Dec. 12, 1939. C. G. FLYGARE 2,183,490

HYDRAULICALLY OPERATED CYLINDRICAL GRINDING MACHINE

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Fig.1

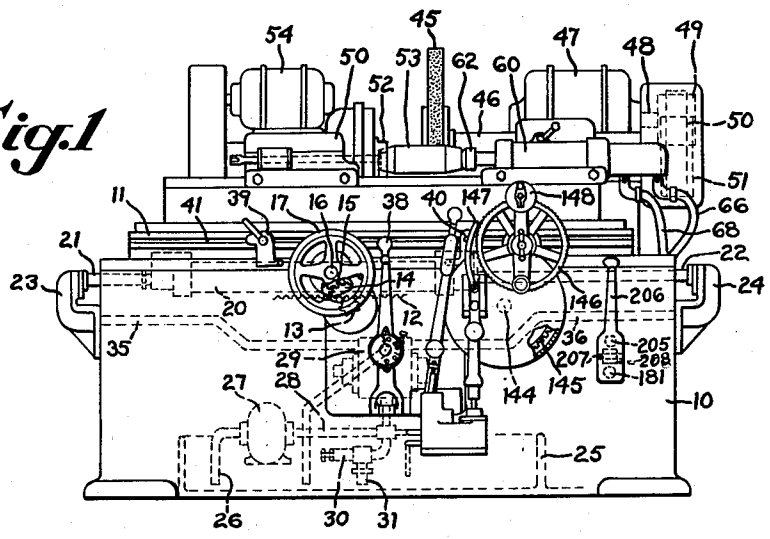


Fig.3

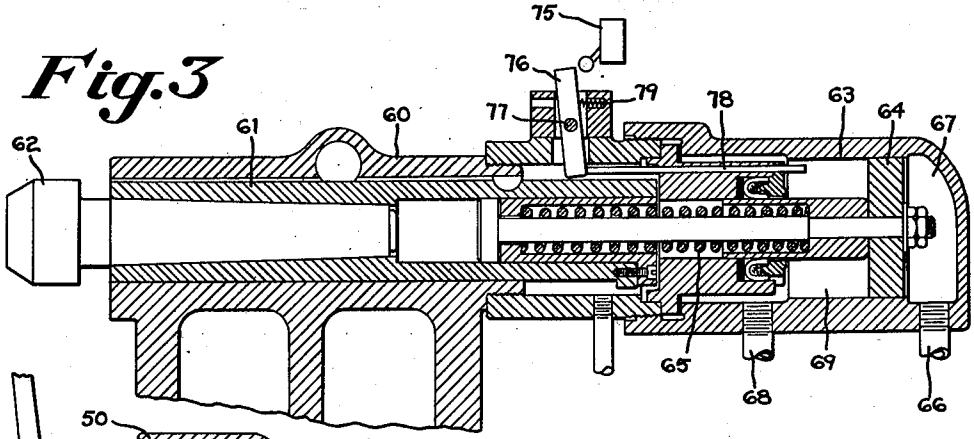
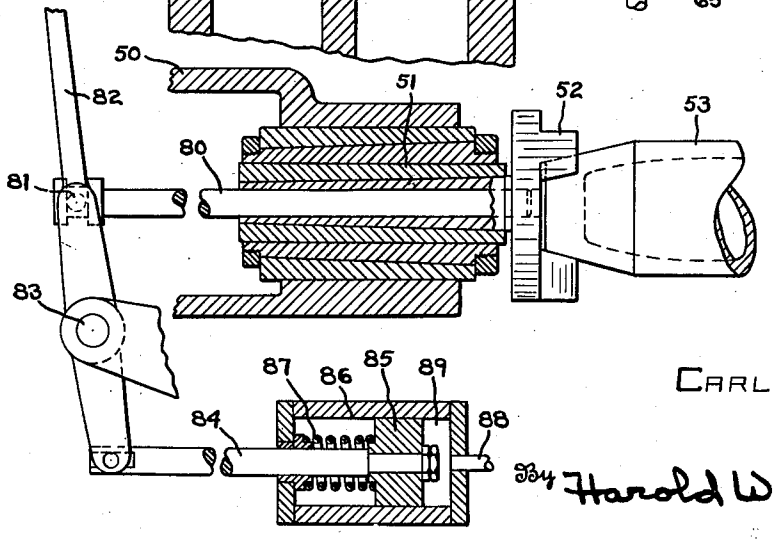


Fig.4



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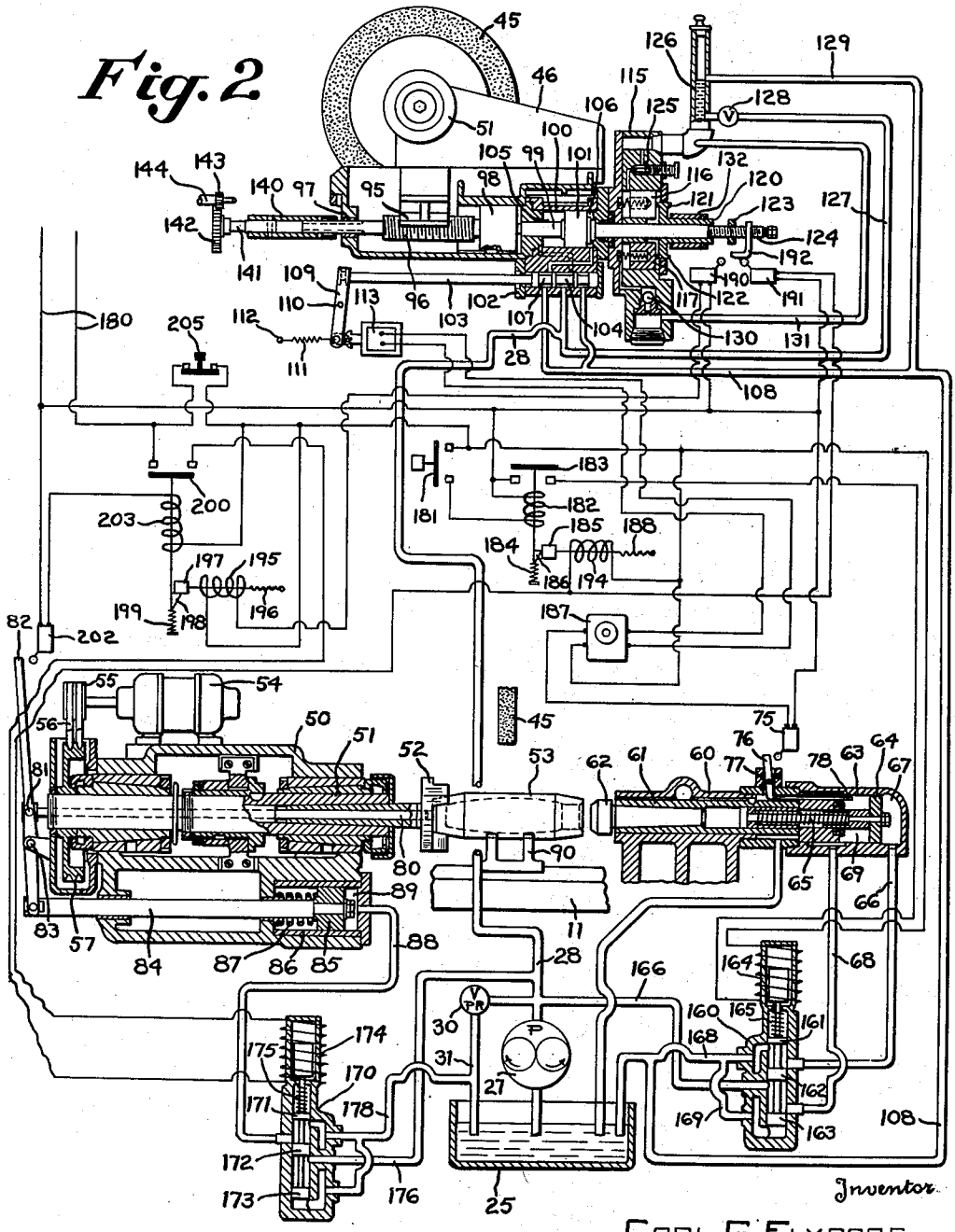
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HYDRAULICALLY OPERATED CYLINDRICAL GRINDING MACHINE

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Fig. 2



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2,183,490

HYDRAULICALLY OPERATED CYLINDRICAL GRINDING MACHINE

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Application July 15, 1939, Serial No. 284,658

8 Claims. (Cl. 51—95)

The invention relates to grinding machines, and more particularly to an electrically controlled hydraulically operated cylindrical type grinding machine.

One object of the invention is to provide an improved electrically controlled, hydraulically operated grinding machine with an improved cycle control mechanism. A further object of the invention is to provide an interlocked control for a grinding machine wheel feed mechanism, a footstock, and a work ejecting mechanism. A further object of the invention is to provide a hydraulically operated grinding machine with an improved electrical control mechanism.

A further object of the invention is to provide a cyclic wheel feeding mechanism which is electrically interlocked with the footstock so that the wheel cannot be advanced until the footstock center is in an operative position. Another object of the invention is to provide an electrical interlock between the work ejector mechanism and the other mechanisms of the machine whereby the wheel feed and the footstock controls are rendered inoperative during the work unloading and loading operations. Other objects will be in part obvious or in part pointed out hereinafter.

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

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

Fig. 1 is a front elevation of the improved grinding machine;

Fig. 2 is a longitudinal sectional view through the headstock and footstock and through the hydraulic wheel feed mechanism combined with an electrical and hydraulic diagram to illustrate the operative cycle of the machine;

Fig. 3 is a longitudinal sectional view, on an enlarged scale, through the footstock, showing the electrical interlock and control mechanism; and

Fig. 4 is a fragmentary longitudinal sectional view, on an enlarged scale, through the headstock, showing the work ejector mechanism.

A grinding machine has been illustrated in the drawings which is of the same general type as that shown in the prior U. S. patent to Wood No. 2,071,677 dated February 23, 1937. A grinding machine has been illustrated in the drawings comprising a base 10 which supports a longitudinally reciprocable work supporting table 11 on the usual V-way and flat way (not shown). The work table 11 may be traversed longitudinally either manually or by power by any of the well known manual or power operated mechanisms. As illustrated in the drawings, a manually operable traverse mechanism has been illustrated comprising a rack bar 12 depending from the table 11 which meshes with a gear 13. The gear 13 is rotatably supported within the base 10 of the machine. A gear 14 is mounted and arranged to rotate with the gear 13 and meshes with a gear 15 mounted on the inner end of a rotatable shaft 16. A manually operable hand traverse wheel 17 is mounted on the outer end of the shaft 16. By rotating the hand wheel 17 in either direction, the work supporting table 11 may be traversed longitudinally in the desired direction.

Power traverse

The table 11 may, if desired, be reciprocated longitudinally by a power operated mechanism, such as that shown in the prior U. S. Patent No. 2,071,677 above referred to, to which reference may be had for details of disclosure not contained herein. The power operated table traverse mechanism is preferably a fluid pressure mechanism comprising a cylinder 20 which is fixedly mounted to the underside of the table 11. The cylinder 20 contains a pair of spaced pistons (not shown) which are connected by a pair of hollow connecting rods 21 and 22 to a pair of hollow brackets 23 and 24, respectively, which are fixedly mounted on opposite ends of the base 10.

The base 10 is formed as a hollow box-like construction, the lower portion of which serves as a fluid reservoir 25 for the fluid pressure system. Fluid is drawn from the reservoir 25 through a pipe 26 by means of a motor driven fluid pump 27 and is forced through a pipe 28 to a table control valve 29. A fluid pressure relief valve 30 is connected in the pipe line 28 which is arranged to allow fluid under pressure to by-pass through a pipe 31 into the reservoir 25 in case the pressure within the fluid system increases above the desired operating pressure.

The table control valve 29 is connected by a pipe 35 with the bracket 23 which connects with a cylinder chamber (not shown) at the left-hand end of the cylinder 20 (Fig. 1). The control valve 29 is also connected by means of a pipe

36 with the bracket 24 which forms a fluid connection with a cylinder chamber at the right-hand end of the cylinder 20. By actuating the control valve 29, the table 11 may be caused to traverse in either direction, as desired. The control valve has not been illustrated in detail in the present case since it is not considered to be a part of the present invention. For further details of the table control valve 29, reference may be had to the above-mentioned prior Patent No. 2,071,677.

A table actuated reversing lever 38 is pivotally mounted on the front of the machine base and is operatively connected to actuate the table control valve. A pair of adjustable table dogs 39 and 40 are adjustably supported by a V-slot formed in the front edge of the table 11 and serve automatically to actuate the lever 30 to shift the control valve 29.

The speed of reciprocation of the table 11 is controlled by means of a speed control valve (not shown) which is actuated by movement of the control lever 38 toward and from the front of the machine. This valve and its connections with the lever 38 are clearly disclosed in the above-mentioned prior patent.

As illustrated in the drawings, the base 10 also supports a rotatable grinding wheel 45 which is supported on one end of a rotatable wheel spindle (not shown) which is journalled in bearings carried by a transversely movable wheel slide 46. The grinding wheel 45 may be driven in any suitable manner such as, for example, by means of an electric motor 47 mounted on the upper surface of the wheel slide 46. The motor is provided with a shaft 48 which supports a pulley 49 which is in turn connected by means of a belt 50 with a pulley 51 mounted on the right-hand end of the wheel spindle (Fig. 1).

The work supporting table 11 serves as a support for a rotatable work supporting mechanism comprising a headstock 50 which is provided with a rotatable headstock spindle 51. The spindle 51 is provided at its right-hand end with a work supporting center or chuck 52, which in the present case has been illustrated as a female center, to engage and support a frusto-conical end portion of a work piece 53. The spindle 51 is rotated by means of an electric motor 54 mounted on the upper surface of the headstock 50. The motor 54 is provided with a driving pulley 55 which is of the multiple V-groove type. The pulley 55 is connected by a multiple V-belt 56 with a multi-grooved pulley 57 mounted on the left-hand end of the headstock spindle 51 (Fig. 2).

The other end of the work piece 53 is supported by means of a footstock 60. The footstock 60 is provided with a longitudinally movable spindle 61 which is provided at its outer end with a footstock center 62 which is arranged to rotatably support the right-hand end of the work piece 53. The footstock spindle 61 is preferably moved to and from an operative position by means of a fluid pressure mechanism comprising a cylinder 63 having a piston 64 slidably mounted therein. A spring 65 is interposed between the piston and the footstock spindle 61 and is arranged to yieldably maintain the footstock center 62 in operative engagement with the work piece 53 during the grinding operation. Fluid may be admitted through the pipe 66 into a cylinder chamber 67 to cause the piston 64 and the spindle 61 together with the footstock center 62 to move toward the left (Fig. 2) into an operative position or, if desired, fluid under pressure may be admitted through a pipe 68 into a cylinder chamber 69 to cause the piston 64 and footstock center 62 to move to an inoperative position. The fluid pressure system and the control mechanism therefor will be described hereinafter.

An interlock is provided to prevent the grinding wheel from starting its forward feeding movement until the work center 62 is in an operative position. A normally open limit switch 75 is interconnected with the wheel feeding mechanism in a manner to be hereinafter described. A lever 76 is pivotally mounted on a stud 77 which is fixedly supported on the footstock 60. The lower end of the lever 76 is arranged in the path of a slidably mounted rod 78 which is slidably supported by a stationary part of the footstock 60. When the footstock piston 64 moves toward the left (Fig. 3) to move the footstock center 62 into supporting engagement with the end of the work piece 53, the piston 64 engages the end of the rod 78 and moves it endwise toward the left. This movement of the rod 78 serves to rock the lever 76 in a clockwise direction against the compression of a spring 79. During the clockwise movement of the lever 76, it engages the actuating roller of the limit switch 75, which serves to close the limit switch 75 only when the piston 64 and the footstock center 62 are moved into an operative position.

Work ejector

The headstock 50 is provided with a work ejector mechanism which is arranged automatically to eject the work piece 53 from the female center 52. As illustrated in the drawings, the ejector mechanism comprises an ejector rod 80 which is slidably mounted within a central aperture within the headstock spindle 51. The end of the ejector rod 80 is pivotally connected by a stud 81 with a pivotally mounted lever 82. The lever 82 is pivotally supported by a stud 83 which is fixed relative to the headstock 50. The lower end of the lever 82 is connected to the end of a piston rod 84. A fluid pressure operated piston 85 is slidably mounted within a cylinder 86 and is fixedly supported on the end of the piston rod 84. A spring 87 surrounds the piston rod 84 and is interposed between the piston 85 and the left-hand end of the cylinder 86 which serves normally to hold the piston and the ejector rod 80 in an inoperative position, as illustrated in Fig. 2. The ejector rod is moved to eject the work piece 53, by means of a fluid pressure mechanism. Fluid under pressure is admitted through a pipe 88 into a cylinder chamber 89 to move the piston 85 and piston rod 84 toward the left (Fig. 2), which movement serves to rock the lever 82 in a clockwise direction. The clockwise movement of the lever 82 serves to move the ejector rod 80 toward the right (Fig. 2) to eject the work piece 53 from the female center 52.

A work supporting or loading cradle 90 is mounted on the table 11 and serves to support the work piece 53 during the loading and ejecting operations.

Wheel feeding mechanism

A wheel feeding mechanism is provided to control the feeding movement and adjustment of the grinding wheel 45 toward and from the work support. The wheel slide 46 is provided with a depending half nut 95 which meshes with a rotatable cross feed screw 96. The feed screw 96 is rotatably supported in bearings 97 and 98 in the base 10. The feed screw 96 may be

rotated manually for adjusting the position of the wheel slide 46 in setting up the machine, by a manually operable feed mechanism to be hereinafter described.

In order that the wheel slide 46 may be rapidly moved toward the work piece 53 to grind the same, the feed screw 96 is connected to a piston rod 99. A fluid pressure cylinder 100 is arranged in axial alignment with the feed screw 96 and contains a slidably mounted piston 101 which is connected with the piston rod 99. The fluid pressure pump 27 forces fluid through the pipe 28 to a feed control valve 102. The feed control valve 102 is preferably of the piston type, comprising a valve stem 103 having a plurality of valve pistons formed integrally therewith. This fluid pressure feeding mechanism, as illustrated in Fig. 2, is substantially identical to that shown in the prior U. S. patent to Cole and Amidon No. 2,101,790 dated December 7, 1937, to which reference may be had for details of disclosure not contained herein. In the position of the feed control valve 102 (Fig. 2), fluid under pressure passing through the pipe 28 enters a valve chamber 104 and passes through a passage into a cylinder chamber 105 formed at the left-hand end of the cylinder 100 (Fig. 2) to cause the piston 101, the wheel slide 46, and the grinding wheel 45 to move into a rearward or inoperative position. During this rearward feeding movement of the grinding wheel, fluid is exhausted from a cylinder chamber 106 formed at the right-hand end of the cylinder 100 (Fig. 2), through a passage, and through a valve chamber 107, and out through a pipe 108 which exhausts into the reservoir 25.

The forward end of the valve stem 103 is pivotally connected to the upper end of a lever 109 which is pivotally supported on a fixed stud 110. A spring 111 is connected between the lower end of the lever 109 and a fixed stud 112 and serves normally to hold the feed control valve 102 in the position illustrated in Fig. 2 to move and hold the grinding wheel 45 and its supporting slide 46 in its rearward or inoperative position. A solenoid 113 is connected to the lower end of the lever 109 and is arranged so that when energized, it rocks the lever 109 in a counterclockwise direction, moving the valve stem 103 toward the left (Fig. 2) to shift the control valve 102 also toward the left so as to admit fluid under pressure passing through the pipe 28 and valve chamber 104 into the cylinder chamber 106 to cause a forward feeding movement of the grinding wheel 45. The admission of fluid under pressure to the cylinder chamber 106 produces a rapid forward movement of the grinding wheel 45.

Dash pot

The piston and cylinder mechanism, above described, serves to cause the grinding wheel 45 rapidly to approach or recede from the work piece 53. In order to reduce the rapid approaching movement to a predetermined grinding feed, it is desirable to provide a wheel feed control mechanism, such as a dash pot mechanism, which may be rendered effective when the grinding wheel 45 is about to contact with the surface of the work piece 53 being ground. As illustrated in Fig. 2, an outwardly extending casing 115 is fixedly mounted to the end of the cylinder 100 and contains a pair of diametrically arranged spaced dash pot pistons 116 and 117 which slide within dash pot cylinders formed within the casing 115. The dash pot pistons 116 and 117 normally are held in a rearward position by means of springs. During the rapid approach of the grinding wheel 45, the dash pot pistons are inoperative. The piston rod 99 extends toward the rear of the machine and is provided at its rearward end with a slidably mounted sleeve 120. The sleeve 120 is provided with diametrically projecting arms 121 and 122 which are provided at their outer ends with bosses positioned and arranged to engage the dash pot pistons 116 and 117, respectively, at a point substantially coinciding with the axes of the dash pot pistons.

When fluid is admitted under pressure to the cylinder chamber 106 to cause the grinding wheel 45 to move toward the work piece, the rapid approaching movement continues until an adjustable collar 123, carried by a threaded end portion 124 of the piston rod 99, engages the end of the sleeve 120. The continued movement of the piston 101 is resisted by the dash pot pistons 116 and 117, which force fluid under pressure from the dash pot cylinders through an adjustable needle valve 125 into a reservoir 126. By adjustment of the needle valve 125, the exhaust of fluid from the dash pot cylinders may be readily controlled to produce the desired grinding infeed, so that the grinding wheel will be moved into the work piece to grind the same at the desired rate of speed. This dash pot mechanism is substantially the same as that shown in the prior U. S. patent to Cole and Amidon No. 2,101,970 dated December 7, 1937, and since this feature is not considered to be a part of the present invention, the details of disclosure have not been completely described herein. For details of disclosure not contained herein, reference may be had to the prior patent above mentioned.

The fluid reservoir 126 and the dash pot cylinders form a separate fluid system which is independent of the main feed cylinder 100. In order to fill the reservoir 126, a pipe 127 is connected with the fluid pressure pipe 28 which leads from the fluid pump 27, and a manually operable valve 128 in the pipe line 127 serves to admit fluid from the pump into the reservoir 126 to fill the dash pot system in setting up the machine and to maintain it full during use. An overflow pipe 129 is provided which is connected with the exhaust pipe 108 to convey excess fluid from the reservoir 126 to the main reservoir 25. If desired, the valve 128 may be maintained slightly open during the use of the machine, so that the reservoir 126 will be at all times filled and any overflow therefrom may readily return to the main reservoir 25. In order to allow the dash pot cylinder chambers to fill rapidly as the wheel slide 46 moves rearwardly, a ball check valve 130 is provided in the dash pot cylinder casing 115 which is connected by means of a pipe 131 with the reservoir 126. By providing the ball check valve 130, fluid is quickly admitted into the dash pot cylinders instead of being drawn wholly through the needle valve 125.

Positive stop

In order to grind the work piece 53 to a predetermined size, it is necessary to feed the grinding wheel 45 toward the work piece 53 to grind the same and then to stop the infeed and allow the grinding wheel 45 to grind out or to allow the sparks to die out in order to round up or finish grind the work so that it will be ground to a true cylindrical surface of a predetermined size. As illustrated in the drawings, a positive

stop sleeve 132 surrounds and is adjustably supported on the sleeve 120 and is arranged to engage a dash pot cylinder head when the grinding wheel has advanced to a predetermined position positively to stop the forward advance of the wheel for a finish grinding operation.

Manual feed adjustment

The rotatable feed screw 96 is arranged so that it may be rotated manually to adjust the position of the wheel slide 46 when desired. The forward end of the feed screw 96 is slidably connected within a sleeve 140 which is in turn fixedly mounted on a rotatable shaft 141 which is journalled in bearings (not shown) within the base 10. A gear 142 is mounted on the forward end of the shaft 141 and meshes with a gear 143 which is carried by a rotatable shaft 144. The shaft 144 is journalled in suitable bearings (not shown) in the base 10. The shaft 144 carries at its forward end a gear 145 which meshes with a small gear (not shown) which is supported to rotate with a manually operable feed wheel 146. The feed screw 96 may be rotated manually by rotation of the manually operable feed wheel 146 in either direction to adjust the position of the wheel slide 46 and the grinding wheel 45. A reciprocable feed pawl 147 is provided for intermittently actuating the feed wheel 146 at the ends of the table stroke when the machine is set up for a traverse grinding operation. The feed wheel 146 is provided with a manually operable micrometer adjusting mechanism 148 to facilitate adjustment of a stop abutment which is carried by the feed wheel 146 and is arranged to engage the feed pawl 147. This mechanism has not been illustrated in detail, since it is not considered to be a part of the present invention. Reference may be had to the prior U. S. patent to Norton No. 762,838 dated June 14, 1904, for details of disclosure not contained herein.

The fluid pressure pump 27 also supplies fluid under pressure for actuating the footstock 60. A solenoid valve 160 is provided for controlling the passage of fluid under pressure to operate the footstock. The valve 160 is preferably a piston type valve having a plurality of valve pistons 161, 162 and 163 formed integral with the valve stem. A solenoid 164 is connected to the upper end of the valve stem and serves when energized to shift the valve in an upward direction. A spring 165 surrounding the valve stem and interposed between the valve piston 161 and the end of the valve casing serves normally to hold the valve in a downward position. Fluid under pressure from the pump passing through the pressure pipe 28, passes through a pipe 166 into a valve chamber located between the valve pistons 162 and 163 and passes out through the pipe 68 into the cylinder chamber 69 to move the footstock center 62 toward the right into an inoperative position, as shown in Fig. 2. During this movement of the footstock center 62, fluid is exhausted from the cylinder chamber 67 through the pipe 66 into a valve chamber located between the valve pistons 161 and 162 and exhausts through a pipe 166 into the main reservoir 25. When the solenoid 164 is energized, the valve pistons 161, 162, and 163 move upwardly so that fluid under pressure passing through the pipe 166 into the valve chamber between the valve pistons 162 and 163, passes through the pipe 66 into the cylinder chamber 67 to move the piston 64 and footstock center 62 toward the left into an operative position to support the right-hand end of the work piece 53. During this movement of the footstock center 62 into an operative position, fluid within the cylinder chamber 69 exhausts through the pipe 68 and passes out through a pipe or passage 169 into the pipe 168 which in turn exhausts into the main reservoir 25.

The ejector mechanism is similarly actuated by fluid under pressure from the pump 27. The passage of fluid to the ejector mechanism is controlled by a solenoid valve 170 which is preferably a piston type valve comprising valve pistons 171, 172 and 173. An electric solenoid 174 is connected to the upper end of the valve stem and serves when energized to shift the valve in an upward direction. A spring 175 which surrounds the valve stem and is interposed between the valve piston 171 and the end of the valve casing, serves normally to hold the valve in a downward position. Fluid under pressure from the pump 27 passing through the pipe 28 also passes through a pipe 176 into a valve chamber located between the valve pistons 172 and 173. In the position of the valve (Fig. 2), nothing happens. The cylinder chamber 89 is connected by the pipe 88 with a valve chamber located between the valve pistons 171 and 172 which, as illustrated, is connected by a pipe 178 which exhausts fluid into the main reservoir 25. When the solenoid 174 is energized, the valve pistons 171, 172 and 173 are moved upwardly against the compression of the spring 175 so that fluid under pressure passing from the pipe 176 into the valve chamber located between the valve pistons 172 and 173, passes through the pipe 88 into the cylinder chamber 89 to cause the piston 85 and the piston rod 84 to rock the lever 82 in a clockwise direction, which in turn shifts the ejector rod toward the right (Fig. 2) to eject the work piece 53 from the female center 52.

The improved grinding machine is provided with an interlock which prevents a forward feeding movement of the grinding wheel until the footstock center 62 is in supporting engagement with the work. Similarly, the footstock center is interlocked so that it cannot be withdrawn from supporting engagement with the work until the wheel slide has moved to its rearward position. In the preferred construction an electrical interlock is provided. The machine receives its source of power from the power lines 180 indicated diagrammatically (Fig. 2). A manually operable push button switch 181 is provided for starting the grinding cycle. The electrical circuit is arranged so that the push button switch must be held closed until the grinding wheel 45 and its supporting slide 46 have started on the forward approaching or feeding movement. The closing of the push button switch 181 energizes a solenoid 182 of a mechanical latch-in electrical reset relay, such as that manufactured by the Struthers Dunn Inc. of Philadelphia, Pa. The energizing of the solenoid 182 closes a switch 183 which is normally held open by means of a spring 184. When the switch moves downwardly into a closed position, a spring-pressed latch 185 engages a projecting lug 186 on the switch plunger and locks the switch 183 in an operating position. The closing of the switch 183 serves to energize the solenoid 164 to shift the footstock control valve 160 upwardly so as to admit fluid under pressure through the pipe 66 into the cylinder chamber 67 to cause the footstock center to move into supporting engagement with the work piece 53.

When the piston 64 reaches the end of its operative stroke, the rod 78 acting upon the pivotally

mounted lever 76 closes the normally open limit switch 75 which in turn sets an electrical time delay relay 187 in motion. The time delay relay 187, as illustrated, is one of the well known electrical time delay automatic reset relays, such as that known as the Microflex instantaneous reset timer relay manufactured by Eagle Signal Corporation of Moline, Illinois, and which is covered by U. S. Patent No. 1,794,762 to J. A. Garell, to which reference may be had for details of disclosure not contained herein. The relay 187 is connected to energize the feed control solenoid 113 which in turn shifts the feed control valve 102 to initiate a forward feeding movement of the grinding wheel 45. A compression spring 188 serves to hold the latch 185 in an operating position. The latch 185 is arranged to be automatically withdrawn at the desired time.

A pair of normally open limits switches 190 and 191 are provided adjacent to the rear end of the piston rod 99 and are arranged to be actuated by means of a cam or dog 192 which is adjustably supported on the threaded end portion 124 of the piston rod 99 and serves in a manner to be hereinafter described to aid in the interlocking of a various mechanisms of the machine.

The manually operable starter push button 181 must be held in a closed position until the footstock center 62 is in supporting engagement with the work piece and the wheel 45 starts its forward feeding movement, and must be held closed until the dog or cam 192 rides off the actuating roller of the normally open limit switch 191 so that the switch 191 opens to break the circuit, thus rendering a solenoid 194 which operates the latch 185 inoperative.

The forward feeding movement of the grinding wheel 45 continues for a definite time interval, as controlled by the adjustable time delay relay 187, which serves after the said time interval automatically to break the circuit so as to deenergize the solenoid 113, thus releasing the compression of the spring 111 which shifts the feed control valve 102 into its rearward position to cause a rearward movement of the grinding wheel.

When the wheel approaches the forward end of its stroke, the cam or dog 192 on the rear end of the piston rod 99 engages the actuating roller of the normally open limit switch 190 which serves to break a circuit, thus deenergizing a solenoid 195 which allows the released compression of a spring 196 to withdraw a latch 197 from engagement with the lug 198. The withdrawal of the latch 197 releases the compression of a spring 199 which moves the switch member 200 of the mechanical latch-in electrical reset relay into a closed position, thus closing the circuit which is connected to the solenoid 194. The solenoid 194, however, is not energized since the normally open limit switch 191 is connected in series therewith. The switch 200 remains in a closed position until the wheel slide moves to its rearward position and the cam or dog 192 again engages the actuating roller of the normally open limit switch 191 which closes the circuit, thus energizing the solenoid 174 to shift the ejector control valve 170 upwardly to admit fluid under pressure through the pipe 88 into the cylinder chamber 89 to move the piston rod 84 toward the left (Fig. 2) which rocks the lever 82 in a clockwise direction and shifts the ejector member 80 toward the right to eject the work piece 53 from the supporting center 52. As the work piece is ejected, the lever 82 engages the actuating roller of a normally open limit switch 202 which closes a circuit to energize a solenoid 203 which opens the switch 200. When the solenoid 174 of the valve 170 is energized, the solenoid 194 of the switch 183 which is connected in series therewith is also energized to withdraw the latch 185, and the released compression of the spring 184 opens the switch 183. This in turn deenergizes the solenoid 164 to allow the valve 160 to drop into its lower position, thus admitting fluid under pressure to withdraw the footstock center 62 from supporting engagement with the work just prior to the actuation of the ejector spindle 80 in ejecting the work piece 53 from the center 52.

It is desirable to provide means for stopping the grinding cycle at any time and returning the respective parts to their initial positions. In order to accomplish this result, a manually operable switch, such as a push button stop switch 205, is connected in the electrical circuit so that in case the machine does not function properly, the circuit can be opened to immediately return the grinding wheel 45 to its rearward position.

A manually operable control lever 206 is pivotally mounted on a stud 207 which is in turn supported by a boss 208 projecting from the front of the machine base. When the upper end of the lever is moved toward the operator, the lower end of the lever operates the push button 181 to initiate a grinding cycle. If at any time during the grinding cycle, it is desirable to stop the grinding operation and remove the wheel from the work, the upper end of the lever 206 is moved toward the machine base which serves to actuate the push button switch 205 immediately to stop the grinding cycle.

The operation of this machine is readily apparent from the foregoing disclosure. Assuming the parts to have been previously adjusted so that the desired grinding cycle may be obtained, a work piece 53 is placed in position on the work supporting cradle 90 (Fig. 2) and its frusto-conical end is moved into engagement with the female center 52. The control lever 206 is then shifted outwardly at its upper end to actuate the main cycle control push button 181 which closes a circuit to energize the solenoid 182 which closes the switch 183 and latches it in a closed position. Closing of the switch 183 energizes the solenoid 164 to shift the footstock valve 160 and admit fluid under pressure to cause the footstock center 62 to move into supporting engagement with the work piece. The shifting of the footstock center into an operative position serves to close the normally open limit switch 75 which closes a circuit to set the time delay relay 187 in operation. The relay 187 is connected so that when it is set in motion, the solenoid 113 is energized to shift the feed control valve 102 to cause a forward feeding movement of the grinding wheel 45. The forward feeding movement continues for a predetermined time interval as governed by the time delay relay 187. When the predetermined time interval has elapsed, the solenoid 113 is deenergized and the released tension of the spring 111 shifts the feed control valve 102 into the position illustrated in Fig. 2 to cause a rearward movement of the grinding wheel after the grinding operation has been completed. When the wheel reaches its rearward position, the solenoid 164 is deenergized which releases the compression of the spring 165 so as to shift the footstock control valve and admit

fluid under pressure to move the footstock center 62 to an inoperative position out of engagement with the work piece 53. The solenoid 174 is then energized to shift the valve 170 so as to admit fluid under pressure through pipe 88 into cylinder chamber 89 to shift the ejector rod 80 to eject the finish ground work piece 53 from the female center 52 onto the cradle. The finish ground work piece 53 may then be removed from the work supporting cradle 90 and replaced with a new work piece to be ground.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support thereon including a headstock and footstock each having a work supporting center, means including an electrical time delay relay to cause a forward and rearward movement of the wheel slide, manually operated electrically controlled means to move said footstock center to an operative position, and an electrical control actuated by movement of the footstock center to an operative position to initiate a forward feeding movement of the grinding wheel.

2. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support thereon including a headstock and a footstock each having a work supporting center, means including an electrical time delay relay to control the transverse movement of said wheel slide, a hydraulic piston and cylinder to move said footstock center toward and from an operative position, a manually operated electrically controlled means to control said piston and cylinder so as to cause the footstock center to move to an operative position, means including an electrical switch actuated by movement of the footstock center to an operative position to initiate a forward feeding movement of the grinding wheel.

3. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support thereon including a headstock and a footstock each having a work supporting center, a hydraulic piston and cylinder to move said slide transversely, means including a electrical time delay relay to control the extent of the forward feeding movement of said slide, a hydraulic piston and cylinder to move said footstock center toward an operative position, a manually operated electrically controlled means to control said piston and cylinder so as to cause the footstock center to move to an operative position, and means including an electrical switch operated by movement of the footstock to an operative position to initiate a forward feeding movement of the grinding wheel.

4. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support thereon including a headstock and a footstock each having a work supporting center, a hydraulically operated piston and cylinder to move said slide transversely, a control valve therefor, means including an electrically operated time delay relay to actuate said valve to initiate and control a grinding cycle, a hydraulically operated piston and cylinder to move said footstock center toward and from an operative position, a control valve therefor, a manually operated electrically controlled means to shift said valve to move the footstock center to an operative position, and means including an electric switch actuated by the movement of the footstock center to an operative position to shift said feed control valve to initiate a forward feeding movement of the slide and to render said time delay relay operative so as to control the grinding cycle.

5. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support thereon including a headstock and a footstock each having a work supporting center, a hydraulic piston and cylinder to move the slide transversely, a control valve therefor, means including an electric solenoid to actuate said valve to produce a forward feeding movement of the slide, means including an electrically operated time delay relay to control the extent of forward movement of the slide, a hydraulic piston and cylinder to move said footstock center toward and from an operative position, a solenoid actuated valve therefor, manually operated electrically controlled means to actuate said solenoid valve to move the footstock center to an operative position, and means including an electric switch actuated by movement of said footstock center to an operative position to energize said solenoid and initiate a forward feeding movement of the grinding wheel and to set said time delay relay in motion.

6. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support therein including a headstock and a footstock each having a work supporting center, a hydraulic piston and cylinder to move said slide, a control valve therefor which is normally held in a position to cause a rearward movement of the slide, an electric solenoid to actuate said valve to initiate a forward feeding movement of the slide, an electrically operated time delay relay to control said solenoid, a hydraulic piston and cylinder to move the footstock center toward and from an operative position, an electric solenoid controlled valve therefor, a manually operated switch to control said solenoid valve to actuate said footstock center, and an electrical interlock between said wheel slide and footstock center whereby the wheel slide actuating mechanism is rendered inoperative until the footstock center has shifted into an operative position.

7. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support thereon including a headstock and a footstock each having a work supporting center, a rotatable work rotating spindle in said headstock to support said headstock center, a work ejector slidably mounted within said cylinder, means including an electrical time delay relay to control the transverse movement of the wheel slide, a piston and cylinder to move said footstock center toward and from an operative

position, a hydraulic piston and cylinder to actuate said ejector, means including a manually operable electrical control means for said footstock and ejector, and means including an electric switch actuated by and in timed relation with the time delay relay to render the ejector operative to eject a work piece after a grinding operation has been completed.

8. In a grinding machine having a rotatable grinding wheel, a transversely movable slide therefor, a longitudinally movable table, a rotatable work support thereon including a headstock and a footstock each having a work supporting center, a rotatable work rotating spindle in said headstock to support the headstock center, a work ejector slidably mounted within said spindle, a hydraulically operated piston and cylinder to move said wheel slide, means including an electrically operated time delay relay to control the forward movement of the slide, a hydraulic piston and cylinder to move said footstock center toward and from an operative position, a solenoid actuated valve to control the admission of fluid to said cylinder, a hydraulic piston and cylinder to actuate said ejector, a solenoid actuated valve to control the admission of fluid to said ejector cylinder, a manually operated electrically controlled means to actuate the footstock solenoid valve to initiate a movement of the footstock center to an operative position, an electrical interlock actuated by movement of the footstock center to an operative position to initiate a forward movement of the wheel slide, and electrically controlled means actuated by the time delay relay to operate said ejector solenoid valve to eject a work piece at the end of a grinding cycle.

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