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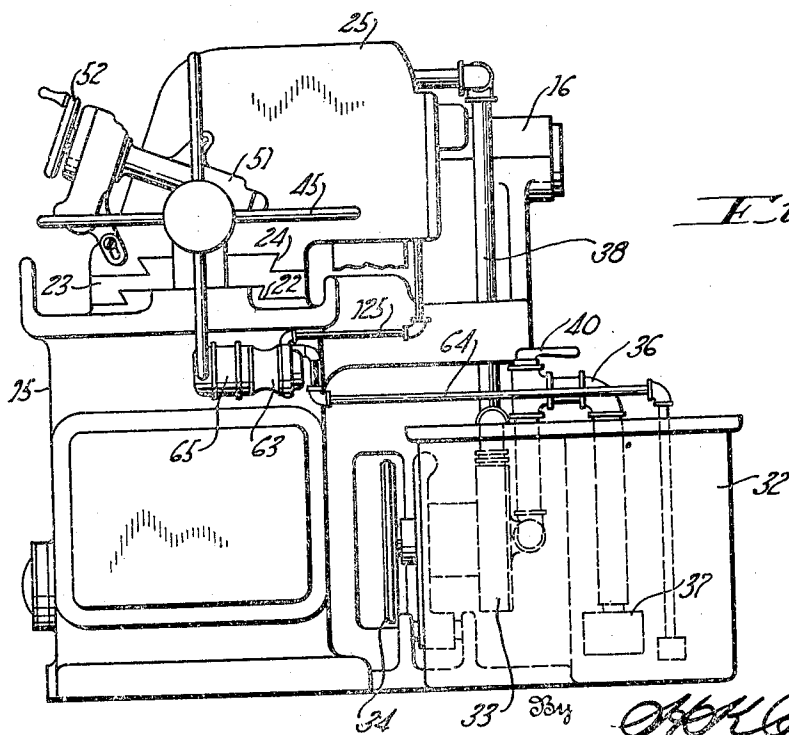
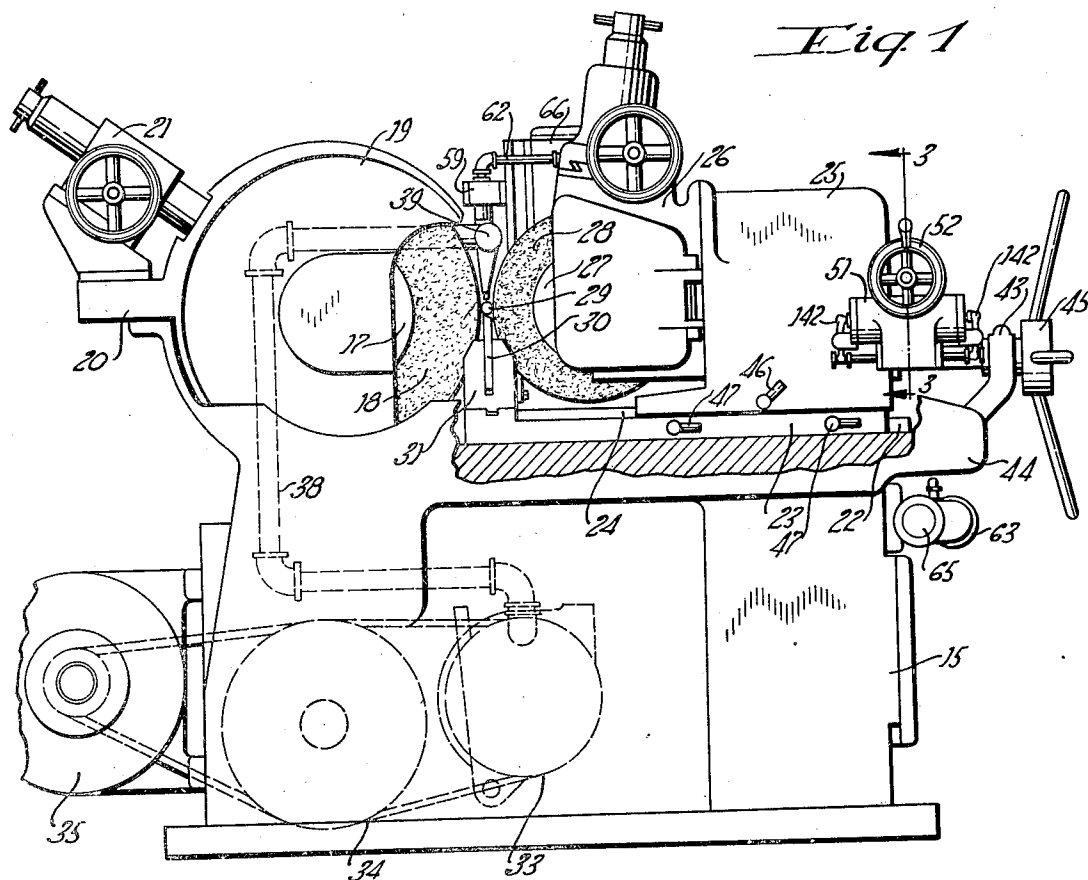
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GRINDING MACHINE

Filed Sept. 11, 1933

5 Sheets-Sheet 1



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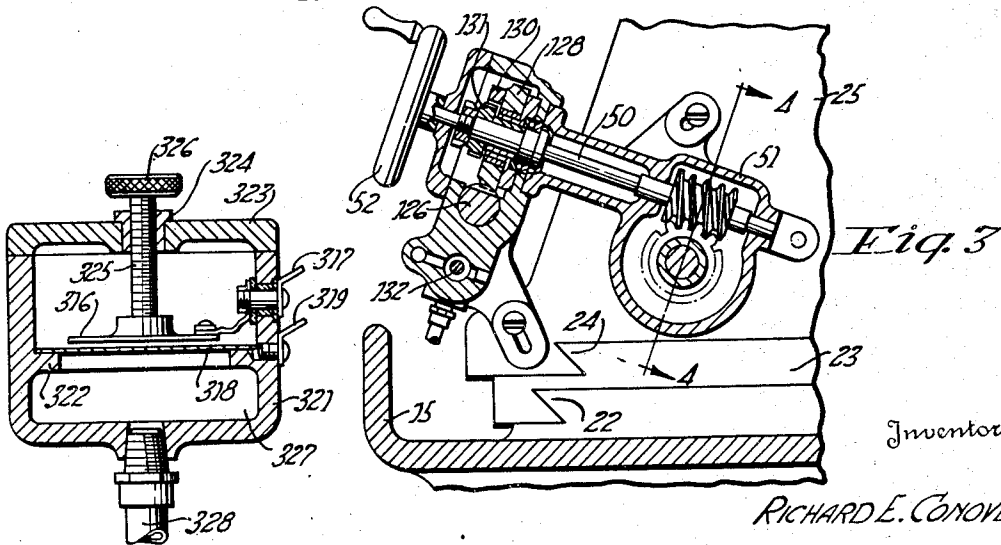
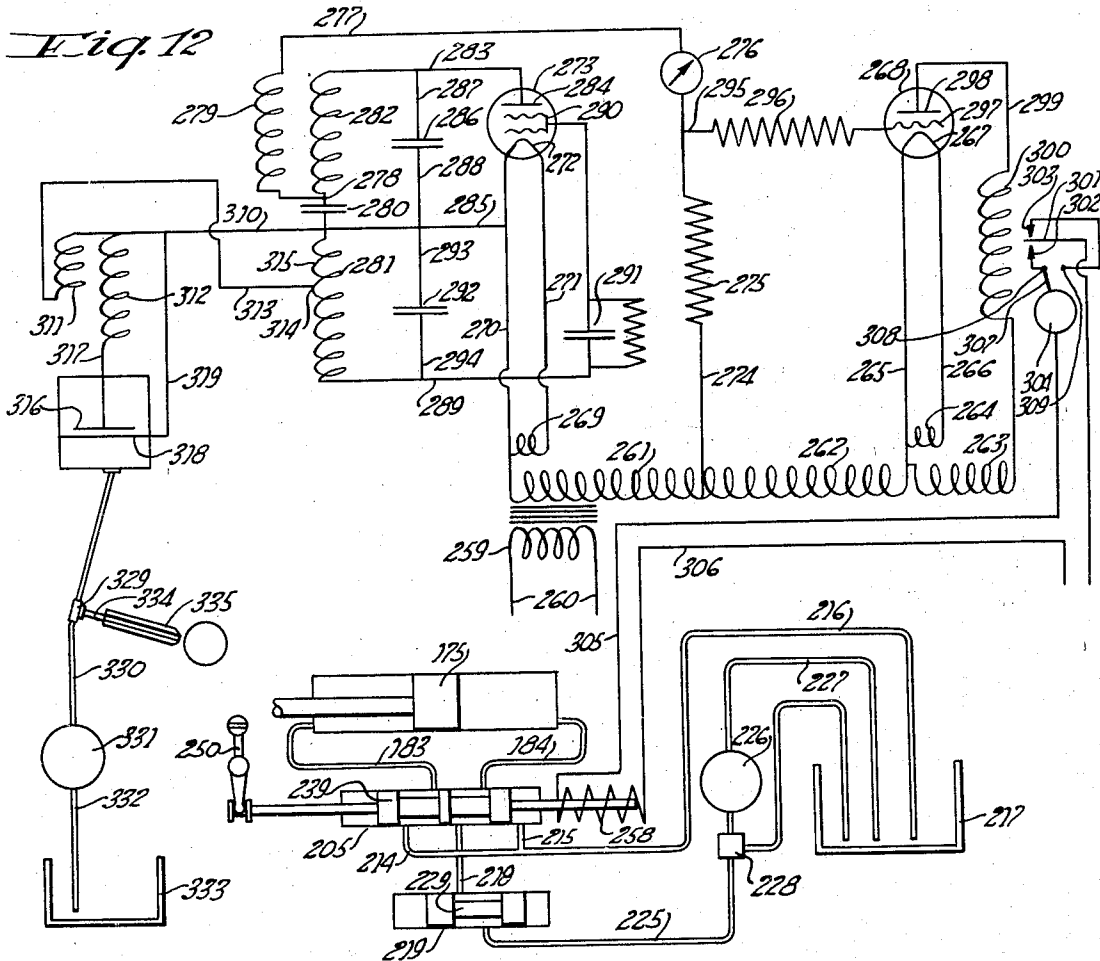


Fig. 11

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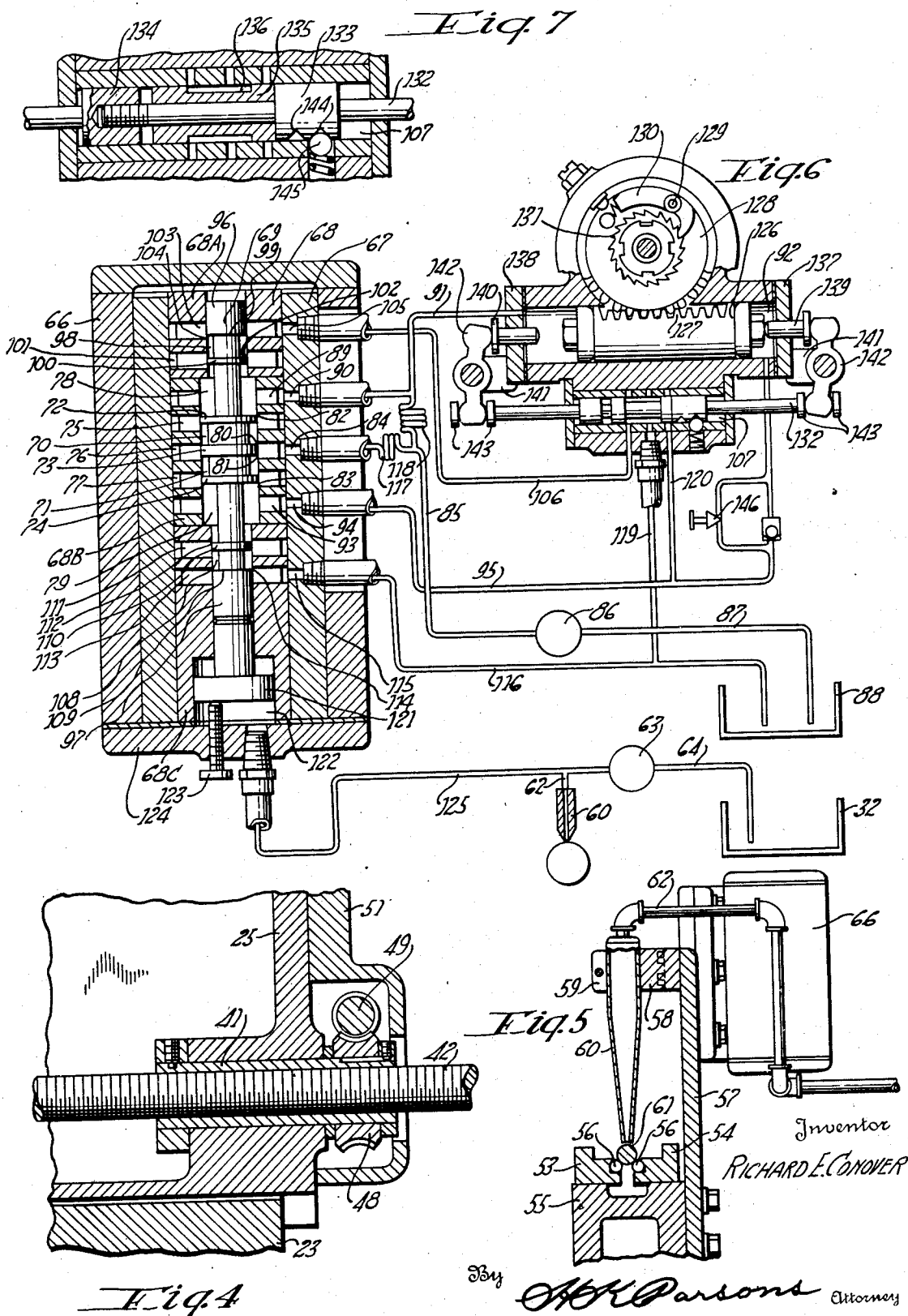
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GRINDING MACHINE

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5 Sheets-Sheet 3



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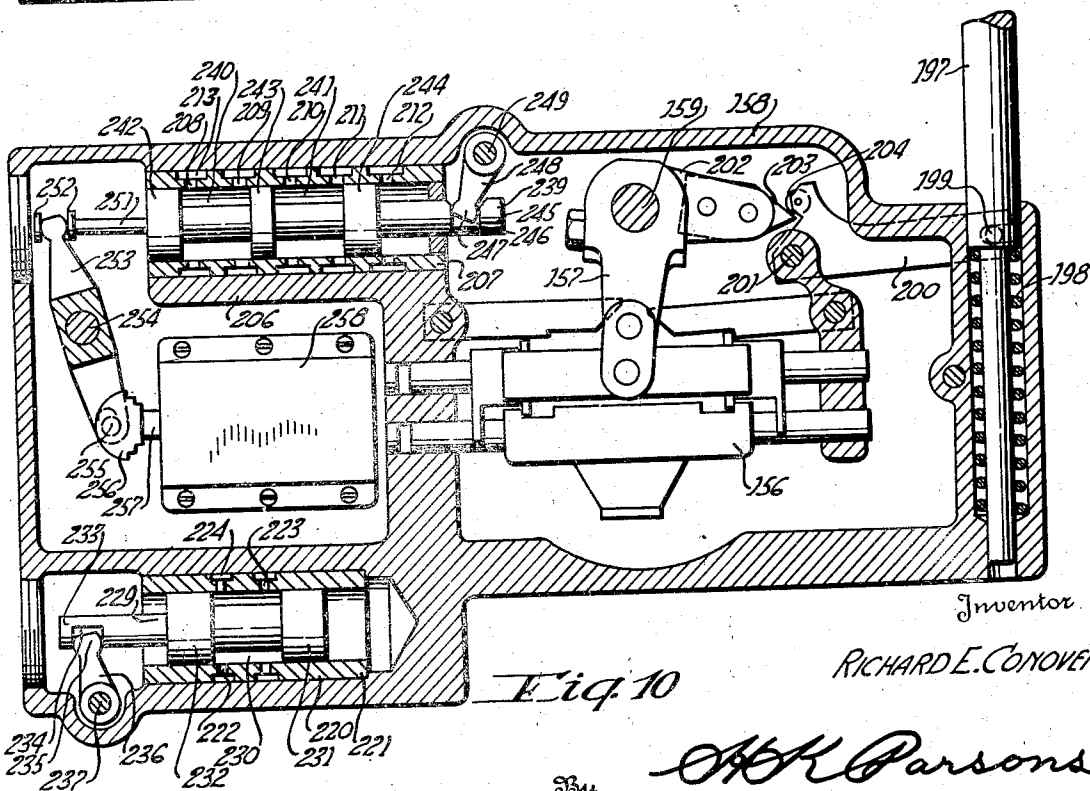
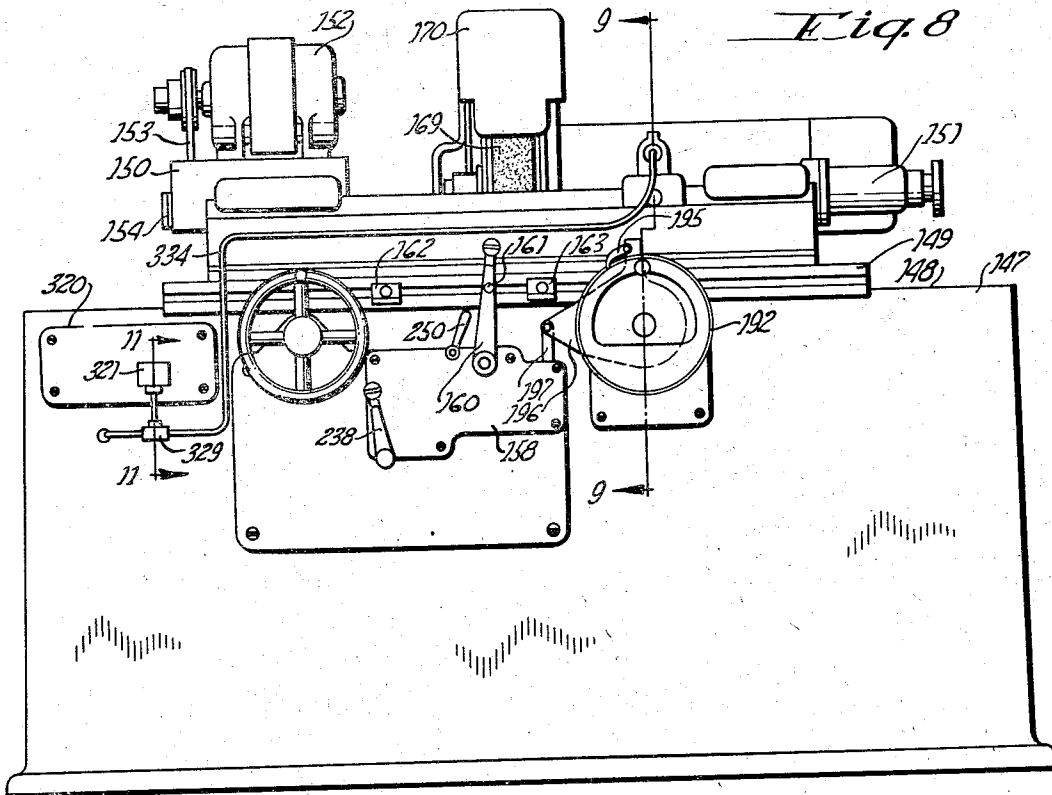
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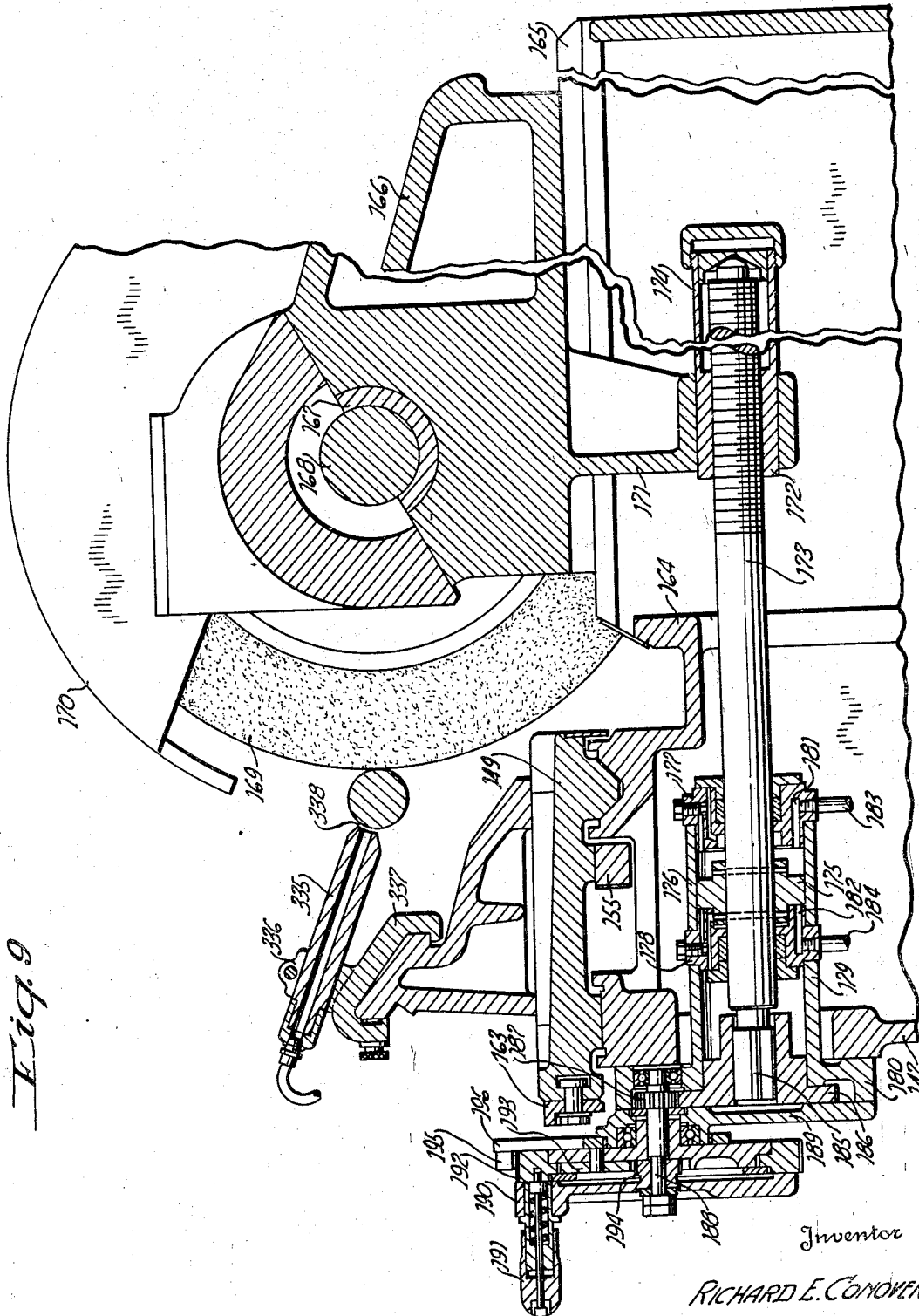
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GRINDING MACHINE

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5 Sheets-Sheet 5



UNITED STATES PATENT OFFICE

1,993,830

GRINDING MACHINE

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6 Claims. (Cl. 51—103)

This invention relates to improvements in machine tool structures and particularly to improvements in control means therefor for maintaining the size of work pieces produced by said machine.

One of the principal objects of the present invention is the provision of an improved size control mechanism for use with machine tool structures, particularly grinding machines to maintain the continuous flow of work pieces from said machines within certain definite limits of tolerance.

Another object of the invention is the provision of a size control mechanism that is not subject to rapid wear, thereby insuring the continuous even functioning of the machine.

A further object of the invention is the provision of a sizing control mechanism for accomplishing the above objects without the use of amplifying levers and the like, thereby eliminating an inherent fault now present in most devices utilized today for accomplishing this result.

A still further object of the present invention is the provision of a size control mechanism utilizing no contacting member which rides on the work, and would, therefore, be subject to wear or influenced by the coolant or other associated machine parts or element, which would tend to influence the operation of the mechanism and render the adjustment of the machine inaccurate.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Figure 1 is a front elevation of a machine tool embodying the improvements of this invention.

Figure 2 is an end elevation of the machine shown in Figure 1, as seen particularly from the left hand end thereof.

Figure 3 is a fragmentary sectional view taken on line 3—3 of Figure 1.

Figure 4 is a sectional view taken on line 4—4 of Figure 3.

Figure 5 is a sectional view through the size control elements.

Figure 6 is a view partly in section and partly diagrammatic, showing the tie-up between the feed actuating mechanism and the control mechanism therefor.

Figure 7 is an enlarged view of a valve asso-

ciated with the feed actuating mechanism and forming a detail of the invention.

Figure 8 is a front elevation of a different type of machine tool embodying a slight modification of the invention.

Figure 9 is a sectional view taken on line 9—9 of Figure 8.

Figure 10 is a sectional view through the reverse plate associated with the machine illustrated in Figure 8.

Figure 11 is a sectional view taken on line 11—11 of Figure 8, and illustrating the control element forming a detail of the invention.

Figure 12 is a diagrammatic view illustrating the hydraulic and electrical circuits involved in the invention as used with the machine in Figure 8.

Throughout the several views of the drawings similar reference characters are employed to denote the same or similar parts.

In the past, size control mechanisms have been employed with machine tools, particularly grinding machines, for effecting a periodic adjustment of the elements of the machine as the work approached the upper limit of tolerance. In these devices, however, contact members were employed which rode either on the work or on the wheel and were, therefore, subject to relatively rapid wear so that the accurate function of said devices was jeopardized. Other sizing control mechanisms utilized in the past included electrical circuits and caliper fingers or the like which engaged the work and frequently were operated either too soon or too late due to the interference set up by coolant and the like and completing the electrical circuit. By the present invention, which utilizes hydraulic principles and electrical circuits, the foregoing faults and inconveniences of prior structures have been overcome as will be made clear in the following description.

This invention may be utilized with substantially all types of machine tools, but will probably find its most useful application in connection with grinding machines which produce work pieces within extremely narrow limits of tolerances, such as fractional thousandths of an inch. The invention has, therefore, been illustrated and will be described in connection with a centerless and a center type of grinder.

Referring first to the centerless type of grinder and its control mechanism illustrated in the drawings in Figures 1 to 7 inclusive, the said machine comprises a bed 15 having rising therefrom a pedestal bearing 16 in which is mounted a spindle 17 for a grinding wheel 18. The grind-

ing wheel 18 is substantially enclosed by a hood or guard 19 for confining the coolant usual with grinding machines. The guard 19 has projecting from its one side a shelf or bracket 20 on which is mounted a truing mechanism 21 for traverse movement relative to the face of the grinding wheel 18. Extending from the grinding wheel 18 the bed 15 provides a guide 22 for a lower slide 23. The slide 23 in turn provides a guide 24 for the upper slide or housing 25. The housing 25 has secured to it a head 26 in which is journaled a spindle 27 for a second wheel 28. The wheel 28 is in practice known as a regulating wheel and controls the rotation of the work while being operated upon by the grinding wheel 18.

The grinding wheel 18 and regulating wheel 28 are respectively rotated at a high grinding rate of speed and a relatively low work rotation controlling rate of speed in the same direction. These wheels are spaced from one another a distance representative of the size of the work to be produced thereby, and forming a grinding throat in which the work 29 is disposed. The work 29 is supported peripherally by a work rest blade 30 secured in a work rest block 31 carried by the inner end of the lower slide 23.

In order to supply the necessary coolant to the work and grinding wheel during the grinding operation, there is supplied a coolant tank 32 disposed in the rear of the machine. Supported by the bed adjacent to the tank is a pump 33 having associated therewith a pulley 34 driven through suitable belts and countershafts by a prime mover 35, all as fully illustrated in Figure 1. The pump 33 has associated therewith an intake or suction pipe 36 having its intake end 37 disposed within the tank 32. Also associated with the pump 33 is a discharge pipe 38 terminating as shown in Figure 1 in a nozzle 39 overlying the work at the point where it contacts with the grinding wheel. A valve 40 is placed in the intake line 36 for controlling the flow of the coolant through the discharge pipe 38.

The grinding wheel 18 and regulating wheel 28 are adapted to be relatively adjusted through the movement of the regulating wheel toward and from the grinding wheel 18. For this purpose, see Figure 4, the upper slide or housing 25 has mounted therein a sleeve nut 41 in threaded engagement with an adjusting screw 42, which has its outer end journaled in a bracket 43 carried by a projection 44 on the bed 15, see Figure 1. The screw 42 projects beyond the bearing or bracket 43 to receive a pilot or hand wheel 45 whereby said screw is adjusted for effecting the major movements of the slide 25.

In order to set up the grinding machine for different sizes of work pieces it is necessary that the work rest blade 30 be also adjusted. This is accomplished by shifting the lower slide 23 and this slide is adapted to be moved with the upper slide or bracket 25. For this purpose, the said upper slide or bracket 25 carries a clamp 46 whereby the two slides may be secured to one another, while for independent adjustment of the slide 25 the lower slide 23 carries clamps 47 for securing same to the bed.

The foregoing description deals with centerless grinders as have been produced in the past and as are well known to the trade. As is also well known, abrasive wheels, such as 18 and 28, are subject to continual, gradual wear during operation and it will be appreciated that this results in a gradually enlarging grinding throat so that

the work pieces produced thereby will gradually increase in size. This wear is at a minute rate but is sufficient that work pieces cannot be continuously produced thereby within the minute limits or tolerance expected therefrom without periodic minute adjustment of the wheels. This adjustment is made by an independent mechanism operable upon the nut 41 carried by the upper slide or bracket 25.

This compensating adjusting mechanism comprises a worm wheel 48 keyed or otherwise secured to one end of the nut 41. Meshing with the worm wheel 48 is a worm 49 integral with or secured to a shaft 50 rotatably journaled in a bracket 51 secured to the rear end of the housing 25. The shaft 50 extends beyond the said housing 51 to receive the hand wheel 52 whereby the said shaft may be rotated for slowly rotating the nut 41 and effecting a slow advancement of the regulating wheel toward the grinding wheel. To utilize this mechanism for effecting the adjustment of the parts it would be necessary for the operator to manually measure each work piece produced by the machine and this would materially restrict the production therefrom. There has been provided, therefore, means automatically effecting this movement of the shaft 50.

The automatic mechanism operable for actuating the compensating mechanism comprises a supplemental work rest or work support in line with the work rest blade 30 to receive the work therefrom. This work support, as seen in Figure 5, comprises a pair of supporting bars 53 and 54 secured to the work rest block 31 or an extension 55 thereof. The work supporting bars 53 and 54 each carry in opposition to one another a row of anti-friction bearing balls 56 on which the work is disposed during the gaging operation. Secured to the block 31 or its extension 55 and rising above, but adjacent to the bars 53 and 54, is a bracket 57 carrying at its upper end a split block 58. The split block 58 provides arms 59 between which is clamped a nozzle 60. The nozzle 60 is so related with respect to the work supporting bearings 56 as to overlie the work substantially centrally thereof. By this relation of parts an outlet orifice 61 is provided by the work for the nozzle. When a work piece is of a given size the orifice 61 will have a definite cross section and permit a definite flow of the fluid and maintain a definite pressure on the fluid within the nozzle, while any other size of work piece will vary the cross section of this orifice and correspondingly vary the pressure on the fluid.

In order to supply fluid through the nozzle, it has connected to its upper end one end of a pipe or conduit 62 which, as shown diagrammatically in Figure 6 and structurally in Figure 2, terminates at the discharge side of a pump 63. The intake or suction pipe 64 from the other side of the pump 63 terminates in the coolant reservoir or tank 32. As shown in Figure 2, the pump 63 is enclosed in a suitable cover or the like secured to or integral with an electrical motor or prime mover 65, furnishing the motive power for the pump 63. The pump and motor unit 63-65 supplies fluid such as the coolant under a given volume at all times to and through the nozzle 60. This fluid, due to the orifice 61, will be at a definite pressure when the said work is at the desired size since the orifice will permit the flow of the fluid only at a restricted rate. From this it will be understood that should the orifice 61 be enlarged or restricted the pressure on the fluid will

correspondingly vary, and therefore as the work piece increases in size the pressure on the fluid will proportionately rise. It is this rise in pressure that is utilized for effecting the automatic operation of the infed mechanism to produce subsequent work pieces to the desired size and thereby lower the pressure in the fluid.

The mechanism on which this variation in pressure operates is shown structurally in Figure 6, and comprises a housing 66 secured to the upstanding bracket 57 on the other side thereof from that of the nozzle 60, as seen in Figure 5. Pressed into the housing 66 is a sleeve 67, in turn carrying a valve bushing 68. The bushing 68 is in reality in three parts—68—A, 68—B and 68—C. The sections 68—A and 68—C have relatively small bores therethrough, while the section 68—B has a relatively larger bore therethrough. Each of these bores is in axial alignment to receive the valve 69, and is provided centrally of its length with an enlarged portion disposed within the enlarged bore through the bushing section 68—B. This enlarged section of the valve is provided with cannelures 70 and 71, thereby forming collars 72, 73 and 74, respectively co-operating with sets of radial ports 75, 76 and 77 formed through the bushing 68—B. The enlarged central portion of the valve, in addition, provides chambers 78 and 79 on opposite ends thereof within the bushing. The collar 73 with the radial ports 76 form resistances 80 and 81 to the flow of a hydraulic fluid through the said ports. The collar 72 with the ports 75 form a resistance 82, while the collar 74 with the port 77 form a resistance 83. The hydraulic fluid is delivered to the radial ports 78 through a port 84 formed in the sleeve 67 and the port 84 is at the terminus of a pipe or conduit 85 extending from the discharge side of a pump 86. The other side or intake of the pump 86 is connected by a second pipe 87 with a reservoir or tank 88. The tank 88 contains an hydraulic medium, preferably oil for circulation through the valve. The pump 86 discharges the fluid through the pipe 85 at a substantially constant volume and under a definite pressure. This volume and pressure are divided through the resistances 80 and 81 and resistances 82 and 83 to the chambers 78 and 79. Depending upon the position of the collars 72, 73 and 74 the pressure in the chambers 78 and 79 will vary. Normally, the pressure in chamber 78 is higher than that in chamber 79, thereby holding the valve in its lowermost position as shown in Figure 6.

The chamber 78 communicates through a set of radial ports 89 formed in the bushing section 68—B with a port 90 formed in the sleeve 67. The port 90 is at one terminus of a pipe or conduit 91, which has its other terminus connected with one end of an hydraulic motor chamber 92 to be later described in detail. The chamber 79 likewise communicates through a set of radial ports 93 formed in valve bushing section 68—C with a port 94 in the sleeve 67. This port 94 is also at one terminus of a pipe or conduit 95 that terminates at its other end at the other end of the hydraulic motor chamber 92.

The valve 69 is provided on its upper and lower ends with piston guide portions 96 and 97 respectively disposed in the bores in bushing sections 68—A and 68—C. The piston guide portion 96 is provided with a cannelure 98 forming a shoulder 99 and a collar 100. The collar 100 co-operates with a set of radial ports 101 to form a resistance 102 to the flow of the hydraulic medium from the chamber 78 into the cannelure 98. The shoulder 99 co-operates with a set of radial ports 103 to form a resistance 104. The radial ports 103 communicate with a port 105 formed in the sleeve 67 which is at one terminus of a pipe or conduit 106, which has its other terminus in a valve chamber 107 adjacent the motor chamber 92 and to be later described in detail.

The lower guide portion 97 of the valve, similar to the guide portion 96, is provided with a cannelure 108 to form a shoulder 109 and a collar 110. The collar 110 co-operates with a set of radial ports 111 to form a resistance 112 to the flow of the hydraulic medium from the chamber 79 into the recess 108. The shoulder 109 co-operates with a set of radial ports 113 to form a resistance 114. The radial ports 113 communicate with a port 115 through the sleeve 67 which is at the terminus of a pipe or conduit 116, terminating at its other end in the sump or reservoir 88.

The conduit or pipe 85 has therein a fixed resistance 117, relatively low in value so that but a slight retardation is offered to the flow of the fluid through the pipe 85. This pipe or conduit 85 also connects with the pipe or conduit 91 through a fixed resistance 118 of a value greater than the resistance 117, whereby the flow is initially through the resistance 117. The pipe or conduit 106 is connected through the valve in the valve chamber 107 with a discharge conduit 119 terminating in the conduit 116 which empties into the sump or tank 88. The pipe 95 is also connected by a branch conduit 120 with the conduit 119 through the valve chamber 107 when the valve therein occupies a second position from that shown in Figure 6.

Referring now to the well known basic proposition of pressure, it may be stated that pressure is equal to the quantity of fluid flowing in a given time through a given orifice or resistance. In practice the resistances 80 and 82 are made equal to the resistances 81 and 83, as are resistances 102 and 104 made equal to resistances 112 and 114. From this it will follow that with the valve 69 in a central position the flow through the ports 84 and 76 will be equally divided to the chambers 78 and 79, thereby making the pressure in said chambers equal and effecting a balance of the valve by acting on equal areas of the enlarged central portion thereof. If, however, the resistances on one side of the valve are changed the resistances on the other side of the valve are correspondingly oppositely varied. This then results in a different quantity of flow through the resistances and correspondingly changes the pressures on said sides of the enlarged portion of the valve and effects a shifting thereof.

With the structure shown in Figure 6 there will be an additional flow into the chamber 78 through the resistance 118, which will augment or increase the pressure in said chamber over that in chamber 79, thereby shifting the valve to the position shown in Figure 6. As there shown the valve is in its lowermost position and is provided on its lower end with a piston 121 disposed within an enlarged counterbore 122 formed in the lower end of bushing section 68—C. The valve is held in this position by an adjustable abutment screw 123 threaded through the lower cover plate or cap 124 of the housing 66. The valve 96 will be held in this position until the pressure in the chamber 79 is built up beyond that in chamber 78 or until additional force is applied to said valve.

In practice use is made of an additional force

namely, the pressure which is built up in the fluid flowing through the pipe 62 and nozzle 60 due to the restriction of the orifice 61 between the nozzle and the work as above described. For this reason the chamber formed by the counterbore 122 is connected by a pipe or conduit 125 with the pipe 62 so that the space between the piston 121 and the cover plate or head 124 is provided with fluid under pressure equal to that in the nozzle 60.

When a standard size work piece is passing beneath the nozzle 60 the orifice formed thereby creates a pressure, which combined with the pressure in the chamber 79, is insufficient to overcome the pressure in chamber 78; therefore, the valve remains in its normal position. As the work gradually increases in size, however, due to the breakdown of the wheels, the pressure on the fluid within the nozzle 60 and pipe 62 builds up, thereby increasing the pressure on the piston 121, which combined with the pressure in the chamber 79, shifts the valve to change the value of the resistances and causes a complete shifting thereof.

Prior to the shifting of the valve the flow from the pump 86 was through the pipe or conduit 85 to and through the ports 84 and 76. At this point, and as above described, the flow is divided into two legs, the first leg passing through resistance 80, cannellure 70, resistance 82, chamber 78, resistances 102 and 104, ports 103 and 105 to the pipe or conduit 106 to the valve chamber 107 where it is directed through the conduits 119 and 116 to the sump 88. The second leg is through the resistance 81, cannellure 71, resistance 83, chamber 79, resistances 112 and 114, ports 113 and 115 to the conduit 116 and the sump 88. It is to be understood that there is no escape from the chambers 78 and 79 because the conduits 91 and 95 extending therefrom terminate in the motor chamber 92 from which there is no outlet under normal conditions. As soon as the valve is shifted, however, the pressures in the chambers 78 and 79 are reversed with the higher pressure in the chamber 79. The flow is then through the conduit 95 to the motor chamber 92 which effects a movement of the motor therein and exhausts the other side of this chamber. It is the movement of this motor, as will later be described, that effects the adjustment of the regulating wheel toward the grinding wheel. As soon as the motor has made a complete stroke the porting through the valve in the valve chamber 107 changes and then connects the conduit 95 through the branch conduit 120 with the exhaust conduits 119 and 116, thereby relieving the pressure on the end of the motor. Also, by the time the motor has completed its stroke the work piece passes from beneath the nozzle 60, thereby enlarging the orifice 61 and effecting a substantial reduction in pressure in the fluid within the nozzle and at the base of the piston 121. The pump 86 has been operated all this time and is discharging through the resistance 118 into the pipe 91, reacting against its end of the motor and filling the chamber 78. The pressure within the chamber 78 and against the motor eventually build beyond the combined pressure in the chamber 69 and on the piston 121, thereby effecting a return of the valve to its normal position as shown in Figure 6. The parts will then remain in this position until another over-size work piece is disposed beneath the nozzle, whereupon the operation just described is repeated.

The motor chamber 92 contains an hydraulic motor in the nature of a double acting piston 126, having formed on one side thereof rack teeth 127

meshing with a segmental gear 128. The motor chamber is formed within the housing 51 and the gear 128 is likewise enclosed within this housing and is loosely journaled on the shaft 50. The gear 128 has pivotally secured thereto, as at 129, a pawl 130, which co-operates with the teeth on ratchet 131, keyed or otherwise secured to the shaft 50. The parts are so arranged that one reciprocatory movement of the piston 126 actuates the pawl in a direction to rotate the shaft 50 and worm 51 thereon, to rotate the worm 48 and nut 41, to effect a movement of the regulating wheel and consequently the work toward the grinding wheel.

The valve chamber 107 is also formed in the housing 51 and encloses a two part valve stem 132 having piston portions or heads 133 and 134 between which is disposed a valve 135. The valve 135 is of a length less than the distance between the heads 133 and 134 so as to provide lost motion utilized in the shifting of the valve 135. The valve 135 is provided with a cannellure 136 which in one position of adjustment connects the pipes 106 and 119, and in the second position connects the pipes 120 and 119.

The valve is shifted by the piston 126 at each end of its stroke for which purpose the chamber 92 is closed at opposite ends by heads 137 and 138 respectively carrying plungers 139 and 140. Projecting from each of the heads 137 and 138 is a lug 141 to which are pivoted levers 142 respectively abutting on one end with the plungers 139 and 140 and on the other end being disposed between collars 143 carried by each end of the valve stem 132. The head 133 on the valve stem is provided with a pair of notches 144 cooperating with a spring pressed ball 145 and the said notches and ball constitute a load and fire mechanism for shifting the valve from one position to the other.

The operation of this mechanism is as follows: as the piston 126 is shifted, for example, to the left, as seen in Figures 6 and 7, it will engage near the end of its stroke the plunger 140 and oscillate the lever 142 at that end of the motor. This shifts the piston rod 132, taking up the lost motion existing between itself and the valve 135. This lost motion is substantially taken up when the ball 145 reaches the apex of the lug between the notches 144. During this shifting of the ball 145 the spring thereof was loaded and as soon as the apex is reached the spring expands or fires the ball into the second notch, thereby effecting the shifting of the valve 135 to its second position.

It should be noted that the building up of the pressure in the chamber 78 after the valve has been shifted takes place at a relatively rapid rate for returning the valve to its initial or normal position. At the same time the piston 126 would be shifted to its right hand position, shown in Figure 6. This shifting of the valve and piston may take place before the work piece beneath the nozzle 60 has a chance to be replaced by a subsequent work piece whereupon the parts would again effect an incremental shift of the regulating wheel and work toward the grinding wheel. Since the parts are initially set so that a single feeding stroke of the motor will reduce the second work piece to the desired size, two such incremental shifts would reduce the work beyond the desired size. To avoid this the pipe 95 has therein an adjustable choke valve 146 which limits the rate of flow of the fluid from the right hand side of the chamber 92 when the motor is actuated in that direction. This flow is so regulated that the piston does not reach its normal position until the second work piece is in a position to be gaged, 75

thereby insuring that each oversize work piece is gaged but once.

From the foregoing it will be noted that there has been provided a size controlled feeding mechanism operable to adjust the position of the work and tool or grinding wheel when the work becomes oversize or above the normal or desired size. It will also be noted that no actual contact is had with the work by a member riding thereon and effecting a wear on said member, thereby eventually destroying the sensitivity of the sizing mechanism and necessitating an adjustment or replacement thereof.

A second type of grinding machine, a center type grinder, and a modified size control mechanism is illustrated in Figures 8 to 12 inclusive and will now be described.

The machine shown in Figure 8 comprises a bed 147 having formed along the upper surface thereof guide ways 148 for guiding the work supporting table 149 during its traverse relative thereto. The work supporting table 149 has mounted thereon at opposite ends thereof a headstock 150 and a tailstock 151 from which project the usual centers for supporting the work. The work is driven by the head stock through a prime mover 152, mounted on the said headstock for driving through the flexible belt transmission 153 the headstock spindle 154. Any suitable means may be employed for effecting the traverse of the table; this means, being well known and therefore not disclosed in the drawings, terminates in a pinion (not shown) in mesh with the rack 155 secured to the under side of said table.

At each end of the table stroke it is reversed by the usual and well known reversing mechanism including the load and fire mechanism 156 shown in Figure 10. The load and fire mechanism is operable by a lever 157 enclosed within the reverse or control plate 158 mounted on the forward face of the bed 147. As usual, the lever 157 is secured in any desired manner to a shaft 159 journaled in the walls of said reverse plate 158 and projecting through the forward wall of said plate. A reversing lever 160 is secured to the projecting portion of the shaft 159, and the said lever has an abutment 161 extending toward the table. This abutment 161 is disposed in the path of movement of adjustable table dogs 162 and 163 which engage therewith to shift the reversing lever 160. The foregoing structure is all well known and has, therefore, not been more fully disclosed or described in this application.

The bed 147 has projecting from the rear thereof an extension 164 having formed on its upper surface guide ways 165 for a carriage or slide 166. The carriage 166 is provided with journal bearings 167 in which is disposed a spindle 168. The spindle 168 has secured to its one end a grinding wheel 169 substantially enclosed by a guard or the like 170, in turn secured to the carriage 166. Any suitable means may be employed for effecting the movement of the carriage 166 toward and from the work supporting table, one said means being clearly illustrated in the drawings.

Depending from beneath the carriage between the guide ways 165 is a lug or bracket 171 supporting a nut 172 in threaded engagement with an adjusting screw 173. The screw 173 has its rear end enclosed in a guard 174 projecting from the nut 172. Near the outer end of the screw 173 it has secured to it a piston 175 enclosed within a cylinder 176. The cylinder in turn is closed at its opposite ends by cylinder heads 177 and 178, which in addition, form bearings for the screw

173 and support said screw for rotative movement relative thereto. The cylinder 176 through the head 178 is secured to and carried by a sleeve like extension 179 of a bracket 180 secured in any desirable manner to the forward face of the bed 147. The cylinder heads 177 and 178 are further provided respectively with a port 181 and 182, respectively communicating with one terminus of a pipe or conduit 183 and 184. These pipes terminate in a reversing valve chamber, as will be later described, for supplying an hydraulic medium preferably oil to the cylinder 176. From the foregoing it will be noted that the screw 173 may be axially shifted for correspondingly actuating the grinding wheel carriage 166.

The extreme outer end of the screw 173 is provided with a spline portion 185 in operative engagement with an internally splined bore in a gear 186 rotatably journaled in the bracket 180. The gear 186 has its teeth meshed with those of a pinion 187 integral with or secured to a shaft 188 journaled on suitable anti-friction bearings supported by the bracket 180 and a cover plate 189 for said bracket. The shaft 188 has keyed, or otherwise secured to it, the usual hand wheel 190 carrying the detachable plunger handle 191 whereby it is connected for unitary movement with a ratchet wheel 192. As is usual practice, the ratchet wheel 192 is further connected through planetary reduction gearing 193 with the hand wheel 190 through a pinion, such as 194, integral with the hand wheel or secured thereto.

From the foregoing, it will be noted that by grasping the handle 191 the hand wheel and all parts connected therewith may be rotated for rotating the pinion 187, and the gear 186 thereby rotating the adjusting screw 173 and effecting the movement of the carriage 166 in a direction dependent upon the direction of movement of the handle 191. It will be appreciated that by disengaging the handle on ratchet wheel and operating the hand wheel while so disengaged the planetary gearing will be employed for manually and slowly rotating the adjusting screw 173.

The ratchet wheel 192 is adapted to be further incrementally, automatically rotated by mechanical means. For this purpose the ratchet wheel teeth are adapted to be engaged by a pawl 195 pivotally secured to a lever or bell crank 196, mounted for oscillation about the axis of the shaft 188. One arm of the bell crank 196 is suitably connected to the upper end of a vertically shiftable plunger 197 mounted and guided for sliding movement in the reverse plate 158. As seen in Figure 10, the plunger 197 is surrounded by a spring 198 adapted to shift said plunger in one direction. The plunger has a pin and slot connection at 199 with an actuating member 200 whereby the said plunger is shifted against the yielding resistance of the spring 198. This actuating member 200 is pivotally mounted at 201 within the reverse plate 158 and is adapted to be oscillated about its pivot at each end of the work table reciprocatory stroke. For this reason the lever 157 of the load and fire reversing mechanism has projecting from one side thereof an arm 202 carrying a cam shaped dog 203. This dog 203 bears an operative relation with a roller 204 on the plunger actuating member 200 so that after each operating stroke of the lever 157 the plunger actuator is oscillated about its pivot 201. This movement of the actuator 200 compresses the spring 198 which expands as soon as the dog 203 passes beyond the roller 204 and thereby effects a feeding stroke of the pawl 195. From the

foregoing it will now be clear that the grinding wheel carriage 166 is incrementally shifted toward the work table for each stroke thereof.

Referring back now to the hydraulic piston mechanism for shifting the grinding wheel carriage, reference is had to Figures 9, 10 and 12. As shown in Figure 12, the hydraulic conduits or pipes 183 and 184 terminate in a valve mechanism indicated generally by the numeral 205 in Figure 12. This valve mechanism is shown structurally in Figure 10 and comprises a circular boss or sleeve 206 formed integral with the housing or plate 158 into which is pressed a valve bushing 207. The bushing 207 is provided with a plurality of sets of radial ports 208, 209, 210, 211 and 212, each of which sets is connected by a similar groove 213 formed circumferentially on the exterior of the bushing. It is with the ports 209 that the conduit 183 connects, while the conduit 184 connects with the ports 211. As shown in Figure 12, the ports 208 are connected with one terminus of a branch discharge conduit 214 and the ports 212 are connected with a second branch discharge conduit 215. The conduits 214 and 215 in turn empty into a discharge conduit 216 that terminates in a sump or tank 217 containing an hydraulic medium, preferably oil that is circulated through the hydraulic system. The remaining ports 210 connect with one terminus of a conduit or pipe 218 connected on its other terminus with a starting and stopping valve mechanism indicated generally by the numeral 219.

The starting and stopping valve mechanism 219 is also shown structurally in Figure 10 and comprises a sleeve like lug 220 integral with the reverse plate 158. Pressed into the sleeve 220 is a valve bushing 221 having formed therethrough two sets of radial ports 222 and 223. Each set of these ports is also connected by a similar circumferential groove 224 formed on the exterior of the bushing 221. It is with the ports 222 that the conduit 218 connects, while the ports 223 are connected with one terminus of a pipe or conduit 225 extending from the discharge side of a pump 226. The other side of this pump 226 is connected by a suction pipe 227 with the sump or tank 217. A pressure controlled relief valve 228 is included in the pipe 225 for returning excess fluid to the tank or sump 217 and for controlling the pressure in the system.

Disposed within the bore in the starting and stopping valve bushing 221 is a piston type valve 229 having formed therein a cannellure 230 for providing piston portions 231 and 232. The cannellure 230 is adapted to connect the ports 222 and 223, thereby connecting the conduits 225 and 218 when the valve is in one of its operative positions, while in the second position the piston portion 232 is adapted to close for communication between these elements.

In order to shift the valve it has projecting from one end thereof a valve stem 233 in which is formed a notch 234 receiving the ball end 235 of a lever 236. The lever 236 is secured to a shaft 237 journaled in the reverse plate 158 and projecting there beyond to receive the manually actuable lever 238. From this it will be seen that in order to operate the hydraulic cross feed mechanism it is necessary to open the starting and stopping valve 229 through the lever 238.

Disposed within the reversing valve bushing 207 is a sliding valve 239 having formed therein cannellures 240 and 241, thereby providing piston portions 242, 243 and 244. The valve is adapted in different positions of adjustment to connect

the several ports formed through the bushing 207. In order to shift the valve in one direction it has projecting from one end thereof a valve stem 245 in which is formed a notch 246 receiving the ball end 247 of a lever 248. This lever 248 is pinned or otherwise secured to one end of a shaft 249 journaled in the reverse plate 158 and projecting there beyond to receive manually actuable lever 250. From this it will be seen that the valve 239 is shiftable in one direction by the manually actuable lever 250.

The valve 239 is adapted to be shifted in the other direction automatically by power means for which reason the said valve has projecting from its other end a valve stem 251 carrying collars 252 between which is disposed the pawl end of a lever 253. The lever 253 is pivoted intermediate its ends at 254 and has its other end connected by a pin and slot connection 255 with the head 256 of a core 257 of the solenoid 258 disposed within the reverse plate 158. The solenoid 258 is included in an electrical circuit energizable by and under the control of the work whereby the said circuit is energized for stopping the feed of the wheel when the work reaches a certain predetermined size.

The electrical circuit involved in the modified size control mechanism is illustrated diagrammatically in Figure 12, and as there shown, may comprise a transformer including a primary coil 259 connected to the normal current source 260. The primary coil 259 supplies current to secondary coils 261, 262 and 263, as well as secondary coils 264 and 269. Extending from the coil 264 are wires 265 and 266 for lighting the filament 267 of a thyratron tube 268. The secondary coil 269 has extending from it wires 270 and 271 for lighting the filament 272 of a radio vacuum tube 273.

Extending from one end of the secondary coil 261 is a wire 274 including a resistance 275 that terminates in one side of a meter 276. Extending from the other side of the meter 276 is a wire 277 which terminates at a wire 278 and includes a radio frequency choke coil 279. The wire 278 includes a fixed condenser 280 and connects the ends of the inductances or coils 281 and 282. Extending from one end of the inductance or coil 282 is a wire 283 terminating at its other end with the plate 284 of the radio or vacuum tube 273. Extending from the wire 278 is a wire 285 that connects with the filament wire 270. Shunted across the inductance coil 282 is a condenser 286 having one side thereof connected by a wire 287 with the wire 283 and having its other side connected by a wire 288 with the wire 285.

The inductance or coil 281 has its one end connected through the wire 285 with the filament wire 270 and its other end connected by a wire 289 with the grid 290 of the vacuum tube 273. Included in the wire 289, as is usual practice, is a grid leak and grid leak condenser 291. Shunted across the inductance coil 281 is also a condenser 292 having its one side connected by a wire 293 with the wire 285 and its other side connected by a wire 294 with the wire 289.

The plate circuit, as will be evident, includes the secondary coil 261, wire 274, meter 276, wires 277 and 278, inductance or coil 282 in parallel with condenser 286, plate 284, filament or cathode 272 and wire 270 back to the secondary coil 261. The grid circuit, as will also be evident, includes the wire 278, inductance or coil 281 in parallel with the condenser 292, wire 289, grid leak and grid-like condenser 291, grid 290, filament or cathode 272 and wires 270 and 285 back to the wire 278 and inductance 281.

The system as thus far described is a fundamental tune plate, tune grid oscillator circuit. In such a system the oscillating power output is dependent on the closeness of tuning of both the plate and grid circuits with respect to each other. When the two circuits are in exact resonance the output is a maximum. In practice, the condenser 286 has a greater capacity than the capacity of condenser 292 so that the circuit is purposely oscillating very weakly, thereby drawing very little plate current.

In view of the fact that there is such a weak flow of current flowing through the wire 274 the negative bias on the grid of the thyatron tube 268 is very weak. The circuit for the thyatron grid includes the secondary coil 262 from one side of which extends the wire 274 connected by a wire 295 and resistance 296 with the thyatron tube grid 297 from which the current flow is to the cathode or filament 267 and wire 265 back to the other side of the secondary 262.

In view of this low negative potential on the thyatron tube grid 297 a maximum flow of current is had therethrough from the thyatron tube plate 298 to the thyatron tube filament or cathode 267. The complete circuit forming the thyatron tube plate includes the secondary coil 263 from one side of which extends the wire 265 to the filament or cathode 267 from which the current flow is to the plate 298 and a wire 299 extending from the plate to the other end of the secondary coil 263. Included in the wire 299 is a relay 300 for effecting the operation of a switch blade 301.

The switch blade or contact 301 is adapted to contact with either contact 302 or contact 303, either of which latter contacts may be connected through a manually operable switch 304 with a wire 305 terminating at one end of the solenoid coil 258. The other end of the solenoid 258 is at all times connected by the wire 306 with the movable switch blade 301. The manually operable switch 304 includes a contact member 307 movable between switch contacts 308 and 309, which are in turn suitably respectively connected with switch contacts 302 and 303.

The purpose of the double throw relay operated switch is for completing an electrical circuit depending upon whether the relay is normally charged, thereby holding the switch blade 301 against the contact 302, or whether the relay is normally de-energized, thereby permitting the switch blade 301 to rest against the switch contact 302. In the first supposition the de-energization of the relay 300 shifts the blade from the contact 303 to the contact 302 while with the second supposition the energization of the relay 300 permits the shifting of the blade 301 from the contact 303 to the contact 302. These two systems are respectively employed when the mechanism is operating on a decrease in work size as in a center type machine or is operating on an increase in work size as in a centerless type of machine.

For controlling the electrical circuit the following pressure actuated mechanism is employed. Extending from one side of the inductance or coil 281 is a wire 310 connected with one end of primary and secondary coils 311 and 312. The primary coil 311 has its other end connected by a wire 313 to the inductance or coil 281 at the point 314 and including a portion 315 of the coil 281. Connected in parallel with the secondary coil 312 is a condenser having one plate 316 thereof connected to one end of the coil 312 by

the wire 317 and having its other plate 318 connected by a wire 319 with the wire 310 and other end of the coil 312.

The condenser 316—318 is in effect connected in parallel with the condenser 292 whereby any modification in the condenser setting correspondingly varies the characteristic of the grid circuit for varying the plate circuit flow. From this it will be seen that variation in the setting of condenser plate 318 will bring the plate and grid circuits in resonance, thereby increasing the plate current flow through the meter. This increased plate current flow raises the negative bias on the thyatron tube grid 297 for shutting off the current flow from plate 298 to filament 267, thereby de-energizing the relay 300 and permitting the operation of switch plate 301 to complete the electrical circuit through the contact 302.

The several elements going to make up the electrical circuit, with the exception of the condenser 316—318, are all enclosed within a housing 320 mounted on the forward face of the bed 147 as seen in Figure 8, while the condenser 316—318 is mounted in a separate housing 321 disposed in front of the housing 320, as seen in Figure 8, and shown in section view in Figure 11. As shown in said Figure 11, the condenser housing 321 is cup-shaped, having provided interiorly thereof a ledge or support 322 to which is secured the lower condenser plate 318. The housing 321 is closed on its upper end by a cap 323 in which is mounted a bushing 324 having a threaded bore therethrough for an adjusting screw 325. The adjusting screw 325 extends beyond the bushing 324 exteriorly of the housing and is provided with a knob 326, while interiorly of the said housing it has a swiveled connection with the upper condenser plate 316, whereby rotation of the screw 325 effects the relative approach of the plates to one another. This adjustment is for initially setting the parts and to obtain the initial desired resonance between the plate and grid circuits. The lower condenser plate 318 is secured to the shelf 322 in such a way as to make a water tight joint, thereby sealing the chamber 327 beneath the said shelf which contains the upper adjustable plate 316. The lower plate 318 is in the nature of a diaphragm and is therefore fashioned from flexible material whereby the flexing thereof will cause an approach of the plates and vary the characteristics of the condenser and the operation of the circuit.

The plate 318 is adapted to be flexed by a fluid under pressure for which reason the chamber 327 is connected with one terminus of a pipe 328 terminating at its other end in a T pipe connection 329. One opening of the T 329 is connected to a pipe or conduit 330 extending from the discharge side of a pump 331. The other side of the pump 331 is connected by a pipe 322 with a sump or tank 333 which contains the coolant for the machine in the same manner as that described in connection with the centerless type above.

The remaining opening of the T connection 329 is connected by a pipe or conduit 334 with a discharge nozzle 335 shown structurally in Figure 9. The nozzle 335 is adjustably carried between the ears of a split lug 336 of a bracket 337 secured to the work table 149 in any desirable manner.

The nozzle 335 is adjustable toward the work so as to provide an orifice 338 for the discharge or flow of the hydraulic medium through the said

nozzle. As was above described, the size of the orifice 338 determines the pressure in the fluid within the nozzle 335, conduits 330 and 328 and chamber 327, thereby determining the amount of flexing of the diaphragm condenser plate 318.

The parts are initially set up so that the over-size work piece forms an orifice at 338 sufficiently small to obtain the maximum flexing of the condenser plate 318. The electrical reaction of this condenser 316—318, plus that of condenser 292, brings the plate and grid circuit for the vacuum tube 273 into resonance, thereby causing the maximum plate current flow. This maximum plate current flow sets up a negative bias sufficient to de-energize the relay 300, thereby permitting the blade 301 to lie against the contact 303 and maintain the circuit to the solenoid 258 broken. The reversing valve mechanism 205 is then actuated to effect an infeed or movement of the grinding wheel 166 toward the work. This movement, as will be appreciated, is at a rapid rate for operatively associating the work and wheel and this movement is arrested by engagement of the piston 175 with the piston head 178. At this time the table reciprocating mechanism is thrown in, which through the plunger 197, pawl 195 and ratchet wheel 192 effect the intermittent feed of the wheel toward the work. As the operation of these parts progresses the work is gradually reduced in size and gradually enlarges the orifice 338 and permits a more rapid flow of the fluid therethrough. This then reduces the pressure on the fluid within the nozzle, conduits and chamber 327, permitting the plate 318 to assume its normal position, thereby throwing the grid and plate circuits for the vacuum tube 273 out of resonance. As soon as this occurs the plate current flow is reduced to a minimum, permitting a flow of current through the thyatron plate circuit for energizing the relay 300 and effecting the operation of the switch blade 301. The switch blade 301 completes the electrical circuit in the lines 305 and 306, energizing the solenoid 258 and reversely shifting the valve mechanism 205 and causing a rapid retraction of the grinding wheel carriage 166, thereby stopping any further grinding on the work.

In the event that the modified mechanism, including the electrical circuit, were utilized with a centerless type of grinder or any other machine in which the increased size of work is the determining factor the manually operable switch 304 would be actuated to cut out the relay switch contact 302 and cut in the switch contact 303. The operation of the parts would then be reversed since a maximum current flow would be had through the thyatron plate circuit which would be negated to de-energize the relay 300 and thereby permit the operation of the blade 301.

From the foregoing it is believed that the operation of the present invention will be thoroughly understood and it should be noted that the controlling fluid utilized is the same fluid at all times associated with grinding machines, namely, the coolant thereof. It will also be noted that there has been provided a size control mechanism for accurately controlling the production of work pieces from grinding machines without the use of contact members or amplification levers of any sort, thereby eliminating inherent weaknesses of prior size control devices.

What is claimed is:

1. In a machine tool organization the combination of a bed, a tool mounted thereon, a work support mounted on the bed, means for adjusting the tool and work support relative to one another, additional means for incrementally adjusting the position of the tool and work support to insure production of work pieces within a given size, and means operable by the work without contacting same for effecting the operation of said additional adjusting means.

2. In a machine tool organization the combination of a bed, a tool mounted thereon, a work support mounted on the bed, means for adjusting the tool and work support relative to one another, additional means for incrementally adjusting the position of the tool and work support to insure production of work pieces within a given size, and means operable by the work without contacting same for effecting the operation of said additional adjusting means, including a pressure controlled mechanism operable by a pressure representative of the size of the work.

3. In a grinding machine the combination with a bed, a grinding wheel rotatably mounted thereon, and a work support on the bed, of means for effecting a relative feed between the grinding wheel and work support, work controlled means for controlling the feeding mechanism including a pressure responsive member, an hydraulic circuit for developing the pressure actuable on the pressure responsive member, a nozzle associated with said circuit and co-operating with the work to provide an outlet orifice for the circuit, said orifice being a characteristic of the size of the work and developing a pressure in the medium representative of the said size of the work, means operable by the said pressure responsive member for varying the operation of the feeding mechanism, said feeding means being hydraulically actuated and including a control valve therefor, and a connection between the pressure operated member and feeding means control valve whereby the said control valve is actuated by a pressure responsive member.

4. In a grinding machine the combination of a grinding wheel, a work support for supporting a work piece for rotation thereon, feeding means for effecting a relative approach and retraction of the grinding wheel and work, actuating means for effecting the operation of the feeding means, and control means for the actuating means including a pressure responsive element in the nature of a plate of a variable condenser, a second variable condenser plate, and an oscillating electronic circuit including the condenser plates in which the oscillation is varied in accordance with the positions of the condenser plates as varied by the pressure variable in accordance with the size of the work.

5. In a centerless grinder of the class described the combination with a pair of opposed grinding and regulating wheels forming a grinding throat therebetween of a predetermined size to which successive work pieces are to be machined, compensating means for actuating one of said wheels toward the other to take up wear thereon and maintain the size of the grinding throat, work supporting means extraneous of said throat for receiving the work pieces as they pass therefrom, a gaging mechanism associated with the extraneous work support and including a nozzle overlying said support through which a fluid medium is discharged onto the work, the nozzle cooperating with the work to form a discharge orifice therebetween for establishing a pressure in the

fluid medium, and pressure responsive means operable by the medium for effecting the operation of the compensating means.

5 6. In a centerless grinder of the class described
the combination with a pair of opposed grinding
and regulating wheels forming a grinding throat
therebetween of a predetermined size to which
successive work pieces are to be machined, com-
pensating means for actuating one of said wheels
10 toward the other to take up wear thereon and
maintain the size of the grinding throat, work
supporting means extraneous of said throat for
receiving the work pieces as they pass therefrom,
a gaging mechanism associated with the extrane-
ous work support and including a nozzle over-
15 lying said support through which a fluid medium

is discharged onto the work, the nozzle cooper-
ating with the work to form a discharge orifice
therebetween for establishing a pressure in the
fluid medium, pressure responsive means oper-
able by the medium for effecting the operation of
the compensating means, including a pair of con-
denser plates one of which is movable relative to
the other by the medium, and an electronic cir-
cuit including the condenser plates adapted to os-
cillate at different frequencies depending upon
the adjustment of the condenser plates and cir-
cuit of said frequencies representing the standard
or desired size of the work incapable of actuating
the compensating means.

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