

April 23, 1935.

W. D. ARCHEA

1,998,603

GRINDING MACHINE

Filed Feb. 3, 1933

4 Sheets-Sheet 1

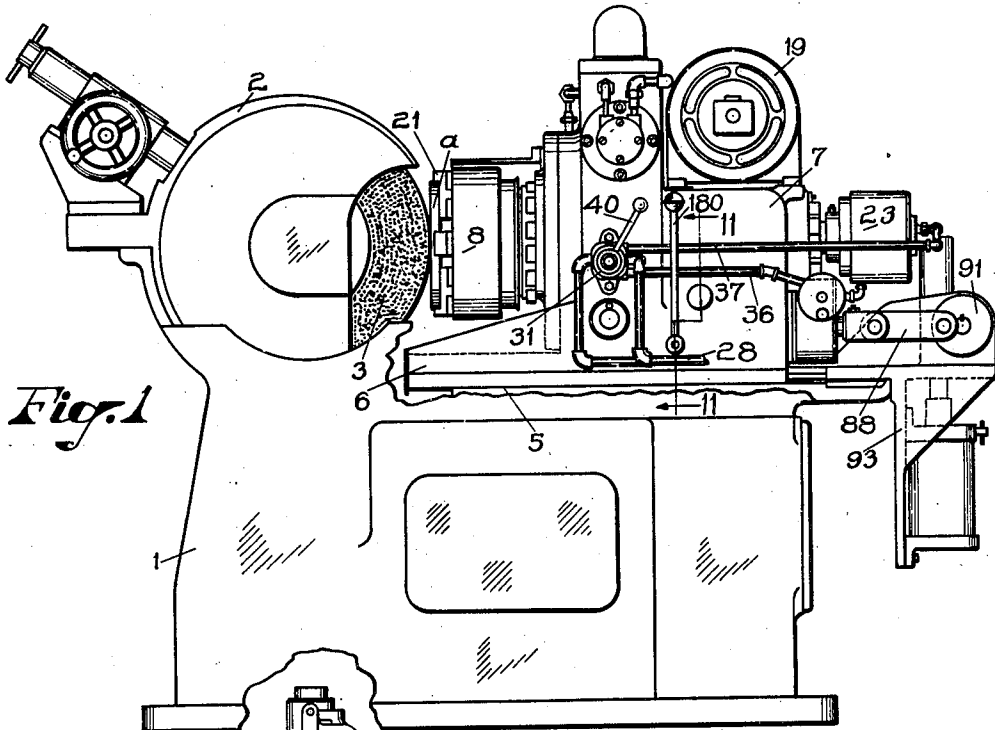


Fig. 1

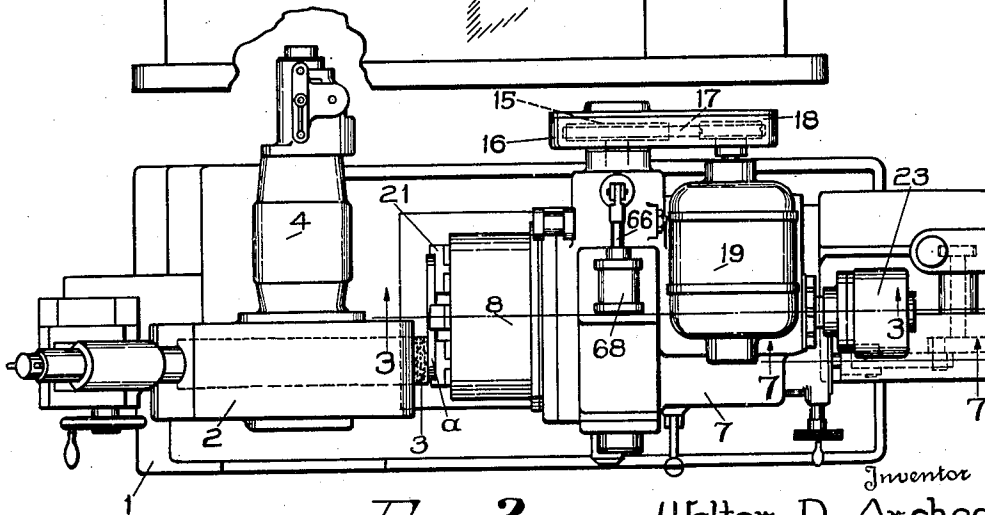


Fig. 2

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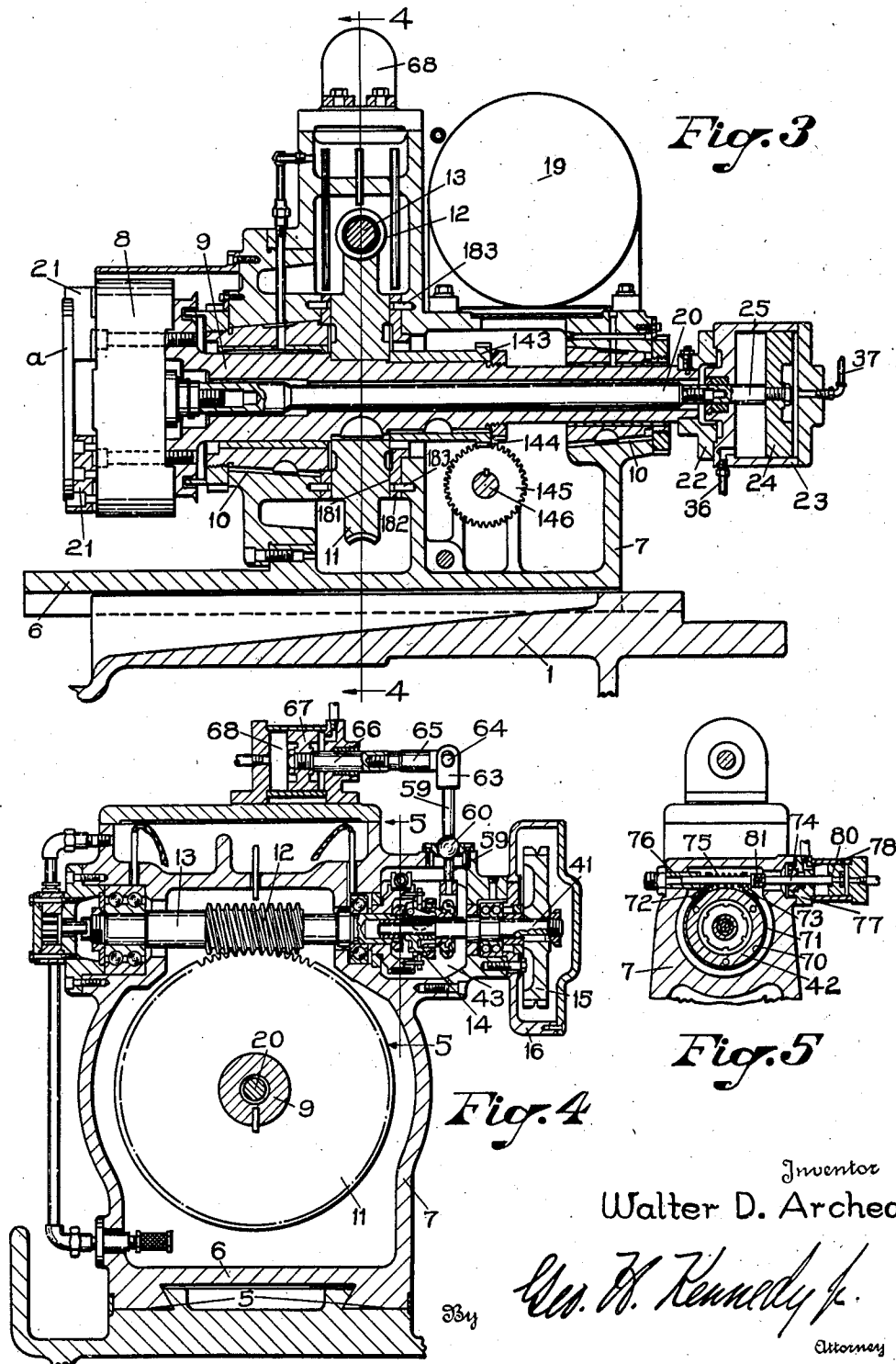
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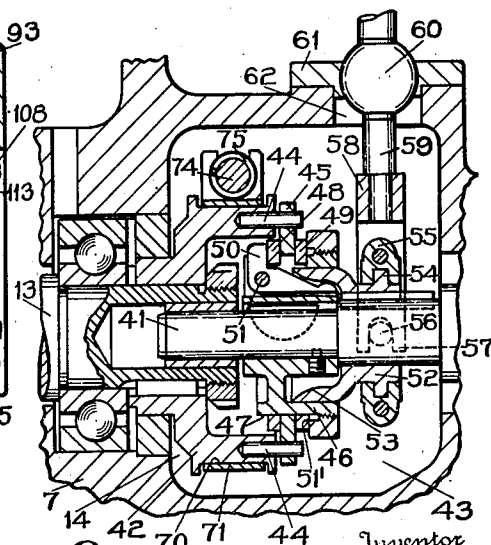
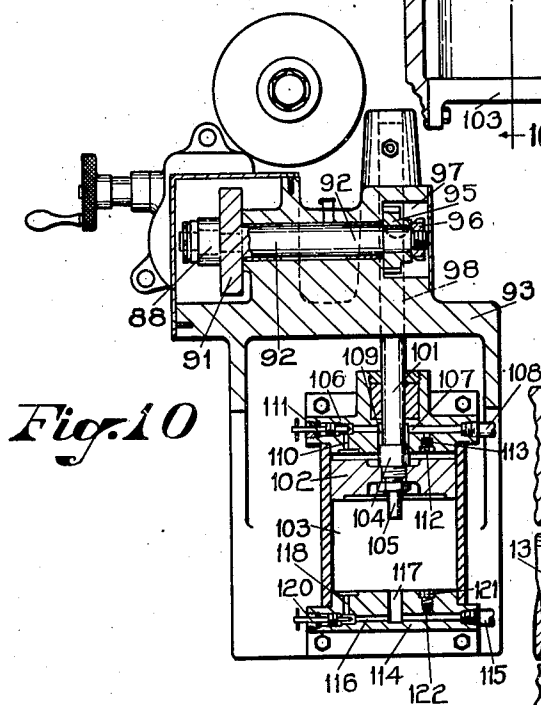
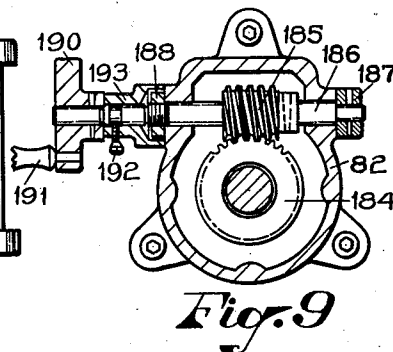
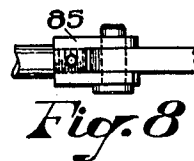
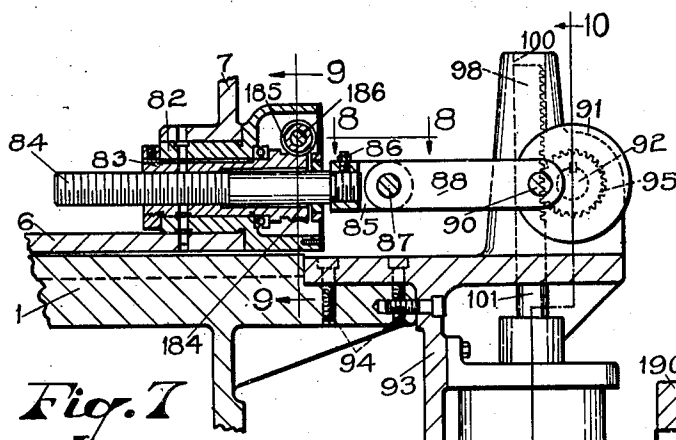
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4 Sheets-Sheet 3



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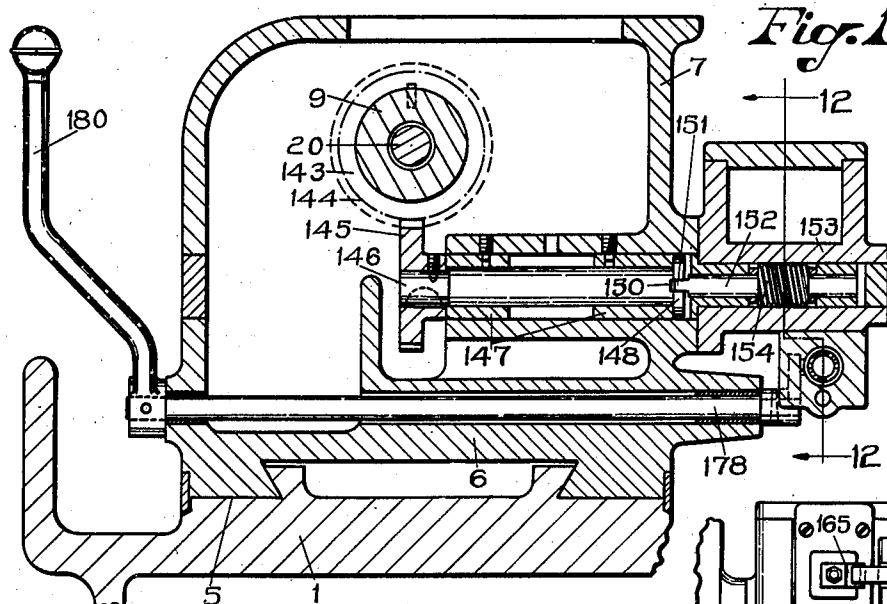


Fig. 11

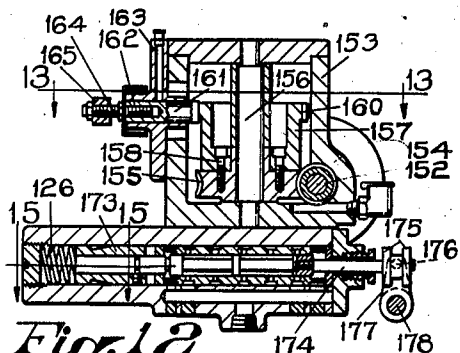


Fig. 12

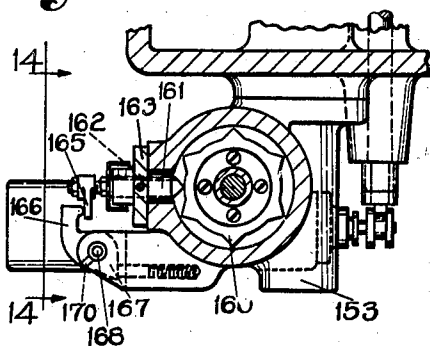


Fig. 13

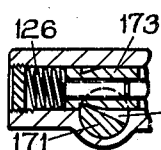


Fig. 15

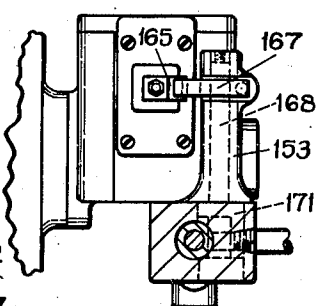


Fig. 14

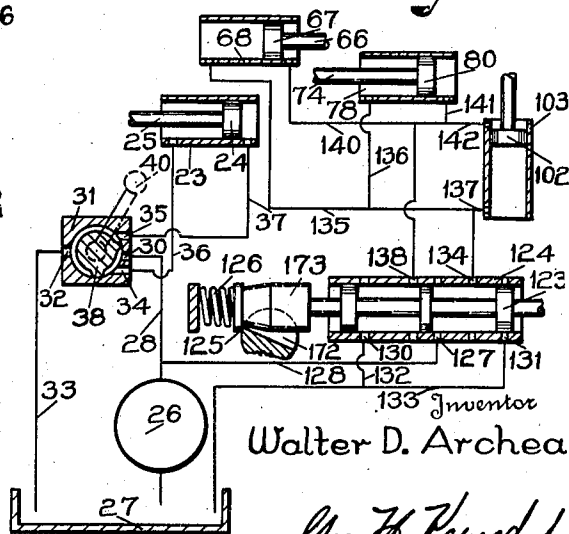


Fig. 16

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1,998,603

GRINDING MACHINE

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Application February 3, 1933, Serial No. 655,069

11 Claims. (Cl. 51—106)

The present invention relates to grinding machines and particularly to a surface grinder for use especially in the grinding of the faces of disc-shaped articles such as clutch discs and the like.

5 In prior devices of this character, the grinding wheel is moved into and out of operative position and the relative feeding movement of the workpiece is procured either manually or in certain cases at a predetermined constant rate by mechanically controlled mechanism. One of the principal objects of the present invention is to provide a feeding movement which advances the workpiece toward the grinding wheel at a constantly diminishing rate. In this manner, the grinding operation begins with a relatively coarse feed and is gradually reduced to a very fine or slow feed which results in a smooth polished surface.

15 A further feature of the invention resides in the provision of a machine of the surface grinder type, the cycle of which is automatically controlled, the machine being brought to rest at the completion of a grinding operation. In this machine, the grinding operation is discontinued in response to rotation of the workpiece or the workholding member in which the workpiece is mounted.

20 Other objects and advantages of the invention will more fully appear from the following detailed description taken in connection with the accompanying drawings in which:—

Fig. 1 is a front elevation of a machine embodying the invention.

Fig. 2 is a plan view of the machine of Fig. 1.

35 Fig. 3 is a vertical section along the line 3—3 of Fig. 2, showing the construction of the workholder.

Fig. 4 is a vertical section along the line 4—4 of Fig. 3 showing the driving mechanism for the workholder.

40 Fig. 5 is a vertical section along the line 5—5 of Fig. 4.

Fig. 6 is an enlarged fragmentary view of the clutch and brake unit shown in Fig. 4.

45 Fig. 7 is a vertical section substantially along the line 7—7 of Fig. 2.

Fig. 8 is an enlarged detail of the structure of Fig. 7 as viewed along the line 8—8 of this figure.

50 Fig. 9 is a sectional view along the line 9—9 of Fig. 7.

Fig. 10 is a vertical section substantially along the line 10—10 of Fig. 7 showing the fluid pressure mechanism for actuating the workhead.

55 Fig. 11 is a vertical section along the line 11—11 of Fig. 1.

Fig. 12 is a vertical section along the line 12—12 of Fig. 11 showing the control valve for the workhead.

Fig. 13 is a section along the line 13—13 of Fig. 12.

Fig. 14 is a section along the line 14—14 of Fig. 13.

Fig. 15 is a detailed section along the line 15—15 of Fig. 12.

Fig. 16 is a fluid pressure diagram.

Like reference characters refer to like parts in the different figures.

Referring to Figs. 1 and 2, the machine comprises a base 1 on which is mounted a housing 2 for a grinding wheel 3, the spindle of which is journaled in horizontal bearings 4 also mounted on the base. The base also provides ways 5, see Figs. 4 and 11, on which a table or carriage 6 is horizontally movable toward or away from the grinding wheel and perpendicularly to the axis thereof. The carriage 6 has, as an integral part thereof, a workhead or housing 7 which provides a support for a rotary workholder 8 in which a workpiece *a* is mounted. Said workpiece, which is shown as a disc having an annular flat surface to be ground, is positioned with the surface to be ground in opposed relation to the periphery of the grinding wheel and the latter, as will be apparent, is at least as wide as the width of the annular surface of the workpiece between the inner and outer edges thereof in order that the wheel may grind over the entire width of the surface of the workpiece without a reciprocatory traverse of said wheel.

Referring now to Fig. 3, the workholder 8 is carried on the end of a hollow spindle 9 which is journaled in bearings 10 provided by the housing 7. A worm gear 11 is secured against rotation and against axial movement on said spindle and is in engagement with a worm 12 carried by a shaft 13 journaled as shown in Fig. 4 in the housing 7. Said shaft 13 is connected through a clutch and brake mechanism 14, shown in detail in Fig. 6 and hereinafter more fully described, to a pulley 15 in a housing 16 secured to the housing 7. Said pulley 15 is connected by a suitable belt 17 to a pulley 18 on the shaft of a driving motor 19, said belt 17 and pulley 18 being also mounted in the housing 16.

A draw rod 20 is longitudinally slidable in the hollow spindle 9 and is connected in any suitable manner to the jaws 21 of the work-supporting member or workholder 8, the latter being of any desired type in which a movement of the draw rod to the right, Fig. 3, operates to

close the jaws for clamping a workpiece therein, and movement of said draw rod to the left operates to open the jaws for releasing the workpiece. For actuation of the draw rod 20, the spindle 9 carries a flange 22 on the right hand end thereof, and said flange has secured thereto a cylinder 23 in which a piston 24 is slidable, said piston being connected by a piston rod 25 to the end of the draw rod 20. Fluid under pressure is admitted selectively to opposite sides of the piston for opening or closing of the jaws of the workholder.

Referring now to Fig. 16, fluid under pressure is supplied by a pump 26 which draws fluid from a tank 27 in the base of the machine. From the pump, fluid under pressure is conducted by a pipe 28 to an inlet port 30 in a valve casing 31, the latter being positioned on the front of the machine, as shown in Fig. 1. Said casing is provided with an exhaust port 32 connected by a conduit 33 to the tank and is also provided with outlet ports 34 and 35 connected by pipes or conduits 36 and 37 to the left and right hand ends respectively of the cylinder 23. The valve casing 31 has a valve 38 therein, the projecting stem of which is provided with a hand lever 40 by which said valve is turned in the casing for selectively connecting the inlet port 30 to either of the outlet ports 34 or 35 and at the same time connecting the opposite outlet port to the exhaust port 32. Fluid under pressure is thereby directed selectively to the cylinder 23 on either side of the piston. The jaws of the workholder may thus be opened or closed as desired by movement of the lever 40 which, as will be apparent, is accessible on the front of the machine.

As above stated, the hollow work-supporting spindle 9 is brought to rest or set in rotation by actuation of the clutch and brake mechanism 14 without stopping the driving motor 19. Referring now to Fig. 6, in which this mechanism is shown in detail, the shaft 13 by which the spindle 9 is rotated is recessed at one end thereof to provide a journal for the left hand end of the shaft 41 on which the pulley 15 is mounted, said shaft 41 being journaled in the housing 7 in axial alinement with the shaft 13. The shaft 13 has secured thereto a member 42 adjacent the right hand end thereof and within the opening 43 provided in the housing 7 for the clutch and brake mechanism. Said member 42 has a plurality of projecting pins 44 which extend parallel to the axis of the shaft 13 and provide a support for an annular friction or clutch disc 45, the latter being axially slidable on said pins.

The end of the shaft 41 adjacent the end of the shaft 13 has a member 46 secured against rotation thereon and the member 46 provides an annular surface 47 on which a pair of annular friction or clutch discs 48 and 49 are longitudinally slidable and supported against rotation thereon. Said member 46 also provides a plurality of bell crank levers 50 mounted in slots provided by said member and pivoted on pins 51 therein. One end of said bell crank levers engages the outer of the two friction discs 48 and 49 for urging said discs toward each other and into engagement with the friction disc 45 which is positioned between them to prevent relative rotation between said disc 45 and the other discs to procure in response to rotation of the member 46 a corresponding rotation of the shaft 13. The member 46 provides a shoulder 51' against which the friction discs are urged by the bell

crank levers, said shoulder preventing movement of said discs to the right.

An actuating member 52 for the bell crank levers 50 which is slidably mounted on the shaft 41 and secured against rotation thereon has an annular cam-shaped surface 53 for engagement with the free ends of the bell crank levers 50 for supporting said levers in the position shown with the friction discs in positive driving engagement. Movement of the actuating member 52 to the right from the position shown releases the bell crank levers to permit separation of the several friction discs, thereby breaking the drive connection between the shaft 41 and the shaft 13 so that the latter may be brought to rest. Movement of the member 52 to the left reengages the clutch disc to procure rotation of the shaft 13 and accordingly rotation of the workholder 8.

The actuating member 52 is provided with an integral annular flange 54 on which a grooved ring 55 is rotatably mounted, said ring being split to permit mounting of the latter upon said flange. Said ring 55 is provided with projecting pins 56 in diametrically opposed relation and said pins are received in notches 57 in the ends of a bifurcated member 58 which is mounted on the lower end of a rod 59. The latter is provided with an enlarged spherical portion 60 which is journaled in a cover plate 61 suitably secured over an opening 62 in the housing 7, said spherical portion providing for rocking movement of said shaft.

Referring now to Fig. 4, the upwardly projecting end of the rod 59 beyond the spherical portion 60 has secured thereto a U-shaped member 63, the ends of which are provided with alined openings for the reception of a pin 64 carried by the end of a rod 65. The latter forms an extension of a piston rod 66 projecting from a piston 67 which is movable in a cylinder 68 mounted on the housing 7 and which is actuated in response to fluid under pressure admitted selectively to the cylinder on either side of the piston. Movement of the piston 67 to the left procures a corresponding movement of the actuating member 52, Fig. 6, to the right to separate the clutch discs, and movement of said piston to the right procures, through movement of the member 52 to the left, reengagement of said clutch discs, thereby procuring rotation of the workholder 8 in response to rotation of the shaft 41.

When the connection between the shafts 13 and 41 is broken, the workholding member 8 is brought to rest by a brake mechanism, the construction of which is best shown in Figs. 5 and 6. Referring to these figures, the member 42 which, as above stated, is secured to the end of the shaft 13, is provided with a cylindrical surface 70 which is encircled by a brake band 71. The opposite ends of said brake band are provided with suitable lugs 72 and 73 through which a rod 74 projects, said lugs being urged apart by a spring 75 which encircles said rod. One end of said rod 74 is slidable in a sleeve 76 secured in the housing 7 and the opposite end of said rod is slidable in a cap 77 forming one end of a cylinder 78 in which a piston 80 secured to the end of said rod 74 is movable, said cylinder being suitably secured to the housing 7. The rod 74 carries a collar 81 adjustable thereon and in a position to engage with the lug 73 during movement of said rod to the left, Fig. 5. The opposite lug 72 engages the end of the sleeve 76 so that a movement of the rod 74 to the left

tightens the brake band around the surface 70 to bring the shaft 13 and accordingly the workholder 8 to rest. Movement of said rod 74 to the right from the braking position releases the lug 73 and the spring 75 procures separation of the lugs 72 and 73 to release the brake band. Shifting movement of the rod 74 is procured by admission of fluid under pressure selectively to the cylinder 78 on opposite sides of the piston 80, as will be pointed out hereinafter, for shifting of said piston to one end or the other of the cylinder, thereby procuring a corresponding movement of the rod 74 secured thereto.

With a workpiece *a* mounted in the workholder 8 and rotated from the driving motor 19, a movement of the workhead to the left, Fig. 1, is procured by fluid under pressure for a movement of the workpiece into grinding position and for a feeding movement of said workpiece against the grinding wheel, said movements being procured by movement of the table 6 on which the workhead is mounted. Referring particularly to Fig. 7, the housing 7, of which the table 6 is a part, has secured thereto a housing 82 in which an internally threaded sleeve 83 is journaled, the latter being supported against axial movement in said housing. Said sleeve 83 receives a threaded rod 84, the right hand end of which is provided with a U-shaped member 85 secured thereto by a set screw 86. The ends of said member 85 are connected by, and provide a support for, a pin 87 on which one end of a link 88 is pivotally mounted. The opposite end of said link 88 is mounted on a pin 90 carried by an enlarged portion 91 of a shaft 92 (see Fig. 10) journaled in a bracket 93 which is secured by bolts 94 to the base of the machine. The pin 90 is eccentric to the axis of the shaft 92 so that turning movement of said shaft procures a longitudinal movement of the member 85 and corresponding feeding movement of the housing 7 to the left.

Rotation of the shaft 92 is procured in response to fluid under pressure. Referring to Figs. 7 and 10, the shaft 92 carries, at the end remote from the enlarged portion 91, a gear 95 secured against removal and against rotation on said shaft by a nut 96. Said gear which is positioned within a recess 97 in the bracket 93 engages a rack 98 vertically movable in a bore 100 provided in said bracket. Said rack 98 is secured to and forms an extension of a piston rod 101 and the lower end of the latter is secured to a piston 102 in a cylinder 103 secured to the bracket 93. The piston rod 101 just above the piston 102 is provided with an enlarged cylindrical portion 104 and a projecting portion 105 on the lower end of said rod extends a short distance below the piston; said portions 104 and 105 control the rate of movement of the piston within the cylinder as will hereinafter appear.

Fluid under pressure is admitted to either end of the cylinder above or below the piston to procure movement of the same for actuating the workhead. As the piston moves upwardly in response to fluid under pressure entering below the piston, the rack is moved upwardly therewith, procuring a turning movement of the shaft 92 (as seen in Fig. 7) and corresponding longitudinal movement of the workhead 7 toward the grinding wheel to advance the workpiece into grinding position and to feed the workpiece against the grinding wheel when in grinding position. The workpiece is withdrawn from the grinding wheel during the downward movement of the piston to provide for removal of the completed workpiece

and positioning of an unground workpiece in the workholding member 8. As will be pointed out hereinafter, the crank motion for feeding the workpiece against the grinding wheel results in a rapid feeding movement at the beginning of the grinding operation which is gradually reduced during that operation until, in the forward position of the carriage which supports the workpiece, there is no forward feed and a very smooth finish is accordingly produced on the workpiece.

The movements of the piston 102 are under the control of valves best shown in Fig. 10. Referring to this figure, the cylinder head 106 at the upper end of the cylinder 103 is provided with a horizontal channel 107 which extends from an inlet port 108 and intersects a vertical cylindrical bore 109 surrounding the piston rod. Said bore is of the proper size to receive the enlarged portion 104 of the piston rod 101 as the piston approaches the upper end of its movement, thereby cutting off the flow of fluid through the bore 109. Said horizontal channel 107 also intersects another vertical bore 110, and the flow of fluid through this bore is adjusted and controlled by a needle valve 111 provided in said horizontal channel. An additional vertical bore 112 is provided in the cylinder head 106 and intersects the horizontal channel 107. The bore 112 is provided with a suitable check valve 113, the latter being, for example, in the form of a ball urged against the valve seat by a spring, said valve being of well-known construction. The check valve 113 is positioned to permit free passage of fluid into the cylinder during downward movement of the piston and to prevent exhaust of fluid through said bore 112 during upward movement of said piston. The lower cylinder head 114 for the cylinder 103 is similarly provided with a port 115 from which extends a horizontal channel 116 intersected by a vertical bore 117 which is of the proper size and in a position to receive the projecting end 105 of the piston rod as the piston approaches the lower limit of movement. Said horizontal channel 116 is also intersected by a vertical bore 118 connecting said horizontal channel to the interior of the cylinder, and the fluid supply through said vertical bore is limited by a needle valve 120 similar to the valve 111 and of any suitable construction. An additional vertical bore 121 which intersects the horizontal channel is provided with a check valve 122 similar to the check valve 113. The check valve 122 is arranged to prevent exhaust of fluid through the bore 121 from within the cylinder, although admitting fluid freely into the cylinder during upward movement of the piston.

As fluid enters the cylinder 103 beneath the piston 102 for advancing the workpiece toward the grinding wheel, the piston moves upwardly to the position shown in Fig. 10 at a rapid rate, fluid being admitted freely to said cylinder past the check valve 122. As soon as the piston is advanced far enough to withdraw the projecting end 105 of the piston rod from the vertical bore 117, the fluid under pressure may enter through said vertical bore for procuring a continued upward movement of the piston. At the same time, fluid from above the piston exhausts through the vertical bore 109 surrounding the piston rod so that the exhaust of fluid is unthrottled.

The rapid movement of the piston upwardly procures a rapid advance of the workpiece from inoperative position into operative or grinding position and this movement would, if not suitably checked, cause the workpiece to engage the grind-

ing wheel too rapidly. To avoid this condition, the rate of movement of the workpiece toward the grinding wheel is materially reduced just as the workpiece comes into contact with said wheel.

At this point in the advancing movement of the workpiece, the piston is approaching the upper end of its movement. Just before the workpiece engages the grinding wheel, the enlarged portion 104 enters and closes the vertical bore 109 so that further exhaust of fluid from above the piston during the remainder of the upward movement of said piston occurs at a very slow rate past the needle valve, escape of fluid through the bore 112 being prevented by the check valve. This material reduction in the rate of exhaust of fluid from the cylinder causes the piston to travel at a very reduced rate of speed during the remainder of its upward movement for a slow feeding movement of the workpiece against the grinding wheel.

The crank motion by which the movement of the workhead is procured in response to the rotation of the shaft 92 results in a constantly diminishing rate of feed in response to the movement of the piston at a uniform rate. The feeding movement of the workhead is discontinued when the piston reaches the upper end of its movement at which time the eccentric pin 90 is in horizontal alignment with the shaft 92 and the workhead remains in the forward position with the workpiece in engagement with the grinding wheel for a short period in order to procure a finish grinding operation on the workpiece. The workhead is then retracted into inoperative position at a rapid rate, as will hereinafter appear.

Upon reversal of the flow of fluid to the cylinder 103 the piston 102 moves downwardly to withdraw the grinding wheel from the work piece. The movement of said piston occurs at a relatively rapid rate, the fluid from beneath the piston exhausting through the bore 117 until the piston approaches the end of its downward movement. At this time, the projecting end 105 of the piston rod enters and closes the vertical bore 117 to prevent further exhaust of fluid through said bore, the fluid thereafter exhausting slowly past the needle valve 120 so that the remaining downward movement of the piston is procured at a relatively slow rate. The workhead is thus brought to rest in inoperative position when the piston reaches the lower end of its movement without any excessive jarring of the parts which would occur if the rate of movement of the piston were not decreased.

The workholding member 8 is set in rotation at the beginning of the forward movement of the workpiece toward the grinding wheel. Referring now to Fig. 16, the admission and exhaust of fluid under pressure to and from the clutch cylinder, the brake cylinder, and the work-feeding cylinder is controlled by a single valve 123 in a casing 124. During the movement of the workpiece toward the grinding wheel the valve 123 is held in the left hand position shown by a latch 125 against the tension of a spring 126. An inlet port 127 in the valve casing 124 is connected by a conduit 128 to the pressure side of the pump, and exhaust ports 130 and 131 in said casing are connected by conduits 132 and 133 to the tank 27. An outlet port 134 in said casing is connected by a conduit 135 to the left hand end of the clutch cylinder 68 and by conduits 136 and 137 to the left hand end of the brake cylinder 78 and to the lower end of the work-advancing cylinder 103 respectively. Another outlet port 138 is connected by leads 140, 141 and 142 to the right hand

end of the clutch cylinders, the right hand end of the brake cylinder and the upper end of the work-feeding cylinder respectively.

With the valve 123 in the position shown, fluid under pressure is admitted to the left hand end of the brake cylinder 78 for shifting the piston 80 therein to the right, thereby releasing the brake to permit rotation of the work-supporting member. At the same time, fluid under pressure is admitted to the left hand end of the clutch cylinder 68 to procure engagement of the clutch discs and thereby to cause rotation of the work-supporting member. Fluid under pressure is also admitted at this time to the under side of the work-advancing piston 102 for advancing the workpiece from inoperative position into operative relation to the grinding wheel and for a feeding movement of said workpiece against the wheel.

The valve 123 is supported in the left hand position shown for a predetermined period and is then released from the latch for movement to its right hand position under the influence of the spring 126. In this position of the valve, fluid under pressure is directed to the right hand ends of the clutch and brake cylinders and to the upper end of the work-advancing cylinder for retracting the workpiece from the grinding wheel, for disengaging the clutch discs, and for bringing the workholding member to rest. The valve 123 in its right hand position also connects the opposite ends of said cylinders to the exhaust port of the casing 124 to permit discharge of fluid from within said cylinders.

The grinding operation is controlled by the rotation of the workholding member, and after a predetermined rotation thereof, the above noted valve 123 is automatically shifted to the right hand end position to bring the grinding operation to a close. Referring now to Fig. 3, the spindle 9 for the work-supporting member 8 has a sleeve 143 secured against rotation thereon and provided with gear teeth 144 engaging with similarly formed teeth on a gear 145 keyed to a shaft 146 journaled, as shown in Fig. 11, in bearings 147 secured in the workhead. Said shaft 146 has an enlarged end 148 remote from the gear 145 and this end is provided with a slot 150 for the reception of a tongue 151 formed on the end of a shaft 152 journaled in a housing 153 which is secured to the workhead. The shaft 152 carries a worm 154, Fig. 12, which engages with a worm gear 155 carried by a shaft 156 also journaled in the housing 153. An annular member 157 surrounds said shaft 156 and is secured to the worm gear 155 by bolts 158 for rotation therewith. One end of said annular member 157 provides a star wheel 160 (Fig. 13) for engagement with one end of a plunger 161 longitudinally slidable in a bearing 162 provided by a cap 163 secured to the housing 153. A threaded rod 164 engages a threaded bore in the end of said plunger 161 and carries on the outer end thereof a projecting arm 165 which is secured against rotation on said rod. The plunger 161 is held against rotation in the bearing 162 by a suitable key and thus supports the arm 165 in a position for engagement with the projecting arm 166 of a member 167 secured against rotation on a shaft 168 by a set screw 170, said shaft being journaled in the housing 153.

As shown in Fig. 14, the end of the shaft 168 remote from the member 167 has an enlarged portion 171 which is provided with a notch 172 forming the above noted latch 125 by which the

valve 123 is held in the left hand position shown. Thus, as the star wheel 160 is rotated, in response to the rotation of the work-supporting member, to carry a point of said wheel beneath the end of a plunger 161, said star wheel shifts the plunger to the left to rock the shaft 168 and thereby withdraw the latch 125 from the collar 173 on the valve 123 with which the latch engages. As the latch is withdrawn, the valve 123 is shifted by the spring 126 into its right hand position, thereby withdrawing the workhead from grinding position and stopping rotation of the workholding member. The control valve 123 has a projecting stem 174, Fig. 12, provided with spaced collars 175 for the reception of a pin 176 carried on the end of an arm 177. The latter is secured against rotation on the inner end of a shaft 178 journaled in the workhead (see Fig. 11), and the forward end of said shaft projects beyond the forward surface of the workhead and carries an upwardly extending lever 180 by which said valve may be manually shifted to the left for starting a grinding operation.

During the grinding operation, the pressure of the grinding wheel against the workpiece exerts an axial thrust on the workholding member and, as shown in Fig. 3, the worm gear 11, which is secured to the spindle 9, is provided with a flat annular surface 181 for engagement with a wear ring 182 secured, as by pins 183, to a portion of the workhead to prevent axial shifting of the spindle within said workhead.

To compensate for the reduction of the diameter of the grinding wheel resulting from wear thereon, as well as from dressing operations by which the surface is maintained in proper cutting position, the position of the carriage relative to the advancing mechanism is shifted by a mechanism best shown in Figs. 7 and 9. Referring to these figures, the sleeve 83 which, as above stated, is journaled in the housing 82, is provided with an integrally formed worm gear 184 which is engaged by a worm 185 mounted on a shaft 186, the latter being journaled in the housing 82. Said shaft is held against longitudinal movement in the housing 82 by collars 187 and 188, Fig. 9, secured in spaced relation to said shaft and engaging the housing 82. One end of said shaft 186 projects beyond the housing and has a hand wheel 190 secured thereto, the latter having a handle 191 by which to procure rotation of the worm 185 and corresponding rotation of the sleeve 83. Rotation of said sleeve, as will be apparent, procures advance or retraction of the threaded rod therein and accordingly shifts the position of the carriage 6 relative to the carriage advancing mechanism. A set screw 192 which extends through a cap 193 carried by the housing engages the shaft 186 to prevent unintended rotation thereof.

Assuming the parts are in the position shown in the figures, the workhead is in its advanced position at the completion of the forward feeding movement between the grinding wheel and the workpiece, the workholding member is being rotated by the motor 18, and the grinding wheel is in contact with the workpiece therein for completing the grinding operation. The rotation of the work-supporting spindle 9 procures a slow turning movement of the star wheel which, after a predetermined period, shifts the plunger 161, thereby to release the valve 123 from the latch 125, said valve then being automatically shifted to the right to supply fluid under pressure to the upper end of the work-feeding cylinder to

retract the workpiece from operative engagement with the grinding wheel. Said valve also, upon movement to the right, directs fluid under pressure to the right hand ends of the clutch and brake cylinders so that, as the workpiece is withdrawn from the grinding wheel, the driving motor is disconnected from the work-supporting spindle 9, and the latter is brought to rest by the brake mechanism. The machine comes to rest with the workhead at the right hand end of its movement in which position the workpiece is spaced from the grinding wheel.

With the workhead in this right hand position, the lever 40 is manually oscillated to admit fluid under pressure to the right hand end of the chuck actuating cylinder for opening the jaws of the chuck to permit removal of the finished workpiece and the substitution of an unground workpiece therein. The lever 40 is then again actuated for directing fluid under pressure to the left hand end of the chuck controlling cylinder, thereby clamping the unground workpiece in said workholder. A grinding operation is then procured on the unground workpiece by rocking movement of the lever 180 which shifts the control valve 123 to the left into the position shown, thereby procuring rotation of the work-supporting member and advance of the workpiece toward the grinding wheel. The work-supporting member then advances rapidly toward the wheel until the workpiece is substantially in engagement with said wheel, when the rate of movement of said work-supporting member is materially reduced for a slow feeding movement of the workpiece against the grinding wheel. The slow feeding movement thereafter continues at a constantly decreasing rate until the piston 102 reaches the upper end of its movement. The workpiece is then in its advanced position where it is retained in contact with the wheel for a predetermined period without any further feeding movement, thereby providing a smooth polished surface on said workpiece. After an interval, the star wheel which is rotated from the work-supporting spindle again procures shifting movement of the valve 123 to the right and the above-described operation is repeated.

I claim,

1. In a grinding machine, a grinding wheel and a workholding member, means for rotating said member, clutch and brake mechanisms between said rotating means and said workholding member, fluid pressure means for actuating said clutch and brake mechanisms, and means responsive to the rotation of said workholding member for controlling the admission and exhaust of fluid under pressure to said fluid pressure means.

2. In a grinding machine, a grinding member, a work-supporting member, means for rotating said work-supporting member, a carriage on which one of said members is mounted, means to actuate said carriage for advancing said members into operative position and for a relative feeding movement between said members, said actuating means also procuring a subsequent retraction of said members, and means responsive to the rotation of said workholding member to procure the retraction of said carriage for separating the grinding member from a workpiece carried by the work-supporting member.

3. In a grinding machine, a grinding member, a workholding member, means for rotating said workholding member, a carriage on which one of said members is mounted, fluid pressure means

for moving said carriage, and means responsive to the rotation of the workholding member to control the admission and exhaust of fluid under pressure to said fluid pressure means.

5 4. In a grinding machine, a grinding member and a workholding member, a carriage on which one of said members is mounted, said carriage having an inoperative position and an operative position, fluid pressure actuated means to procure
10 movement of said carriage into operative position, means responsive to movement of said fluid pressure actuated means to reduce the rate of movement of said carriage as the latter approaches operative position, and means for pro-
15 curing a subsequent feeding movement of the carriage at a continuously changing rate in response to the operation of said fluid pressure actuated means.

5. In a grinding machine, a grinding member and a workholding member, a carriage on which
20 one of said members is mounted, said carriage having an inoperative position and an operative position, fluid pressure actuated means to procure movement of said carriage into operative position, and means responsive to movement of said
25 fluid pressure actuated means to reduce the rate of movement of said carriage as the latter approaches operative position, said fluid pressure actuated means thereafter procuring a slow feed-
30 ing movement of the carriage at a continuously decreasing rate.

6. In a grinding machine, a grinding member and a workholding member, a carriage on which
35 one of said members is mounted, fluid pressure actuated means including a cylinder and piston, and means providing a connection between said fluid pressure means and the carriage and re-
40 sponsive to a uniform movement of said fluid pressure actuated means to procure a movement of said carriage at a continuously changing rate.

7. In a grinding machine, a grinding member and a workholding member, a carriage on which
45 one of said members is mounted, fluid pressure actuated means, means responsive to a uniform movement of said fluid pressure actuated means to procure a movement of said carriage at a continuously changing rate, and means to procure
50 a change in the rate of movement of said fluid pressure actuated means during the operation thereof.

8. In a grinding machine, a grinding member

and a workholding member, a carriage on which one of said members is mounted, fluid pressure actuated means, means responsive to a uniform movement of said fluid pressure actuated means to procure a movement of said carriage at a
5 continuously changing rate, and means operable in response to the movement of said fluid pressure means to procure a change in the rate of movement of said fluid pressure actuated means during the operation thereof.

9. In a grinding machine, a grinding member and a workholding member, means to rotate said
10 workholding member, a carriage on which one of said members is mounted, hydraulically actuated means to procure movement of said carriage for a relative feeding movement between said grind-
15 ing member and a workpiece in said workholding member, and means responsive to the rotation of the workholding member to procure retraction of the carriage after the carriage has remained
20 at the end of its feeding movement for a pre-determined period said retraction procuring separation between said grinding member and the workpiece.

10. In a grinding machine, a grinding member and a work-supporting member, means for ro-
25 tating a workpiece in said work-supporting member, a carriage on which one of said members is mounted, hydraulically actuated means to procure a movement of said carriage for a relative
30 feeding movement between said grinding member and the workpiece in said work-supporting member, and means responsive to the rotation of the workpiece in the work-supporting member for procuring a retraction of the carriage and a
35 cessation of rotation of the workpiece.

11. In a grinding machine, a grinding member and a work-supporting member, a carriage on
40 which one of said members is mounted, and hydraulically actuated means for procuring movement of said carriage for a relative feeding movement between said grinding member and a work-
45 piece in said work-supporting member, said means including a cylinder and piston, a rack on one of said parts, a pinion engaging said rack, and means providing a connection between said pin-
50 ion and carriage and responsive to rotation of said pinion for procuring movement of said carriage at a constantly changing rate when the pinion is rotated at a uniform rate.

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