March 8, 1949. V. J. MARSHALL 2,464,142

INFEED FOR GRINDING MACHINES

Filed Nov. 15, 1946 2 Sheets-Sheet 1

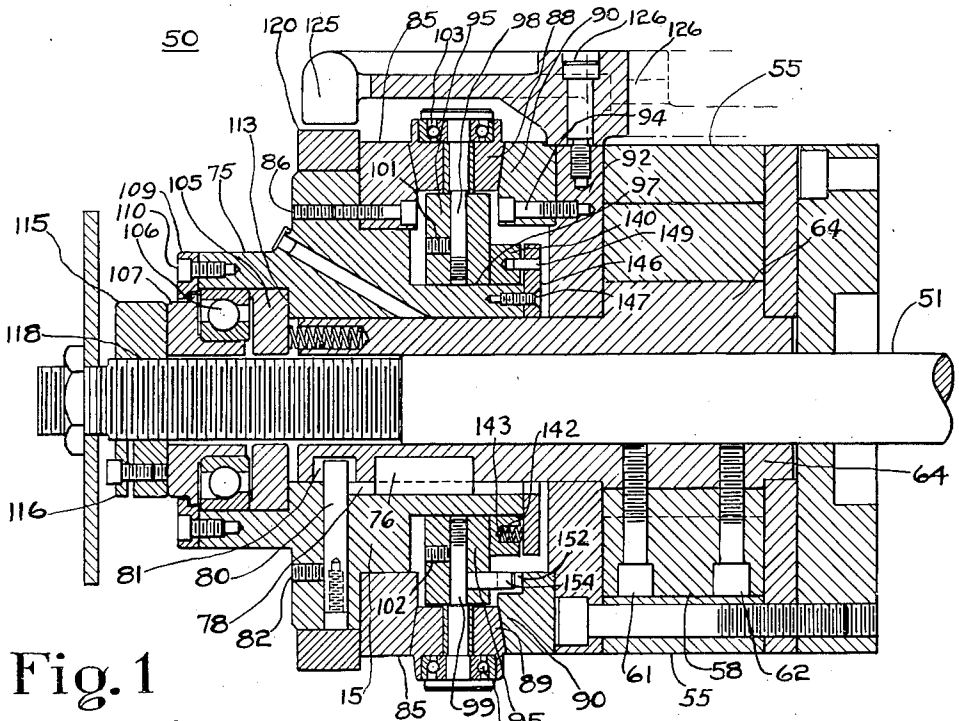


Fig. 1

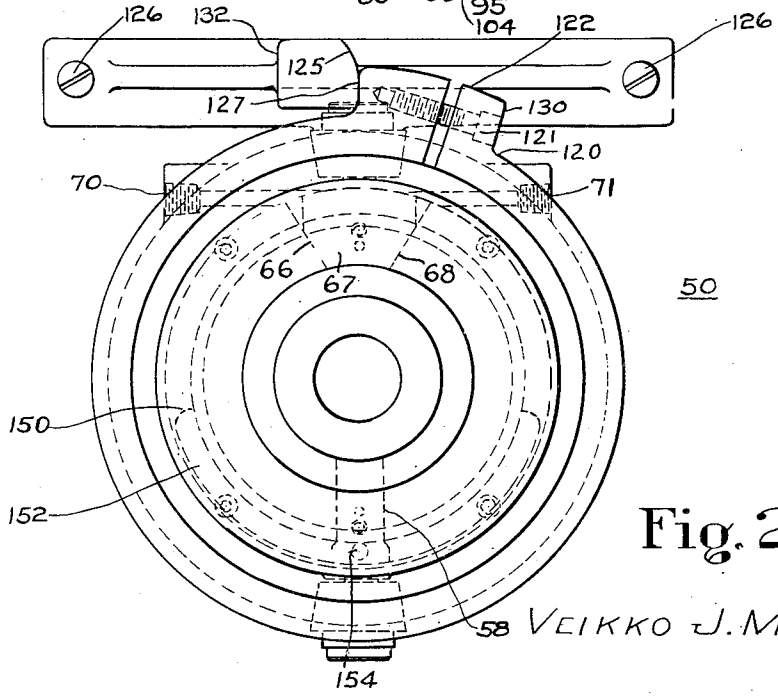


Fig. 2

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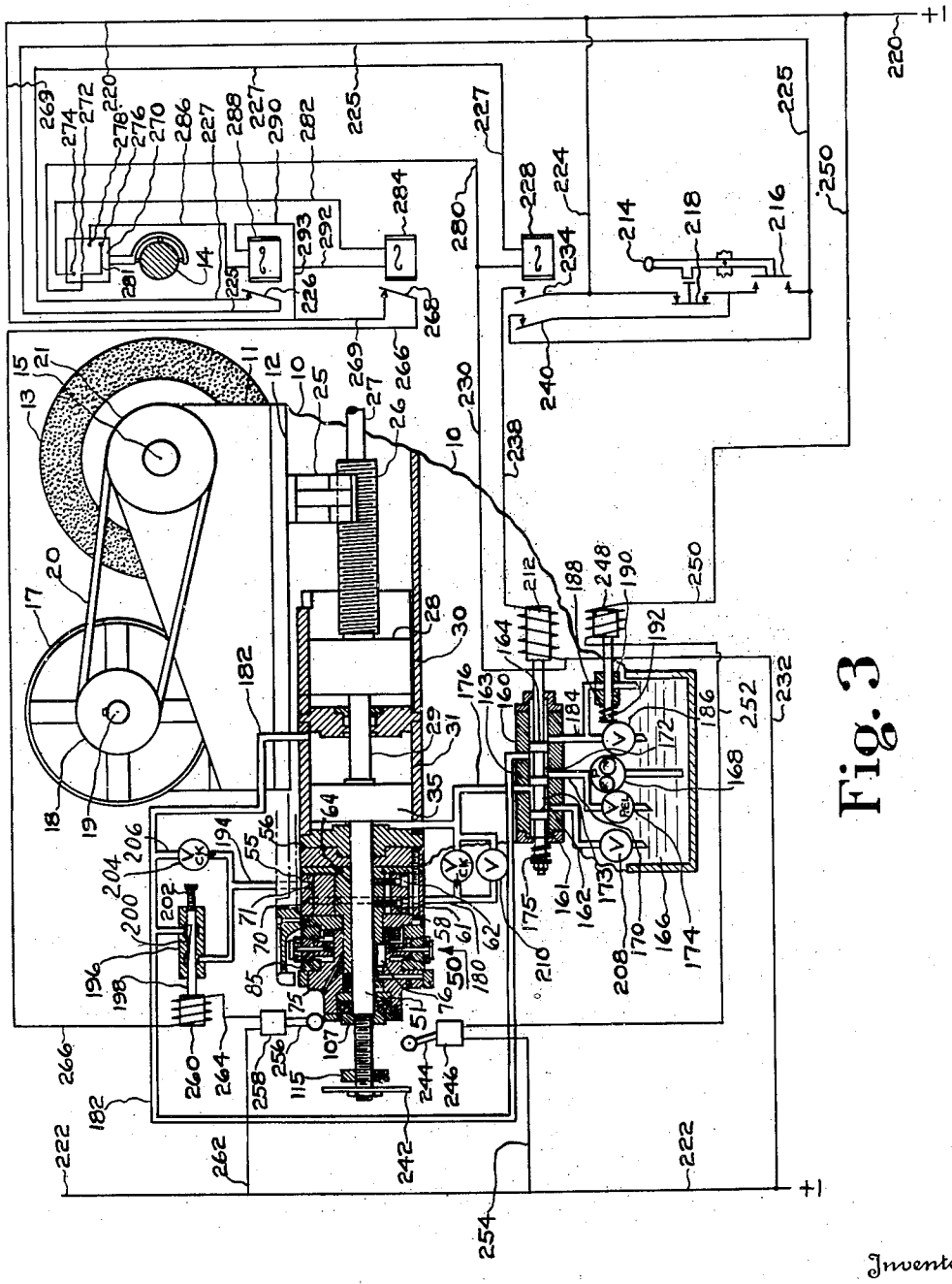


Fig. 3

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2,464,142

INFEED FOR GRINDING MACHINES

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15 Claims. (Cl. 51—2)

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The invention relates to grinding machines and more particularly to cylindrical grinding machines.

One object of the invention is to provide an improved cylindrical grinding machine for grinding cylindrical surfaces wherein the finished size may be automatically controlled with great accuracy. Another object is to improve the machine of U. S. Patent No. 2,267,391 to Astrowski. Another object of the invention is to provide a readily controlled apparatus for rapidly moving the grinding wheel and the work relatively toward and away from each other. Another object is to provide automatically controlled and variable slow speed grinding wheel infeed during the grinding operation after rapid relative approach of the wheel and the work with automatic separation of the wheel and the work when desired work size is reached. Another object is to provide smooth grinding infeed action of the grinding wheel relative to the work at various grinding infeed speeds with or without automatic work size control within extremely fine limits of accuracy. Another object is to provide increased production in finish grinding. Another object is to provide apparatus of the character indicated which may be economically manufactured and compactly assembled on a standard grinding machine and which will give accurate and dependable operation over a long period of time.

Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combination of elements, and arrangement 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,

Fig. 1 is a longitudinal sectional view of the apparatus of the invention mounted upon the wheel feed shaft;

Fig. 2 is an end view of the apparatus;

Fig. 3 is a vertical sectional view of the apparatus of the invention and associated mechanism together with a wiring diagram and a fluid diagram.

As conducive to a clearer understanding of the invention, it is noted that the illustrative embodiment discloses an improvement of a type of apparatus now commonly in use for moving the grinding wheel relative to the work. Such a

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machine has a work table upon which is mounted a headstock and a tailstock to hold a cylindrical work piece and rotate it against the grinding wheel for cylindrical grinding. Such a machine also has fluid pressure means for rapid infeed and retraction and for normal grinding infeed and slow grinding infeed.

The terms "rapid infeed and retraction" as used herein mean positioning of the grinding wheel relative to the work preparatory to grinding and retracting it rapidly from the work when grinding is completed. The term "normal grinding infeed" means feeding the wheel against the work during rough grinding, and the term "slow grinding infeed" means feeding the wheel against the work for the final finishing cut.

According to the present invention additional fluid pressure means hereinafter described are provided whereby after the wheel slide has rapidly approached the work piece and is ready to grind, a very finely controlled smooth and accurate slow grinding infeed is provided with uniformity within close tolerances and with automatic stopping of the grinding infeed and rapid retraction of the wheel slide relative to the work when size is reached.

As illustrated in the drawings the machine of the invention comprises a base 10 which supports a wheel slide 11 for transverse movement thereon on the V-ways 12 which in turn rotatably supports a grinding wheel 13. The base 10 also supports a longitudinally movable work supporting table (not shown) which is arranged to slide on ways.

Work rotation

A cylindrical work piece 14 may be held between a power driven headstock and a tailstock mounted upon the longitudinally movable work supporting table (none of these being shown) so that it can be rotated against the grinding wheel 13 when the latter is in position to grind, and moved longitudinally across the grinding face of the wheel to grind a cylindrical surface on the work piece 14.

Grinding Wheel Drive Mechanism

The grinding wheel 13 is mounted on a spindle 15 which is journalled in bearings in the top of the wheel slide 11, and it is driven by any convenient source of power such as an electric motor 17 which may be mounted on the wheel slide 11 to drive a pulley 18 mounted on the motor shaft 19, a belt 20 and a pulley 21 on the wheel spindle 15.

Grinding wheel rapid infeed mechanism

A half nut 25 depending from the under side of the wheel slide 11 and fastened to it engages a threaded portion 26 of a feed screw 27 which is rotatably connected to an enlarged portion 28 of a longitudinally slidable feed shaft 29 in bearings 30 in the base 10 of the machine. A hand wheel (not shown) on the front of the machine is connected to turn the feed screw 27. Rotation of the hand wheel in one direction feeds the wheel slide 11 and grinding wheel 13 into the work, and in the other direction retracts the wheel slide 11. For rapidly moving the grinding wheel 13 to and from a grinding position, fluid pressure means are provided comprising a cylinder 31 which is either formed as an integral part of the base 10 or fixedly mounted thereon. The shaft 29 is aligned with the axis of the cylinder and serves as a piston rod. A piston 35 is slidably mounted within the cylinder 31 and is fixedly supported by suitable means on the piston rod 29. It will be apparent that when the piston 35 is moved endwise, it will transmit a feeding movement to the grinding wheel 13 through the rod 29, its enlarged portion 28, the feed screw 27 and half nut 25 to move the wheel slide 11. The feed screw 27 is arranged so that it may be rotated relative to the piston 35 so that the operator, by manual rotation of the feed screw 27 may readily adjust the position of the grinding wheel 13 relative to the fluid pressure mechanism.

Grinding infeed mechanism

A fluid pressure actuated face cam mechanism 50 is provided in alignment with and assembled about an extended portion 51 of the feed shaft 29 for accurate control of grinding wheel infeed during the grinding operation and positive stopping thereof upon grinding of the work piece to desired size.

A fluid motor casing 55 concentric with the shaft 51 is mounted upon a head 56 of the cylinder 31. A motor vane 58 is secured by bolts 61 and 62 to a sleeve 64 which is rotatable on shaft 51. The motor vane 58 may be rotated within the motor casing 55 from a position against a face 66 of a stop 67 through the substantial part of a circle to a position against a face 68 of the stop 67 by fluid pressure applied to one side of it within the motor casing 55. As viewed in Fig. 2, when fluid pressure is applied in a passage 70 and allowed to exhaust from a passage 71 the motor vane 58 will rotate counter clockwise from the face 66 to the face 68. When pressure is applied in the passage 71 and allowed to exhaust from the passage 70, the motor vane 58 will rotate clockwise from the stop face 68 to the stop face 67. Rotation of the motor vane 58 rotates the sleeve 64 with it. A face cam driving member 75 is keyed to the sleeve 64 by a key 76 so as to rotate with the sleeve 64. The face cam driving member 75 is slidable endwise of the sleeve 64, the key 76 being slidable in a keyway 78. The limits to which the face cam driving member 75 can slide endwise of the sleeve 64 are determined by a pin 80 mounted in the face cam driving member 75, which rides in a slot 81 in the sleeve 64. The pin 80 is held in place by a lock screw 82. A face cam 85 is secured by a plurality of bolts, of which one 86 is shown, to the face cam driving member 75 to turn with it. The face cam 85 rides against a pair of conically shaped rollers 88 and 89 which in turn roll against a second face cam 90 which is secured to the end plate 92 of the vane motor casing 55 by a plurality of bolts of which one 94 is shown. The face cams 85 and 90 have helical surfaces which are bevelled. The rollers 88 and 89 are secured to a roller ring 95 by means of threaded studs 98 and 99 respectively. The studs 98 and 99 may be adjusted so that the rollers are exactly equidistant from the axis of rotation of the face cam 85. The roller ring 95 is rotatable and slidable endwise on the cylindrical portion 97 of the face cam driving member 75. The studs 98 and 99 are locked in place by lock screws 101 and 102. The rollers 88 and 89 ride on ball bearings 103 and 104. When the motor vane 58, sleeve 64, cam driving member 75 and face cam 85 are caused to rotate about the shaft 51 by fluid pressure in the fluid motor casing 55, in a counter clockwise direction in this instance as viewed in Fig. 2, the cam driving unit 75 moves to the right as viewed in Figs. 1 and 3 a distance sufficient for grinding infeed. The cam driving unit 75 has a thrust bearing assembly comprising a bearing member 105 abutting the member 75, bearing 106 and an abutment member 107 which rides upon the ball bearings 106. The thrust bearing assembly is held in place against the face 113 of the cam driving member 75, by a ring 109 and bolts 110. An adjustable stop collar 115 having a split locking portion 116 is mounted upon a threaded portion 118 of the feed shaft 51 and serves as an abutting member which is abutted by the abutment member 107 when the wheel slide 11 moves to the right.

When fluid pressure is exerted in the cylinder 31 to drive the wheel 13 to the right to position it for grinding, the collar 115 makes contact with and stops against the abutment member 107 of the thrust bearing assembly. Although a full head of pressure is maintained in the cylinder 31, the wheel can go no further until fluid pressure is admitted to actuate the motor vane 58. Thereupon a very fine grinding infeed is permitted due to a slight motion of the abutment member 107 and cam driving unit 75 to the right, Fig. 1. An adjustable split stop ring 120 having, as shown in Fig. 2, a locking bolt 121 in a boss 122 is mounted upon the outside periphery of the cam driving member 75. A limit stop 125 is mounted on the base 10 of the machine by suitable bolts 126. The split stop ring 120 is so positioned that its surface 127 will abut the stop 125 at the limit of the possible grinding infeed stroke, and it may be adjusted to afford a positive grindnig infeed stop at a predetermined finished work size when the grinding machine is to be used without a work sizing device.

In such fine and precisely measured grinding infeed it is apparent that for exact uniformity it is necessary that the face cam 85, the rollers 88 and 89 and the face cam 90 be in exactly the same relative position at the beginning of each grinding infeed cycle, and to that end means to reposition accurately the rollers 88 and 89 relative to the two face cams 85 and 90 are provided. The cam 85 can easily be returned to the same position each time by reversing the fluid motor until the motor vane 58 stops against the face 66 of the stops 67. It will be recalled that the cam driving member 75 is keyed to and slidable endwise on sleeve 64. A plurality of compression springs of which one 135 is shown are provided and seated in holes 136 in the sleeve 64. These springs 135 bear against the bearing member 105 of the thrust bearing assembly, and through the ball bearings 103, abutment member 107 and holding ring 109 they move the entire cam driv-

ing unit 75 to the left as shown relative to the sleeve 64 when pressure upon the thrust bearing abutment member 107 by collar 115 is released by reversing fluid pressure in the cylinder 31 to retract the wheel 13 from the work. Furthermore a friction ring 140 attached to the cam driving member 75 bears against the roller ring 95 and as the member 75 is pushed to the left by the springs 135 the friction ring 140 pushes the roller ring 95 to the left with it causing separation of the rollers 88 and 89 from the surface of the face cam 90. The friction ring 140 is slidable endwise of the surface 97 of the driving member 75 and it is urged against the roller ring 95 by a plurality of compression springs of which one 142 is shown, which are seated in holes 143 in the ring 140 and which thrust against an annular ring 146 which is secured to the cam driving unit 75 by suitable bolts 147. The annular ring 146 is rotatable and slidable upon the surface of the sleeve 64. The friction ring 140 is connected to be rotated with the cam driving unit 75 by a drive pin 149. When the wheel 13 is retracted by reversing fluid pressure in the cylinder 31, the fluid pressure is also reversed in the vane motor casing 55 causing the motor vane 58, cam driving member 75, and cam 85 to move clockwise to reposition the cam 85. As the pressure of the collar 115 on the abutting member 107 of the thrust bearing assembly is released, the cam driving unit 75 and cam 85 move slightly to the left by spring action as described. The friction ring 140 pressing against the roller ring 95 separates the rollers 88 and 89 from the surface of cam 90 but holds them pressed against the surface of the face cam 85. Therefore as the face cam 85 rotates to be repositioned, the rollers 88 and 89 move with it and relative to the face cam 90 until they are in their original starting position. This point is determined by a limit stop 150 formed by the end of an annular groove 152 in the face cam 90. A pin 154 in the roller ring 95 rides in the groove 152 and upon reaching its end the roller ring 95 and rollers are in the predetermined starting position for grinding infeed. They no longer rotate with the face cam 85 which continues on to its starting position, the face cam 85 now rolling upon the rollers 88 and 89 and the friction ring 140 sliding over the roller ring 95 as the latter is stopped by the pin 154. Since the face cam 85 rotates twice as far as the rollers 88 and 89 during grinding infeed, it must carry the rollers back half way of its rotation to reposition them and continue its full distance to the original starting position.

When fluid pressure is introduced in the cylinder 31 to cause rapid infeed, the collar 115 on shaft 51 finally makes contact with the thrust bearing abutment member 107 and compresses the cam driving member 75 and cam 85 against spring compression to the right until the rollers 88 and 89 are in contact with both cams 85 and 90 so that cam action may take place when the vane motor is operated.

Fluid pressure control

A fluid pressure control valve 160 is provided to regulate the admission of fluid to the cylinder 31 and the vane motor casing 55. This valve is preferably of the balanced piston type having a valve stem 161 and a plurality of valve pistons 162, 163 and 164 which are slidably mounted in the valve 160. The ports in the valve 160 are so arranged that fluid from a reservoir 166 is forced by a pump 168 through a conduit 170 into either

of two valve chambers 172 and 173. As the valve stem 161 is shifted from one extreme to the other extreme position, the fluid flow may be changed from one side of the piston 35 to the other to reverse the direction of movement of the wheel slide, and from one side of the motor vane 58 to the other to reverse its direction of movement. The pump 160 has a relief valve 174 on its outlet side so as to maintain a constant pressure into the valve 160 and to drain off excess oil which is not pumped into the fluid pressure system. In the construction shown, with the valve stem 161 normally positioned to the left by means of a spring 175 the valve 160 is set to retract the wheel slide. When the valve stem 161 is set to the right against the spring 175 it is in the rapid and grinding infeed position wherein fluid under pressure enters the valve chamber 173 at the left side of the valve piston 163 and goes to the left side of the piston 35 through a conduit 176. It may also enter the fluid motor casing 55 through a check valve 178, a conduit 180 and the passage 70 on the left side of the mechanism as viewed in Figure 2 to drive the motor vane 58 counterclockwise. Fluid is exhausted from the right side of the piston 35 through a conduit 182, the valve chamber 172 and back into the reservoir 166 through a conduit 184, a hand adjusted valve 186 and also through a conduit 188 and a solenoid operated valve 190 which is kept normally open by a spring 192.

Fluid is exhausted also from the right side of the motor vane 58 (as viewed in Figure 2) through the passage 71, a conduit 194, a solenoid operated metering valve 196, the conduit 182 and back to the reservoir 166 by way of the conduit 184 as described. With rapid infeed to position the wheel 13, it is desirable to slow the action down somewhat just before the collar 115 makes contact with the abutment member 107 so as to avoid jarring of the mechanism. To this end the solenoid operated valve 190 is provided. While normally open to allow rapid exhaust from the cylinder 31 during infeed, it is momentarily closed just before the collar 115 makes contact with the abutting member 107. When the valve 190 is closed, exhaust fluid is metered through the hand adjusted valve 186 to slow down the infeed action.

The movement of the motor vane 58 is delayed while the piston 35 is actuated for rapid infeed because the solenoid operated metering valve 196 is normally almost closed to allow only a very fine stream of exhaust fluid from the vane motor housing 55 to pass through it as rapid infeed and slow grinding infeed take place. It is only opened for normal grinding infeed after the collar 115 has made contact with the abutting member 107. The valve 196 has a stem 198 having a wedged slot 200, which when normally positioned to the right as shown, meters fluid through it at a slow rate which is adjustable by a set screw 202 to allow only a very slow grinding infeed by slow cam action of the face cams 85 and 90. When the valve stem 198 is to the left, fluid is metered at a more rapid rate for normal grinding infeed. Positive stopping of the grinding wheel infeed is immediately brought about by reversing the flow of fluid through the cylinder 31 and in the vane motor casing 55 by reversing the solenoid operated valve 160.

During retraction of the piston 35 and repositioning of the motor vane 58, fluid delivered from the reservoir 166 by the pump 168 under pressure passes through the valve chamber 172

and the conduit 182 to the right side of the piston 35. It also passes through a check valve 204 which is provided in a shunt conduit 206 across the metering valve 196 between the conduits 182 and 194, and into the vane motor casing 55 through the passage 71 under full head to reposition the face cam 85 rapidly to its initial starting position. The cylinder 31 exhausts from the left side of piston 35 through the conduit 176, the valve 160 and a hand adjusted metering valve 208 to the reservoir 166. The valve 208 is provided to adjust the speed of retraction of the piston 35, and the exhaust from the vane motor during repositioning of the cams also passes through it. The exhaust rate from the vane motor casing 55 during repositioning is also adjustable when it passes through a hand adjusted valve 210 into the line 176. While the speed of rapid infeed and grinding infeed may be controlled by closing the valves 190 and 196, the speed of retraction is unaffected by the valves which are bypassed when the main valve 160 is reversed so that retraction and repositioning speeds may be set as high as desired by the hand operated valves 208 and 210.

Electrical control

The main solenoid operated control valve 160 is normally positioned by the spring 175 to retract the wheel slide from the work. By energizing its solenoid 212, rapid and grinding infeed are effected. This is done by moving a main operating switch lever 214 to the right which closes a main switch contact 216, another 218 being normally closed.

An electric circuit is then completed across two wires 220 and 222 from an alternating current power source which may be one hundred and ten volts. The current from wire 220 runs through a wire 224, switch contacts 218 and 216, a wire 225, a relay operated switch 226 which is normally closed, a wire 227, through a relay 228, wires 230 and 232 to wire 222 to energize the relay 228. A relay operated switch 234 is then closed to complete the circuit from the wire 224 by way of wire 238 through the solenoid 212 to energize it and through the wire 232 to wire 222. When the relay 228 was energized it also closed a relay operated switch 240 to form a holding circuit so that when hand pressure is released on the lever 214 to reopen the contact 216 which is normally open, the circuit energizing solenoid 228 will nevertheless remain closed. The wheel slide 11 and shaft 51 now start rapidly to the right. Just before the collar 115 makes contact with the abutment member 107 of the thrust bearing assembly a plate 242 which is adjustably mounted on the end of shaft 51 engages an arm 244 of a limit switch 246 to close it. The arm 244 is normally held by springs in the position shown but can be forced out of position to the right and left. This momentarily energizes a solenoid 248 to close the valve 190 and slow the speed of movement of the wheel slide 11 to the right as the collar 115 makes contact with the abutment member 107. The circuit is completed from the wire 220 through a wire 250, the solenoid 248, a wire 252, the switch 246 and a wire 254 to the wire 222. Just as the collar 115 makes contact with the abutment member 107, the plate 242 rides over the arm 244 to reopen the limit switch 246 and the valve 190. At this instant the plate 242 also engages an arm 256 of a limit switch 258 to energize a solenoid 260 and open the valve 196 to allow exhaust from the vane motor casing

55 at normal grinding infeed rate. The circuit is completed from the wire 222 through a wire 262, the switch 258, a wire 264, the solenoid 260, a wire 266, a relay operated switch 268 and a wire 269 to the wire 220. The relay operated switch 268 is normally closed and the trip switch 258 remains closed during the remainder of the grinding infeed cycle.

A standard electrical work sizing gage 270 is provided such as that disclosed in U. S. Patent to S. A. Foster, No. 2,267,559, having double contacts which are normally open and which close successively as work size is reduced. The gage 270 is available as a complete unit. The first contacts to close have terminals 272 and 274 and are adjusted to close when work size is reduced to the point when it is desired to change from normal grinding infeed rate to slow grinding infeed rate. The second pair of contacts have terminals 276 and 278 and are adjusted to close when the work has been ground to finished size. As work size is reduced at normal grinding infeed speed, the first contacts having terminals 272 and 274 close to complete the circuit from the wire 222 by way of wires 232, 230 and 280, across the terminals 272 and 274, a wire 282, a relay 284 and the wires 292, 293 and 269 to the wire 220. This energizes the relay 284 to open the switch 268. The solenoid 260 is deenergized and the valve 196 closes to meter oil at the slow grinding infeed rate. As the work is ground to its predetermined finished size the second pair of contacts of the gage 270 having the terminals 276 and 278 close to complete the circuit from the wire 222 by way of wires 232, 230, and 281 across the terminals 276 and 278, through a wire 286 to a relay 288 and thence through the wires 290, 293 and 269 to the wire 220. This energizes the relay 288, opens the relay operated switch 226 to break the circuit through the relay 228 by way of the wire 227, thereby allowing the relay operated switch 234 to open and deenergize the solenoid 212. The main valve 160 is then reversed, grinding infeed comes to a positive instantaneous stop and the wheel 13 is retracted from the work 14.

To operate the machine, starting with the grinding wheel in retracted position, I place a cylindrical work piece 14 in the headstock and footstock and set the gage 270 to change the grinding infeed from normal to slow or finish grinding rate at the required size, and to stop the grinding at the required finished size. I start the work piece rotating and throw the starting switch lever 214 to the right for an instant. The wheel 13 starts rapidly toward the work (to the right, as shown). As the collar 115 is about to make contact with the abutment member 107, the plate 242 hits the arm 244 of the switch 246 and the motion is slowed down until the collar 115 actually makes contact with the abutting member 107. At that instant the collar 115 actuates the arm 256 to close the switch 258 and open the metering valve 196. The wheel now makes contact with the work and grinds at normal grinding infeed speed until the gage contacts across terminals 272 and 274 close. This shuts down the metering valve 196 so that only a small stream of oil is exhausted from the vane motor casing 55 and the motor vane 58 continues rotating at a slower rate to allow a finish grinding infeed rate. When the work is ground to the desired predetermined size, the gage contacts across the terminals 276 and 278 close. The valve 160 is instantly reversed to retract the wheel from the work and the motor vane 58, cam 85 and cam

rollers 88 and 89 are repositioned so that a new cycle of operation may be started. A new work piece may then be inserted and the operation repeated. I may want to use the machine without an electric sizing gage. In that case I adjust the split stop ring 120 about the periphery of the cam driving unit 75 so that its face 127 will stop against the limit stop 125 when the predetermined work size is reached in grinding. In that case I use only one grinding infeed speed, and the wheel is retracted by hand operation of the lever 214 to the left which opens the contact 218 and reverses the valve 160.

The mechanism of the invention provides smooth, finely controlled grinding infeed action in a compact unit which may be mounted upon any standard machine. Pressure exerted between the face cams 85 and 90 is evenly balanced upon the double cam rollers 88 and 89.

It will thus be seen that there has been provided by this invention an apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved.

As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth as shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a grinding machine a cross slide mounted on ways, a feed shaft connected to said cross slide, means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction including a collar on said shaft, an abutment member to abut said collar, a rotatable cam driving member, fluid pressure means to rotate said cam driving member and face cams arranged in connection therewith whereby rotation of said cam driving member allows further movement of said cross slide.

2. In a grinding machine a cross slide mounted on ways, a feed shaft connected to said cross slide, power means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction including an adjustable collar on said shaft, an abutment member to abut said collar, a rotatable cam driving member, a vane motor to rotate said cam driving member and face cams arranged in connection therewith whereby rotation of said cam driving member allows further movement of said cross slide.

3. In a grinding machine a cross slide mounted on ways, power means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction, face cams to control movement of said abutment means, rollers between said face cams and fluid pressure means to rotate one of said face cams.

4. In a grinding machine a cross slide mounted on ways, power means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction including an abutment member to abut said cross slide, face cams to control movement of said abutment member, rollers between said face cams, fluid pressure means to rotate one of said face cams and means to reposition said rollers and said cam.

5. In a grinding machine a cross slide mounted on ways, a feed shaft connected to said cross slide, means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction including a collar on said shaft, an abutment member to abut said collar, a rotatable cam driving member, fluid pressure means to rotate said cam driving member, face cams arranged in connection therewith whereby rotation of said cam driving member allows further movement of said cross slide and an adjustable stop whereby said cross slide may be stopped at any predetermined location.

6. In a grinding machine a cross slide mounted on ways, a feed shaft connected to said cross slide, power means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction including an adjustable collar on said shaft, an abutment member to abut said collar, a rotatable cam driving member, a vane motor to rotate said cam driving member, face cams arranged in connection therewith whereby rotation of said cam driving member allows further movement of said cross slide and an adjustable stop whereby said cross slide may be stopped at any predetermined location.

7. In a grinding machine a cross slide mounted on ways, power means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction, face cams to control movement of said abutment means, rollers between said face cams, fluid pressure means to rotate one of said face cams and an adjustable stop whereby said cross slide may be stopped at any predetermined location.

8. In a grinding machine a cross slide mounted on ways, power means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction, face cams to control movement of said abutment means, rollers between said face cams, fluid pressure means to rotate one of said face cams and means to reposition said rollers and said cam.

9. In a grinding machine a cross slide mounted on ways, power means to move said cross slide in either direction and to urge it in one direction, an adjustable abutting member attached to said cross slide, abutment means precisely to control final movement of said cross slide in one direction including an abutment member to abut said abutting member, face cams to control movement of said abutment member, means to rotate said face cams in timed relation with said power means and an adjustable stop whereby said cross slide may be stopped at any predetermined location.

10. In a cross slide controlling mechanism, a main shaft whose axial position determines the position of the cross slide, a sleeve around said main shaft, a vane connected to said sleeve, a circular casing in which said vane is located, a rotatable member keyed to said sleeve including a face cam, rollers engaging said face cam, said face cam having a helical surface, abutment means connecting said main shaft to said rotatable member, fluid pressure means to move said vane in said casing, and means to urge said shaft in an axial direction, the rotation of the face cam by the vane causing a controlled movement of the main shaft.

11. In a grinding machine a cross slide mounted on ways, power means to move said cross slide in either direction and to urge it in one direction, and mechanism to limit and control the movement of said cross slide in the direction in which it is urged in order to produce a fine feed, said mechanism comprising a rotatable face cam, a roller ring mounted coaxial with said face cam, rollers on said ring in engagement with said face cam, and a stationary track in the form of a ring positioned to be engaged by said rollers on the sides thereof opposite said face cam to take the thrust, the power means urging the face cam against the rollers which thrust against said track.

12. In a grinding machine as claimed in claim 11, the combination with the parts and features therein specified, of the further feature that said rollers are frusto-cones and said face cam and said track are also frusto-conical, these three parts being of such relative frusto-conical shape that an accurate rolling engagement between them is achieved.

13. In a grinding machine as claimed in claim 11, the combination with the parts and features therein specified, of resetting means for the roller ring comprising a friction device connected to said face cam.

14. In a grinding machine as claimed in claim 12, the combination with the parts and features therein specified, of resetting means for the

roller ring comprising a friction device connected to said face cam.

15. In a grinding machine a cross slide mounted on ways, power means to move said cross slide in either direction and to urge it in one direction, abutment means precisely to control final movement of said cross slide in one direction including a movable abutment member which allows another member to move slowly, and mechanism for feeding said movable abutment member slowly thus to produce a fine feed comprising a face cam, fluid pressure means to rotate said face cam, a roller ring coaxial with said face cam, rollers on said ring engaging said face cam, means to take the reaction of said rollers, and resetting means for the roller ring comprising a friction device connected to said face cam.

VEIKKO J. MARSHALL.

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