traverse solenoid **100**.

As the contact **97** opens the circuit to the traverse valve solenoid **100**, the traverse valve **102** is permitted to shift to the right under pressure of the spring **103**, directing fluid under pressure through pipe **107** to the left hand end of the traverse cylinder **41** to shift the traverse piston and the wheel slide to the right, thus re-setting the rough grinding wheel **17** in position to grind the next workpiece.

Pressure pipes **79**, **81**, **105** and **107**, are each equipped with suitable throttle valves (VT) and check valves (VC).

By the means above described, the smaller grinding wheel **17** is brought rapidly up to position opposite the workpiece for plunge rough grinding, first at high speed, then at low speed. At the limit of its forward travel, the wheel slide is caused to move longitudinally of the work, thus bringing the larger grinding wheel **16** of fine grain across the surface of the workpiece ending with the wheel and workpiece being opposite. This is followed by a spark-out and then by a retraction of the wheel slide and return movement to bring the smaller wheel opposite the next workpiece to be presented.

The difference in radii of the wheels is the amount of material to be removed in finish grinding.

When the wheels become worn and this difference in radius changes, it is restored by movement of the dresser tool **22**. This is advanced opposite the edge of the larger wheel **16**. As the wheel is rotated, the dresser tool traverses the face of the wheel. The radial position of the dressing tool relative to the grinding wheel during the traverse movement is determined by the contour of the profile bar **25**. Follower **24** on the dressing tool engages profile bar **25**, and the difference in radius between the wheels is maintained by the differences in level of the two portions **25***a* and **25***b* of profile bar **25**.

The essential features of the invention have been described in this specification without restricting the invention in minor details, materials and proportions other than by the scope of the following claims.

What I claim is:

1. In a grinding machine, a rotary work support, a grinding wheel base, a grinding wheel slide thereon, a grinding wheel shaft rotatably mounted on the wheel slide, means for rotating said shaft, a grinding wheel mounted on the shaft, a second grinding wheel mounted on the shaft adjacent said first wheel, means for moving said wheel slide transversely toward and from the work support with said first grinding wheel in position to engage a workpiece, means for stopping the movement of said wheel slide toward said workpiece, means actuated by said stopping means for moving said wheel slide longitudinally of said work support to subject said workpiece to the operation of said second grinding wheel, a time delay circuit operable at the end of said longitudinal movement to provide a sparkout interval and thereafter to move said grinding wheel slide away from said work support.

2. In a grinding machine, a rotary work support, a grinding wheel base, a grinding wheel slide thereon, a grinding wheel shaft rotatably mounted on the wheel slide, means for rotating said shaft, a grinding wheel

mounted on the shaft, a second grinding wheel mounted on the shaft adjacent said first wheel, means for moving said wheel slide transversely toward and from the work support with said first grinding wheel in position to engage the workpiece, a stop limiting the movement of the wheel slide toward the work support, means for thereafter moving the wheel slide longitudinally of the work support with the second grinding wheel engaging the workpiece, a time delay circuit operated at the end of the longitudinal movement to provide a sparkout interval and thereafter to reset said grinding wheel support in initial position.

3. In a grinding machine, a rotary work support, a grinding wheel base, a grinding wheel slide thereon, a grinding wheel shaft rotatably mounted on the wheel slide, means for rotating said shaft, a grinding wheel mounted on the shaft, a second grinding wheel mounted on the shaft adjacent said first wheel, means for moving said wheel slide transversely toward and from the work support with the said first grinding wheel in position to engage the workpiece, a stop limiting the movement of the wheel slide toward the work support, fluid means for moving the slide longitudinally of the workpiece, a valve circuit, and fluid means operated by the limiting advancing movement of the wheel slide to actuate said circuit, and separate fluid pressure means operated by said valve circuit to move the slide longitudinally of the workpiece.

4. In a grinding machine, a rotary work support, a grinding wheel base, a grinding wheel slide thereon, a grinding wheel shaft rotatably mounted on the wheel slide, means for rotating said shaft, a grinding wheel mounted on the shaft, a second grinding wheel mounted on the shaft adjacent said first wheel, means for moving said wheel slide transversely toward and from the work support with the said first grinding wheel in position to engage the workpiece, a stop limiting the movement of the wheel slide toward the work support and means for thereafter moving the wheel slide longitudinally of the work support with the second grinding wheel engaging the workpiece, a fluid jet forming a part of said stop, and control means operable in response to change in flow from said fluid jet to start said longitudinal moving means.

5. In a grinding machine, a rotary work support, a grinding wheel base, a grinding wheel slide thereon, a grinding wheel shaft rotatably mounted on said wheel slide, a grinding wheel mounted on said wheel shaft, a second grinding wheel mounted on said shaft adjacent said first grinding wheel, means for moving said wheel slide transversely toward and from said work support with said first grinding wheel in position to engage a workpiece, means for stopping the movement of said wheel slide toward said workpiece, means actuated by said stopping means for thereafter moving said wheel slide longitudinally of said work support with said second grinding wheel engaging said workpiece, a time delay circuit actuated by said stopping means and operable at the end of an interval longer than that required for said longitudinal movement to provide a sparkout operation and thereafter to move said wheel slide away from said work support.

6. In a grinding machine, a rotary work support, a grinding wheel base, a grinding wheel slide thereon, a grinding wheel shaft rotatably mounted on said wheel slide, a grinding wheel mounted on said shaft, a second grinding wheel mounted on said shaft adjacent said first grinding wheel, means for moving said wheel slide transversely toward and from said work support with said first grinding wheel in position to engage a workpiece, means for stopping the movement of said wheel slide toward the workpiece, means actuated by said stopping means for thereafter moving said wheel slide longitudinally of said work support with said second grinding wheel engaging the workpiece, means to stop said longitudinal movement when said second grinding wheel is in contact with the entire width of said workpiece, a time delay circuit

actuated by said transverse stopping means and operable at the end of an interval longer than that required for said longitudinal movement to provide a sparkout operation and thereafter to move said wheel slide away from said work support.

7. In a grinding machine, a rotary work support, a grinding wheel base, a grinding wheel slide thereon, a grinding wheel shaft rotatably mounted on said wheel slide, a grinding wheel mounted on said shaft, a second grinding wheel mounted on said shaft adjacent said first grinding wheel, means for moving said wheel slide transversely toward and from said work support with said first grinding wheel in position to engage a workpiece, means for stopping the movement of said wheel slide toward the workpiece, means actuated by said stopping means for thereafter moving said wheel slide longitudinally of said work support with said second grinding wheel engaging the workpiece, means to stop said longitudinal movement when said second grinding wheel is in contact with the entire width of said workpiece, a time delay circuit actuated by said transverse stopping means and operable at the end of an interval longer than that required for said longitudinal movement to provide a sparkout operation and thereafter to reverse said transverse and longitudinal movements.

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