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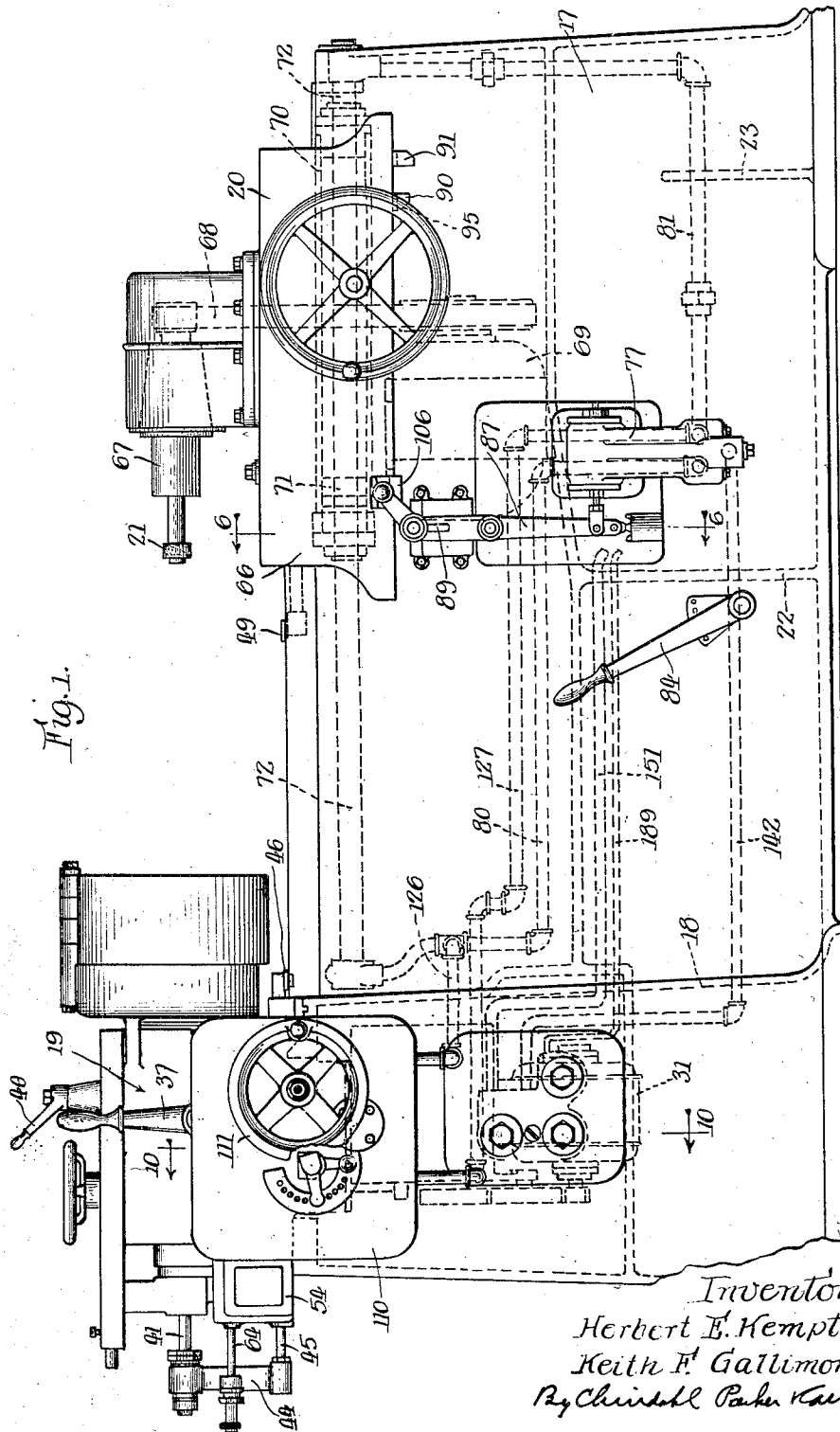
H. E. KEMPTON ET AL

1,826,178

GRINDING MACHINE

Filed June 22, 1925

10 Sheets-Sheet 1



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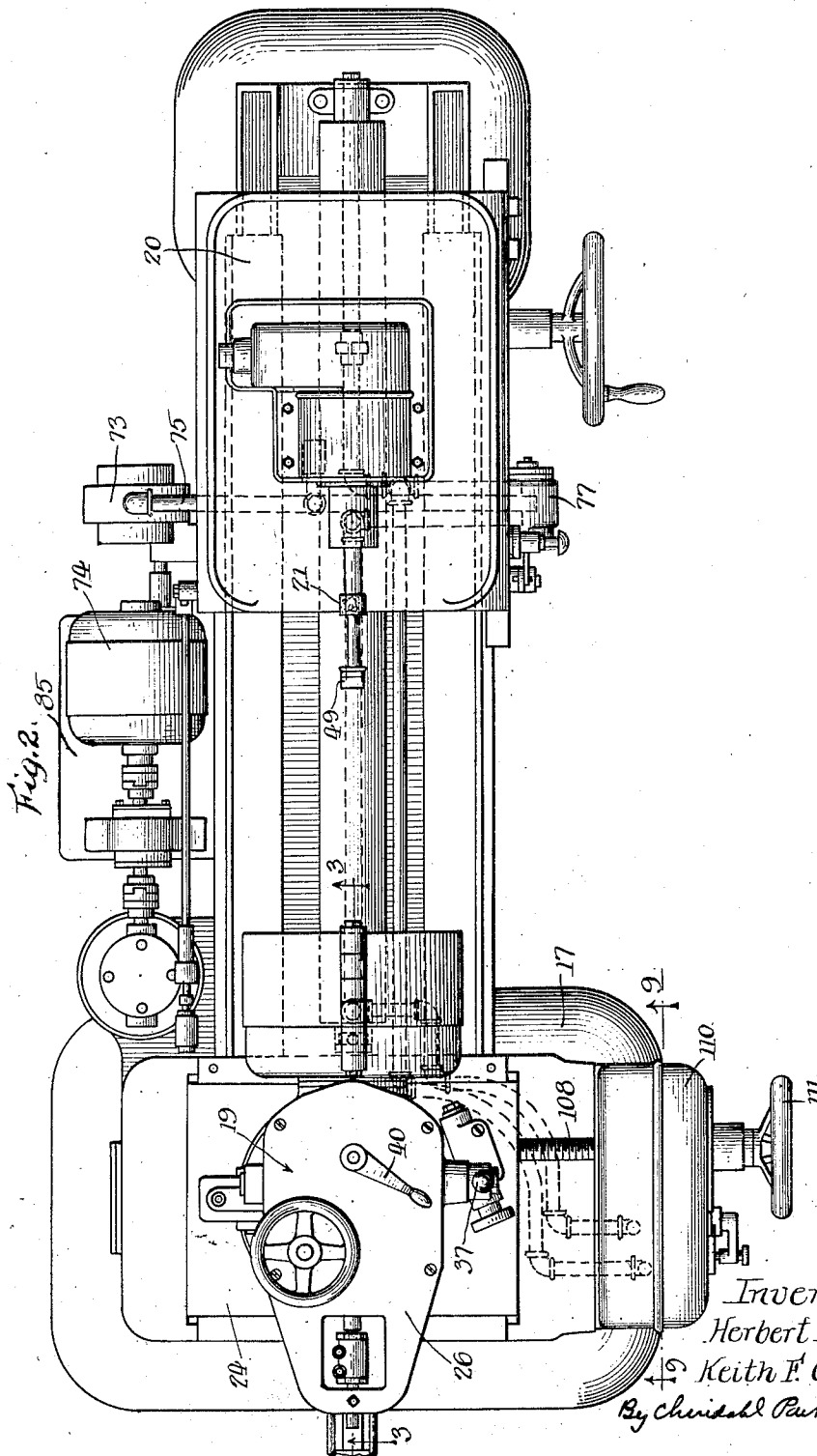
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GRINDING MACHINE

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10 Sheets-Sheet 2



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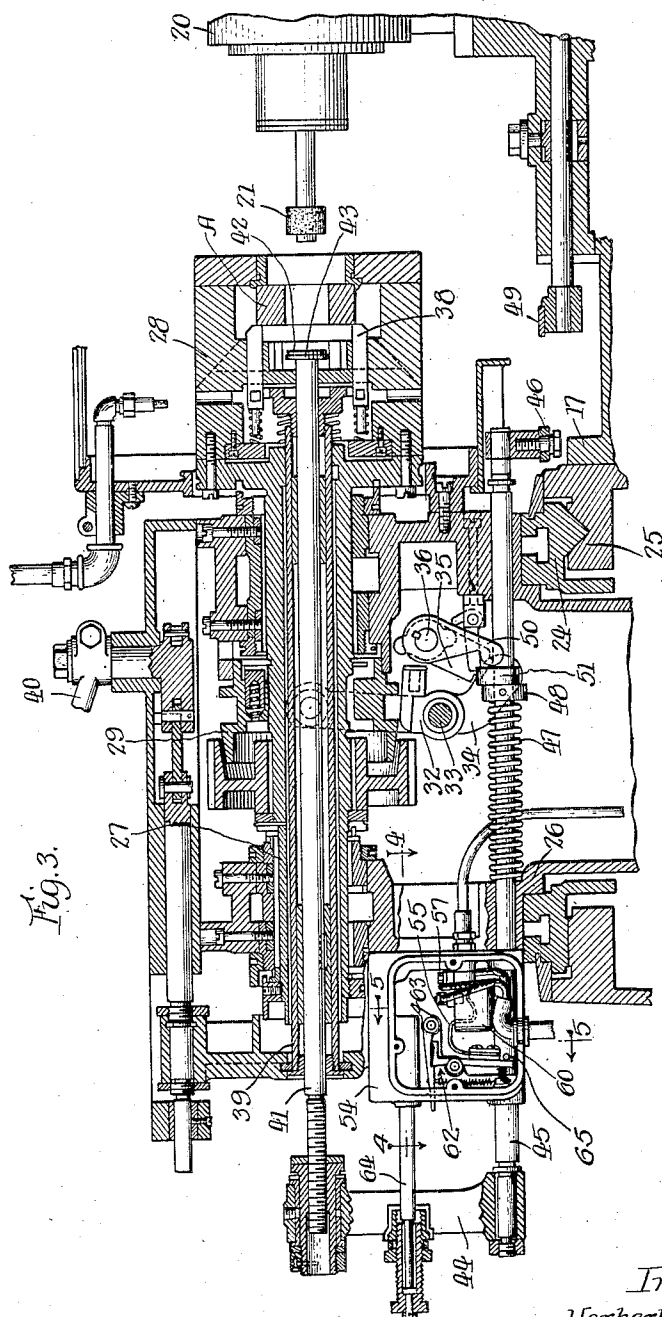
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GRINDING MACHINE

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10 Sheets-Sheet 3



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GRINDING MACHINE

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Fig. 4.

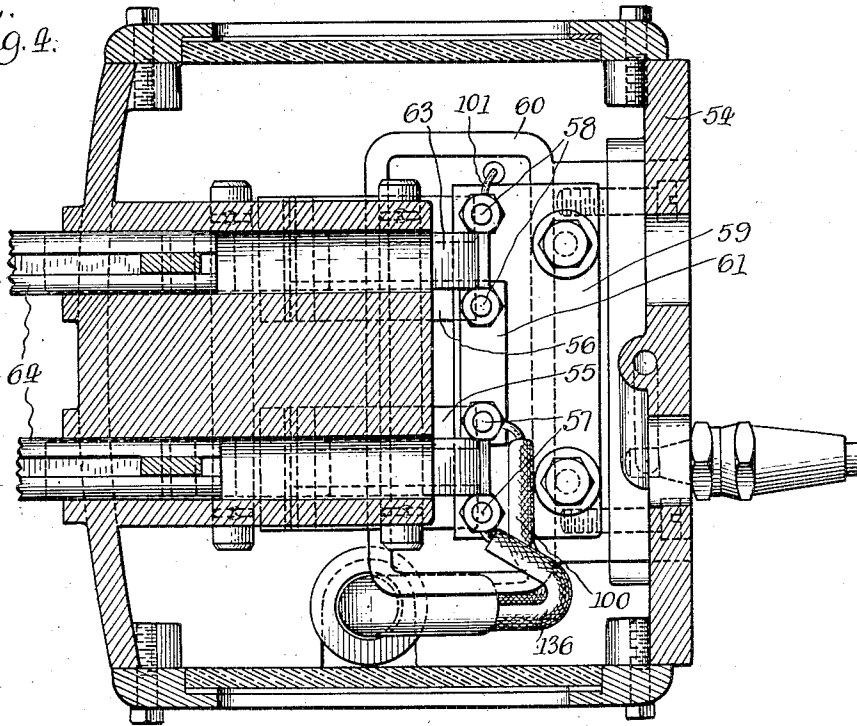
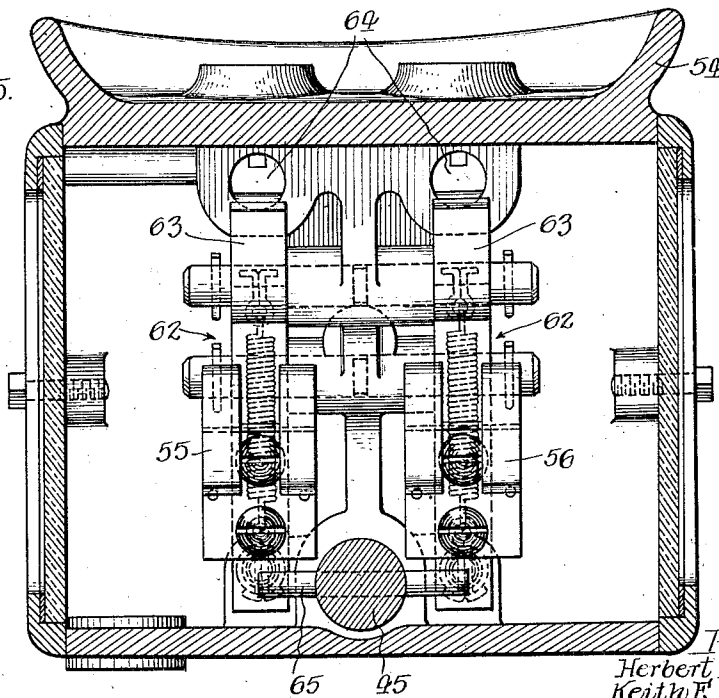


Fig. 5.



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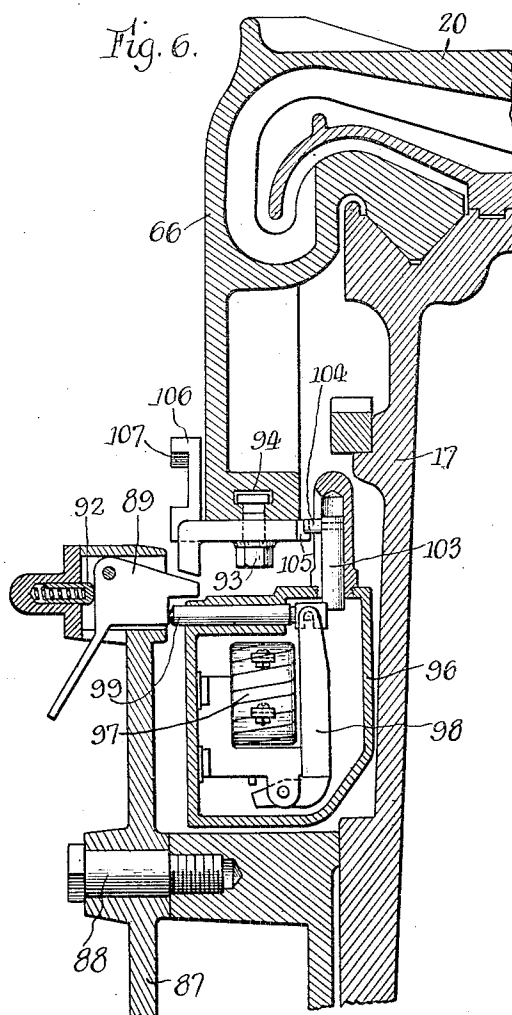
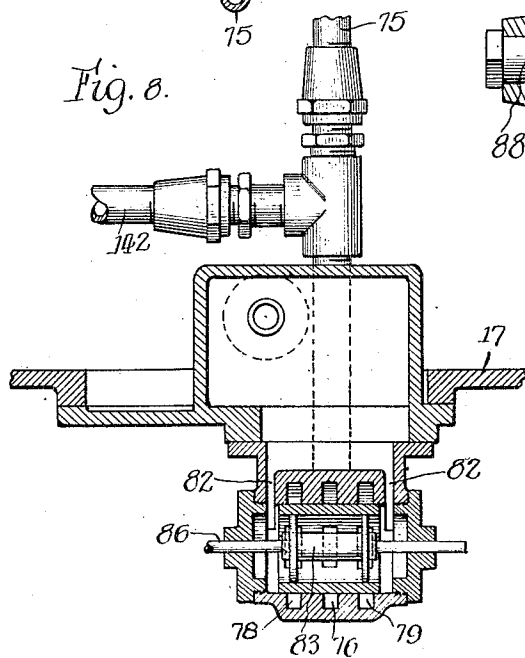
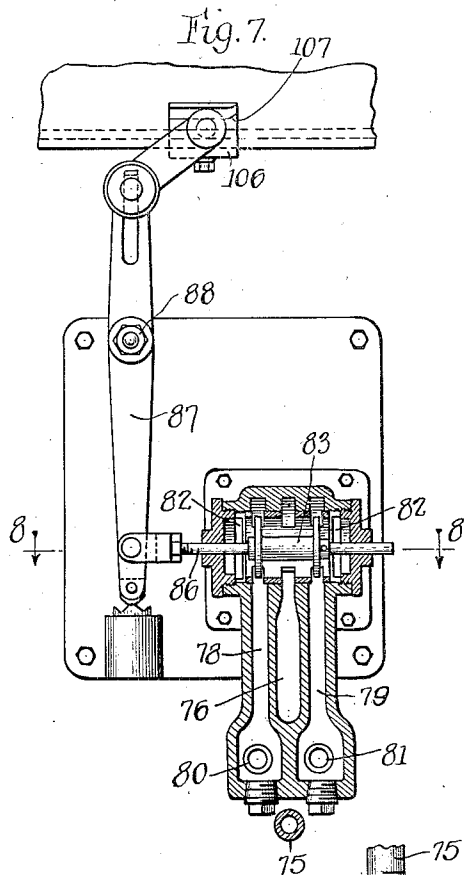
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GRINDING MACHINE

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10 Sheets-Sheet 5



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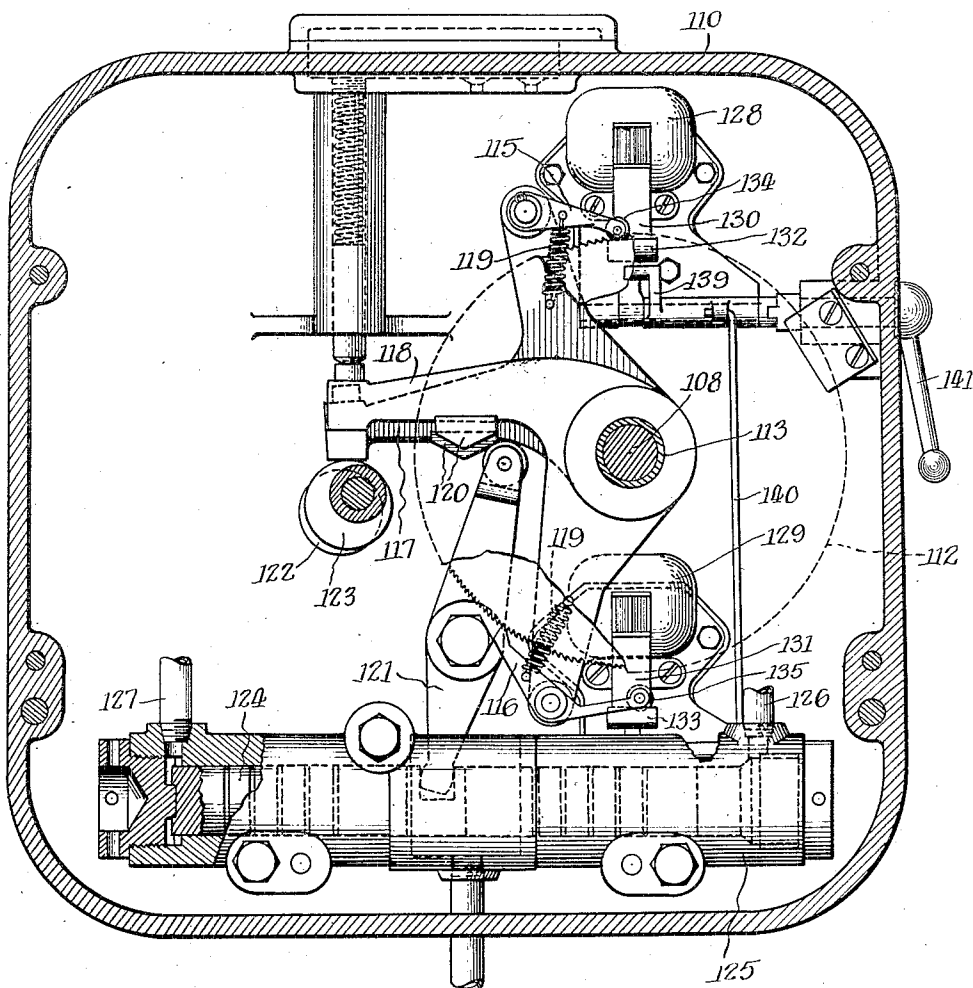
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Fig. 9.



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Fig. 11.

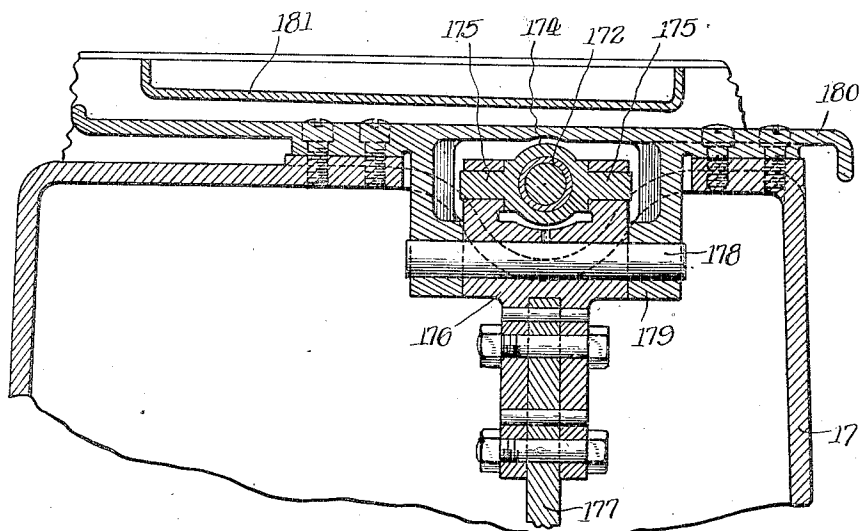


Fig. 12.

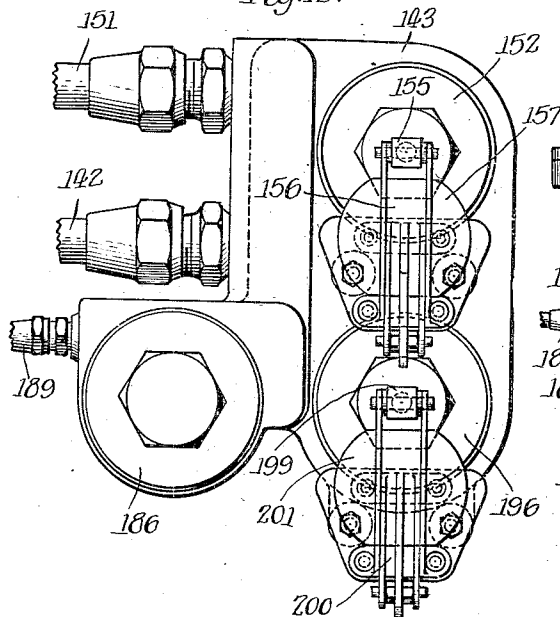
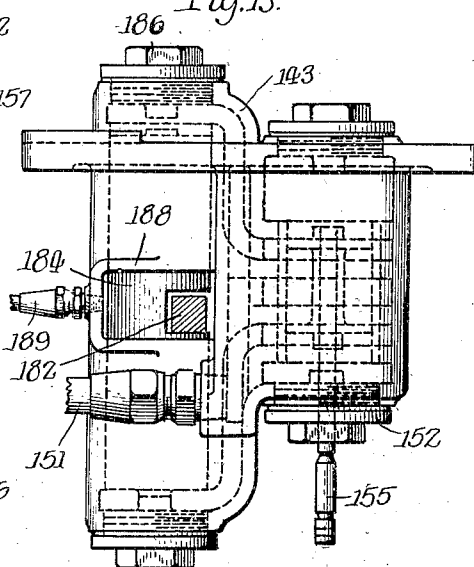


Fig. 13.



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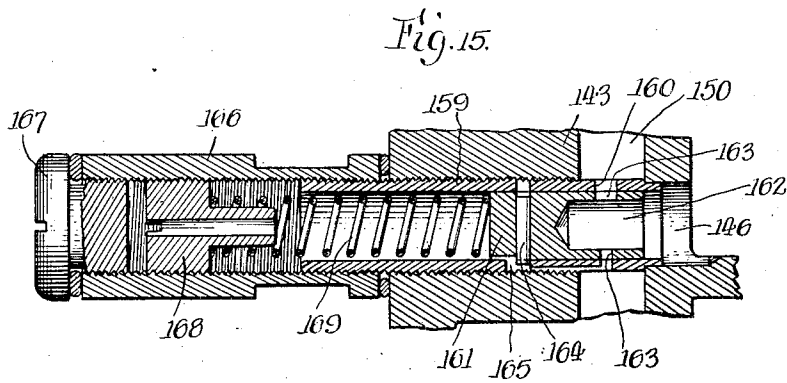
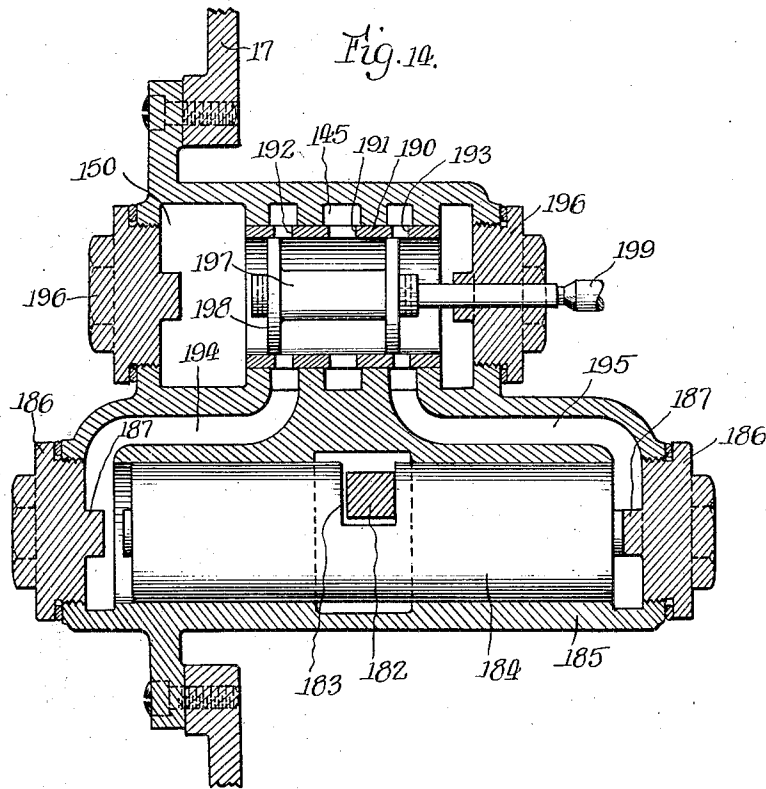
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10 Sheets-Sheet 9



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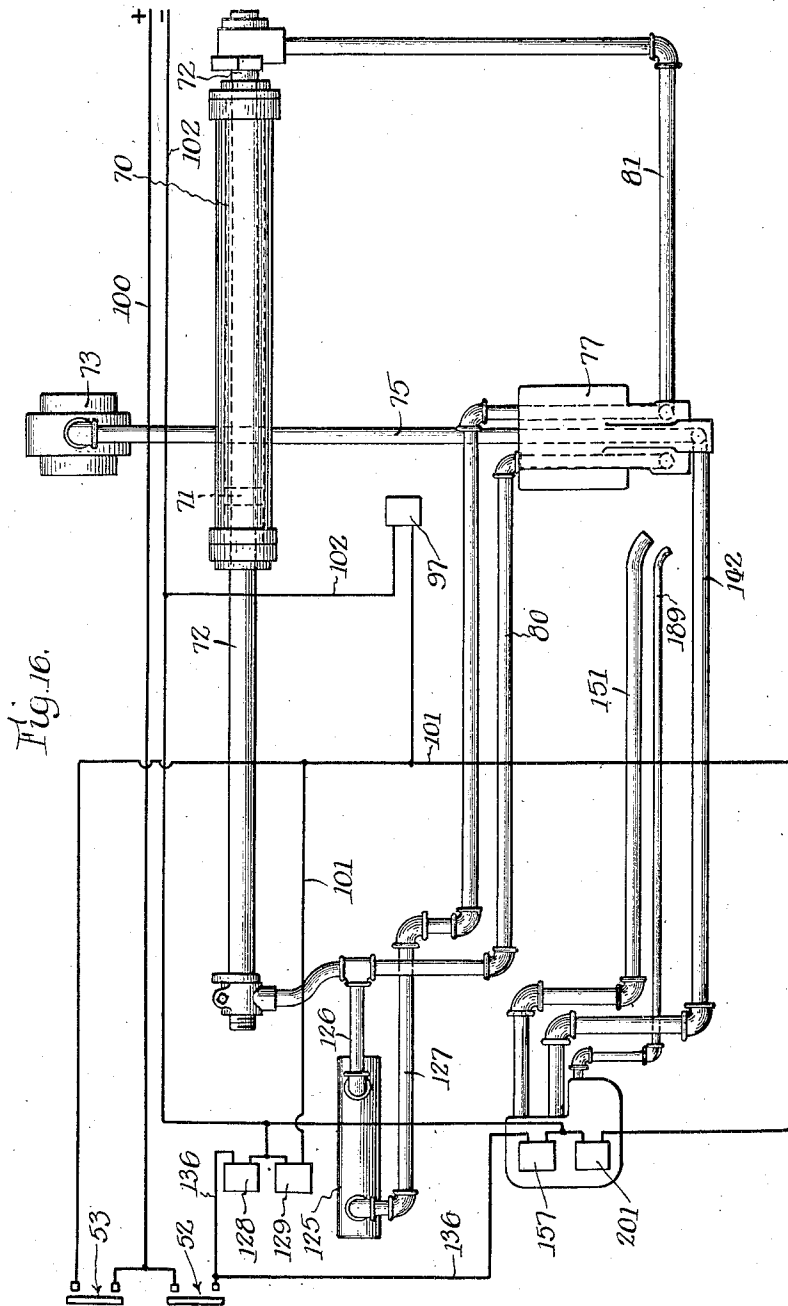
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GRINDING MACHINE

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10 Sheets-Sheet 10



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UNITED STATES PATENT OFFICE

HERBERT E. KEMPTON AND KEITH F. GALLIMORE, OF FOND DU LAC, WISCONSIN, ASSIGNORS, BY MESNE ASSIGNMENTS, TO THE HEALD MACHINE COMPANY, OF WORCESTER, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS

GRINDING MACHINE

Application filed June 22, 1925. Serial No. 38,629.

The invention relates to improvements in grinding machines, and is herein shown embodied in an internal grinding machine of the type disclosed in U. S. Letters Patent No. 1,534,302, issued April 21, 1925, to Prentice Conradson and ourselves.

The machine disclosed in that patent comprises broadly, a grinding spindle carriage having a grinding wheel, a headstock carriage for supporting the work, operating means for effecting a relative reciprocation and a relative cross feed between said carriages, and a gage adapted to coact with the work to control the grinding operation. In the operation, the grinding spindle carriage is automatically moved from a remote inoperative position to an operative position, reciprocated in said last mentioned position, and automatically returned to said inoperative position when the work has been ground to a predetermined size. The cross feed is reduced as the grinding operation nears completion to provide a finishing cut, and is subsequently discontinued when the work is ground to the predetermined size. By a finishing cut is meant the relatively slow grinding during the latter part of the grinding operation for producing a smooth finish on the surface of the work. We have found that an improved finish and other improved results are obtained if the speed at which the grinding spindle carriage reciprocates is reduced for the finishing cut. An important object of the present invention, therefore, is to provide means automatically operable when the work is ground to a predetermined size to slow down the rate of the traverse of the grinding wheel during the finishing cut.

Another object is to provide self adjusting means automatically operable to compensate for changes in the resistance to the movements of the grinding spindle carriage, and thereby to maintain a constant speed during the finishing cut.

A more specific object is to provide a new and improved means for controlling the speed of the grinding spindle carriage, which means is under the control of the gage, and serves on occasion to automatically by-pass a part

of the hydraulic pressure fluid normally directed to move said carriage.

We have also found that in withdrawing the grinding wheel axially from the finished surface of the work, marks and scratches are made near the end of the surface, thereby injuring the finish and lowering the quality of the product. Particularly is this true where cast iron is ground, and where the ground surface is of considerable length. Another object of the invention therefore is to provide means for automatically withdrawing the grinding wheel laterally from the surface of the work before withdrawing the grinding wheel axially into its inoperative position.

A more specific object is to provide a new and improved means of the above character which is under the control of the gage, which is operated hydraulically, and which effects a lateral separation of the grinding wheel and the finished work surface by shifting the cross feed screw longitudinally.

Other objects and advantages reside in the specific construction of the mechanical means for accomplishing the above results.

A general object of the invention is to provide an improved grinding machine which will produce an improved finish on the surface of the work to be ground.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawings, Figure 1 is a front side view of a grinding machine embodying the features of our invention.

Fig. 2 is a plan view of the machine.

Fig. 3 is a vertical sectional view of the headstock carriage taken along line 3—3 of Fig. 2.

Fig. 4 is a sectional view of the gage controlled switch taken along line 4—4 of Fig. 3.

Fig. 5 is a sectional view of said switch taken along line 5—5 of Fig. 3.

Fig. 6 is a vertical sectional view taken along line 6—6 of Figure 1.

Fig. 7 is a fragmentary sectional view of the main control valve and the actuator therefor.

Fig. 8 is a sectional view of the valve taken along line 8—8 of Fig. 7.

Fig. 9 is a vertical sectional view of the feeding mechanism taken along line 9—9 of Fig. 2.

Fig. 10 is a vertical sectional view taken substantially along line 10—10 of Figure 1.

Fig. 11 is a fragmentary sectional view taken substantially along line 11—11 of Fig. 10.

Fig. 12 is an inner end view of the mechanism for slowing down the rate of traverse between the work and the grinding wheel, and for separating the grinding wheel and the ground surface of the work when the grinding operation has been completed.

Fig. 13 is a plan view of the mechanism shown in Fig. 12.

Fig. 14 is a sectional view taken along line 14—14 of Fig. 10.

Fig. 15 is a sectional view taken along line 15—15 of Fig. 10.

Fig. 16 is a diagrammatic representation of the hydraulic system and of the electric circuits for operating and controlling the operation of the machine carriages.

While the invention is susceptible of various modifications and alternative constructions and adaptations, we have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that we do not thereby intend to limit the invention to the specific form disclosed, but aim in the appended claims to cover all modifications and alternative constructions and adaptations falling within the spirit and scope of the invention.

Referring now more particularly to the specific construction of the exemplary embodiment of the invention, the machine comprises a hollow base casting 17 having an internal transverse wall 18 which separates the base into a side portion on which a headstock or headstock carriage 19 is mounted and a long bed on which a grinding spindle carriage 20 having a grinding wheel 21 is mounted. Between the wall 18 and another transverse wall 22 is a chamber adapted to contain a coolant fluid for the work, and between the last mentioned wall and a third transverse wall 23 is a reservoir adapted to contain a pressure fluid, such as oil, for actuating the carriages 19 and 20.

Hydraulic operating mechanism is provided for effecting a relative approaching movement between said carriages to bring them into operative relation, for automatically instituting and effecting a reciprocation of one of said carriages while in said operative relation, and for automatically effecting a separating movement of said carriages when the grinding operation is completed. A feeding mechanism is also provided for effecting a relative cross feed between said carriages during the working reciprocation. A gage coacting with the work being ground is operable to automatically effect a reduction in the

rate of cross feed for the finishing cut or operation and in the speed of reciprocation during said cut, and is further operable to automatically discontinue the cross feed and institute a lateral separating movement between the grinding wheel and the finished surface of the work and the separating movement between the carriages when the grinding operation is completed. By coacting with the work, the gage causes the relative movements of the carriages to be accurately determined by the actual progress of the grinding operation.

The headstock carriage

The headstock carriage 19 (see Fig. 3) comprises a body section 24 which is slidably mounted on transverse ways 25 on the machine base 17, and a top section 26 which is rotatably mounted in the body section and extends therethrough into the base. Journalled in the top section 26 is a rotary work spindle 27 which carries a suitable chuck or work fixture 28 on one end for holding the work to be ground, such as the blank A, and which is driven through suitable connections including a clutch 29 by an electric motor 31 mounted on the underside of the top section to move or rotate therewith. The clutch 29 is provided with a yoke 32 pivotally mounted on a rod 33 and having a depending arm 34. A cam 35 is rigidly mounted on a shaft 36 having a suitable operating handle 37, and is adapted to engage the arm 34 upon being actuated to throw the clutch 29.

The chuck 28 in the present instance is provided with a plurality of clamping members 38 normally spring pressed into engagement with the work, and adapted to be withdrawn therefrom by means of a suitable draw bar 39 operable by means of a hand lever 40.

The gaging mechanism

The gaging mechanism (see Figs. 3 to 5) consists of a gage rod 41 extending slidably and axially through the work spindle 27 into the chuck 28, and having a pair of gages 42 and 43, designated respectively as a "roughing gage" and a "finishing gage", mounted on its forward end. The roughing gage 42 is slightly smaller in diameter than the finishing gage 43, and a little in advance thereof to permit the former to enter the bore of the blank A before the latter in the course of the grinding operation. The rear end of the gage rod 41 is connected by a bracket 44 to corresponding end of a parallel push rod 45 reciprocable in the top section 26 and carrying an abutment roller 46 at its forward end. A coil spring 47 engaging a collar 48 on the push rod 45 tends to move the gages forward into yielding engagement with the inner edge of the bore in the blank A, and an adjustable abutment 49 on the grinding spindle carriage 20 is adapted to strike the roller 46

to withdraw the gages from the work blank A as the grinding wheel 21 advances into the bore of said blank. When the bore has been ground to a predetermined size, the roughing gage only will enter the bore, and when ground to the desired size, i. e. when the grinding operation is completed, both gages will enter. The gaging mechanism thus far described is fully disclosed in the Patent No. 1,534,302 hereinbefore referred to.

An arm 50 rigidly mounted on the shaft 36 is adapted to engage a block 51 loosely mounted on the push rod 45 against the collar 48, and thereby to move the gages into inoperative position away from the work when the clutch 29 is thrown into open position to stop the spindle 27.

In moving initially past the inner edge of the work being ground, the gages 42 and 43 cause the successive closing of two switches 52 and 53 respectively. Preferably switches of the type disclosed in our U. S. Letters Patent No. 1,751,204, dated March 18, 1930, are employed. These switches are housed in a casing 54 secured to the left end of the body section 26 of the headstock carriage, and comprise two forked spring contacts 55 and 56 associated respectively with two sets of fixed contacts 57 and 58. The fixed contacts are supported on an insulating plate 59 over an oil reservoir 60 into which the spring contacts 55 and 56 extend, and two of the fixed contacts, one from each set, are connected by a conducting plate 61 to which a common lead wire is attached.

The two spring contacts 55 and 56 are movably supported by a pair of tripping mechanisms 62 which at the beginning of the grinding operation are locked in inoperative position and which when released will move the contacts 55 and 56 into engagement with the fixed contacts. The tripping mechanisms comprise two trip dogs 63, one for each mechanism, which are adapted to be engaged by a pair of plungers 64 slidably extending into the casing 54 and adjustably mounted in the bracket 44 for movement with the gages 42 and 43. These plungers are so adjusted that as the gage rod 41 is moved sufficiently to the right they will trip the two mechanisms successively to close the switches 52 and 53 in predetermined sequence.

The switches 52 and 53 after once being closed will be unaffected by the slight withdrawals of the gages from the work by the abutment 49. A pin 65 carried by the push rod 45, which extends through the casing 54 between the two tripping mechanisms, is adapted to reset both mechanisms, thereby opening the switches 52 and 53, when the clutch 29 is thrown into open position.

The grinding spindle carriage

The grinding spindle carriage 20 (see Figs. 1, 2 and 6 to 8) is mounted to reciprocate lon-

gitudinally on the base 17, and is provided with sides 66 overhanging the side walls of the base. Rotatably mounted in the carriage 20 is a spindle 67 which carries the grinding wheel 21, and which is driven by a belt 68 from an electric motor 69 mounted on the underside of the carriage to travel therewith.

The carriage is arranged to be reciprocated by a piston and cylinder unit, one element of which is mounted on the carriage to travel therewith and the other element of which is rigidly mounted within the base. In the present instance, the cylinder 70 is rigidly secured to the underside of the carriage 20, and the piston 71 is stationarily supported by hollow rods 72 having their remote ends mounted in the machine base. These rods communicate with the cylinder 70 at opposite sides of the piston 71 to introduce and permit the escape of pressure fluid.

Hydraulic pressure fluid, preferably oil, is drawn from the oil reservoir in the machine base 17 by an oil pump 73 driven by an electric motor 74, said pump and said motor being mounted on the rear side of the base. The oil is discharged from the pump 73 through a pipe 75 into the inlet port 76 of a main control valve 77 mounted on the front side of the base. This valve is formed with ports 78 and 79 connected to the remote ends of the hollow piston rods 72 by pipes 80 and 81. Spent oil flowing back to the valve 77 through either of the ports 78 and 79 is returned through outlet ports 82 to the oil reservoir. The flow of oil through the valve 77 is controlled by a reciprocable valve member 83 adapted to connect the ports 78 and 79 successively and alternately with the ports 76 and 82. With the valve member 83 in a neutral or central position the oil is bypassed directly from the inlet port 76 to the outlet ports 82. The volume of oil passing through the valve 77 can be varied to change the speed at which the carriage 20 moves by means of a hand lever 84 for adjusting a speed change gearing 85 in the connection between the motor 74 and the pump 73.

The valve member 83 is provided with a stem 86 pivotally connected to the lower end of an actuator which is in the form of an upright lever 87 pivoted between its ends at 88 to the machine base. A pivotal dog 89 is mounted in the upper end of the lever 87, and is normally maintained in the path of two dogs 90 and 91 by a spring follower 92. The dogs 90 and 91 are adjustably secured to the front depending side 66 of the carriage 20 by bolts 93 engaging in a T-slot 94. The dog 90 is beveled on its lower left end to provide an inclined face 95 which upon movement of the carriage from its inoperative position, shown in Figure 1, to the left will engage and depress the pivotal dog 89 to permit the latter to snap into position between the dogs 90 and 91. Upon continued

movement of the carriage, the dogs 90 and 91 will automatically oscillate the lever 87 to reciprocate the carriage in its operative position. The distance through which the carriage will reciprocate will depend upon the spacing of the dogs 90 and 91, and corresponds substantially to the length of the piece of work to be ground.

Mounted in a housing 96 on the base of the machine is an electromagnet 97 having a pivotal armature 98. A pin 99 is secured to the free end of the armature 98, and is slidably mounted in the housing 96 in position to engage and depress the pivotal dog 89 when the electromagnet 97 is excited. When the pivotal dog 89 is depressed, it will permit the dog 90 to move past without oscillating the lever 87, thereby prolonging the outward stroke of the reciprocating grinding wheel 21 so as to position the latter outside of the bore of the work. While the electromagnet 97 may be excited to effect this separation on any desired occasion, it is controlled in the present instance by the switch 53 adapted to be closed when the grinding operation is completed. The circuit through the electromagnet 97 is as follows: From the positive terminal of the line through wire 100, the switch 53, wire 101, the electromagnet 97, and wire 102 to the negative terminal of the line.

To hold the dog 89 in depressed position after the excitation of the electromagnet 97, a catch 103 is adapted to fall back of the pin 99 when the latter moves forward. The catch 103 is provided with a pin or lateral projection 104 which is adapted to ride upon an inclined cam face 105 on the inner end of the dog 90 to release the dog 89 when the grinding wheel 21 is separated from the work. A cam 106 is adjustably mounted on the carriage 20, and is formed with a cam surface 107 adapted to engage the upper end of the lever 87 and move it into neutral position when the carriage 20 is moved into its inoperative position remote from the headstock carriage.

Feeding mechanism

The headstock carriage 19 is arranged to be fed along the ways 25 to move the work blank A against the grinding wheel 21 by means of a feed screw 108 mounted in the base 17 and engaging a nut 109 on the under side of the body section 24 of the carriage (see Figs. 9 and 10). The outer end of the feed screw 108 extends through a feed box 110 on the front side of the machine, and is provided with a hand wheel 111 whereby it may be manually rotated.

Within the feed box, a ratchet wheel 112 is mounted on a sleeve 113 on the feed screw 108, and is connected through a train of gears 114 to the screw. The ratchet wheel 112 is adapted to be rotated intermittently by

either one or both of two feed pawls 115 and 116. These pawls are pivotally mounted on the oppositely extending arms of two bell crank levers 117 and 118, respectively, loosely mounted on the sleeve 113, and are resiliently held in engagement with the ratchet wheel 112 by springs 119. The other arms of the bell crank levers extend horizontally side by side, and are provided with cams 120 on their lower sides adapted to be engaged by a lever 121 to reciprocate the pawls. The degree of oscillation of these arms may be independently adjusted by means of two eccentrics 122 and 123 underlying them and limiting the downward movement of each of the cams 120. In practice, the eccentrics 122 and 123 are so adjusted that the pawl 115, designated as the "coarse feed pawl" is given a relatively long reciprocation, and the pawl 116 designated as the "fine feed pawl" is given a relatively short reciprocation.

The lever 121 is oscillated by means of a floating piston 124 reciprocable in a stationary horizontal cylinder 125. Pressure fluid is successively and alternatively received by and discharged from opposite ends of the cylinder 125 through pipes 126 and 127 branching from the pipes 80 and 81, respectively.

Mounted in the feed box 110 are a pair of electromagnets 128 and 129 provided with armatures 130 and 131 having curved tracks 132 and 133 respectively. The latter underlie rollers 134 and 135 on the pawls 115 and 116, and upon excitation of the electromagnets will raise the corresponding pawls out of engagement with the ratchet wheel 112. The electromagnets are connected in the following circuits controlled by the switches 52 and 53: from the positive terminal through the wire 100, thence branching through the switch 52, wire 136 and the electromagnet 128, and through the switch 53, the wire 101, and the electromagnet 129 to the wire 102 and negative terminal. Since the switches 52 and 53 close in sequence, the electromagnets will be closed in succession to automatically reduce and finally discontinue the cross feed as the grinding operation progresses.

To permit manual operation of the feed screw 108 by means of the hand wheel 111, the pawls 115 and 116, after excitation of the electromagnets are automatically locked in inoperative position by a pair of latches 137 engaging the heels of the armatures 130 and 131. The latches 137 are mounted on a pair of shafts 138 together with releasing levers 139 which are connected by suitable linkage 140 and which can be oscillated simultaneously by a lever 141 to disengage said latches and thereby release the pawls.

The slow traverse mechanism

To obtain a relatively slow traverse of the grinding wheel 21 in its working reciprocation during the finishing cut, a part of

the pressure fluid normally passing through the main control valve 77 is upon entry of the gage 42 into the bore of the work automatically by-passed to the oil reservoir in the base. To this end, the supply pipe 75 is connected with a pipe 142 which leads to a hollow casing 143 mounted in an opening 144 in the front wall of the machine base (see Fig. 10). The casing 143 is formed with an inlet passage 145 and an outlet passage 146, said passages communicating respectively through ports 147 and 148 with the interior of a valve sleeve 149. Opposite ends of the sleeve 149 open into an exhaust chamber 150 having an exhaust pipe 151 leading to the oil reservoir in the base. A pair of plugs 152 are removably threaded into opposite ends of the casing 143 in alinement with the valve sleeve 149.

Reciprocably mounted in the sleeve 149 is valve member 153 having a pair of spaced enlargements 154 controlling the ports 147 and 148. The valve member is provided with a stem 155 extending slidably through the inner plug 152. The outer end of the stem 155 is pivotally secured to the free end of the armature 156 of an electromagnet 157 rigidly mounted on the casing. The circuit through the electromagnet 157 is as follows: from the positive terminal through the wire 100, the switch 52, the wire 136, the electromagnet 157, and the wire 102 to the negative terminal. It will be evident that as the gage 42 moves past the inner edge of the surface being ground, the valve member 153 will be actuated by the electromagnet 157 to connect the ports 147 and 148 so as to by-pass a part of the pressure fluid normally passing to the main valve 77. A coil spring 158 on the stem 155 between the plug 152 and the armature 156 tends to cut off the ports 148 from the ports 147, and serves to return the valve member 153 to its initial position when the electromagnet 157 is deenergized.

As the grinding spindle carriage 20 reciprocates, its movements are opposed by a variable resistance. Thus, at the end of its inward stroke, the carriage assumes the added burden of moving the gages 42 and 43 away from the work. These changes in resistance result in a change of the pressure of the fluid in the cylinder 70, which tends to vary the speed of the carriage by causing unequal volumes of pressure fluid to be shunted through the pipe 142. To maintain a constant carriage speed, a self adjusting valve (see Fig. 15) is provided in the outlet passage 146. This valve comprises a cylinder 159 threaded into the wall of the casing 143 and having one or more ports 160 opening into the exhaust chamber 150. A piston 161 is slidably mounted in the cylinder 159 and is formed with a central passage 162 opening into the outlet passage 146 and communicating through ports 163 with the ports 160. Movement of the piston 161 is controlled and

limited by a pin 164 mounted therein and engaging a slot 165 in the cylinder 159. The slot 165 extends along the outside of the cylinder 159 to the exhaust chamber 150, and permits fluid from the cylinder to be exhausted when the piston 161 moves to the left. A sleeve 166 is threaded onto the front end of the cylinder 159, and is closed by a plug 167. Threaded into the sleeve 166 is an adjusting nut 168 between which and the inner end of the piston 161 a coiled spring 169 is positioned to counterbalance the pressure required to move the carriage at a predetermined speed. The ports 160 and 163 normally are in full register to provide the largest possible openings between the outlet passage 146 and the exhaust chamber 150. If the pressure increases, the piston 161 will move the ports 160 and 163 partly out of register to reduce the effective area of the openings therethrough. If the pressure is reduced, the piston 161 will move to the right to enlarge the openings through the ports 160 and 163. The valve thus permits a constant volume of pressure fluid to pass into the exhaust chamber 150 independent of the pressure, and consequently causes the carriage to move at a uniform speed irrespective of changes in the resistance opposing its movement.

The back-off mechanism

According to our invention, the grinding wheel 21 and the finished work surface are to be slightly separated laterally when the grinding is completed, and when the grinding wheel is about to be separated longitudinally from the work. While either of the carriages 19 and 20 may be moved to effect this separation, preferably the headstock carriage 19 is shifted through the feed screw 108 by a back-off mechanism (see Figs. 10 to 14) controlled by the gage 43. This mechanism comprises a pair of collars 170 mounted on the feed screw 108 next to a shoulder 171, and separated by a spacer 172. The collars 170 are held in place by a spacer sleeve 173 positioned between the front collar and the sleeve 113 in the feed box. Mounted on the spacer 172 between the collars 170 is a yoke 174 having two lateral cylindrical extensions 175 which are pivotally mounted in the arms of a bifurcated head 176 on the upper end of a lever 177. The head 176 is pivotally supported on a pin 178 in a bracket 179 rigidly secured to the base 17. The bracket 179 is formed integral with a water guard 180 which is also secured to the base 17 and which overlaps with a shield 181 on the headstock carriage 19 to protect the parts underneath.

The lower end of the lever 177 is formed with a knob 182 which engages in a milled slot 183 in a reciprocable piston 184. The piston is mounted in a cylinder 185 formed in the casing 143 and closed at its opposite ends by plugs or caps 186 having stops 187

formed thereon. A pocket 188 is formed in the casing 143 over the slot 183 to receive pressure fluid leaking past the ends of the piston, and a drain pipe 189 serves to return the fluid from said pocket to the oil reservoir.

The position of the piston is controlled by a valve comprising a valve sleeve 190. This sleeve is formed with a set of central ports 191 communicating with the inlet passage 145, and two sets of end ports 192 and 193 communicating with passages 194 and 195 leading to opposite ends of the cylinder 185. The opposite ends of the sleeve 190 open into the exhaust chamber 150. End plugs 196 are threaded into opposite ends of the casing 143 in line with the sleeve 190.

Reciprocally mounted in the valve sleeve 190 is a valve member 197 having two enlargements 198 adapted upon reciprocation to successively and alternately connect the end ports 192 and 193 with the exhaust chamber 150 and the inlet ports 191. The member 197 is provided with a stem 199 which extends slidably through one of the end caps 196, and the free end of which is pivotally secured to the free end of the pivotal armature 200 of an electromagnet 201. The electromagnet 201 is rigidly supported on the casing 143, and the circuit therethrough is as follows: from the positive terminal through the wire 100, the switch 53, the wire 101, the electromagnet 201, and the wire 102 to the negative terminal. A coil spring 202 on the stem 199 between the armature 200 and the end cap 196 tends to maintain the valve member 197 to the right to connect the ports 191 and 193. It will be evident that when the gage 43 moves past the inner edge of the finished work surface, thereby closing its switch 53, the electromagnet 201 will be excited, and will cause the feed screw 108 to be shifted longitudinally to the left to separate the grinding wheel 21 and the finished work surface.

The operation

The operation of the machine will be evident from the foregoing description, and briefly stated is as follows: The work to be ground is placed in the chuck 28, and the lever 37 is actuated to throw in the clutch 29 and start operation of the spindle 27. By actuating the lever 37, the cam 50 releases the push rod 45, thereby permitting the gages 42 and 43 to move into engagement with the inner end of the work. The lever 87 at the front of the machine base 17 is thrown to the right thereby instituting movement of the grinding spindle carriage 20 to the left.

When the grinding wheel 21 has reached the work, the dog 90 will depress the pivotal dog 89 and cause the latter to be positioned between the dogs 90 and 91 to institute and effect an automatic reciprocation of the wheel in its operative position. At the in-

ner end of each reciprocation, the abutment 49 will temporarily withdraw the gages 42 and 43 from the work to avoid contact of the gages with the grinding wheel. Meanwhile the work is moved into engagement with the grinding wheel 21 by turning the hand wheel 111, and the automatic cross feed is then instituted by actuating the lever 141 to release the feed pawls 115 and 116.

The grinding wheel 21 continues to reciprocate and the headstock carriage to be fed transversely of the grinding wheel until the work is ground to a predetermined size whereupon the foremost gage 42 will move past the inner edge of the surface being ground. This action permits the gage rod 41 to move forwardly a distance sufficient to close the switch 52.

Closure of the switch 52 results in the excitation of the electromagnets 128 and 157. The electromagnet 128 raises the pawl 115 and effects a reduction in the rate of cross feed. The electromagnet 157 simultaneously moves the valve member 153 to bring the ports 147 and 148 into communication with each other, thereby by-passing a part of the pressure fluid normally passing to the main control valve. As a result the speed of the grinding spindle carriage 20 is reduced during the finishing cut. The speed of the carriage 20 is maintained constant by the self adjusting valve in the outlet passage 146.

When the work has been ground to the desired size, the second gage 43 will move past the inner edge of the finished work surface thereby permitting the gage rod 41 to move forward sufficiently to close the switch 53. Closure of the last mentioned switch simultaneously closes the circuits through the electromagnets 129, 201 and 97. Excitation of the first electromagnet raises the feed pawl 116 to discontinue the cross feed. Excitation of the second electromagnet 201 causes the movement of the valve member 197 to the left to bring the ports 191 and 192 into communication. Pressure fluid is thereupon directed to the outer end and from the inner end of the cylinder 185 to move the piston 184, thereby shifting the feed screw 108 longitudinally a small distance to the left. This causes a lateral separation of the grinding wheel 21 and the finished work surface. Excitation of the third electromagnet 97 results in the tripping of the dog 89 to permit a prolongation of the outward stroke of the grinding wheel. Since the grinding wheel is now separated from the finished work surface it will pass beyond the work without engaging said surface.

When the grinding wheel 21 has been withdrawn longitudinally just beyond the work, the clutch 29 is thrown out to stop the spindle 27 and permit reloading of the chuck. In opening the clutch, the gage rod 41 is far withdrawn, thereby opening the

switches 52 and 53, and resetting the tripping mechanisms 62 therefor. Opening of these switches causes all of the electromagnets to be deenergized. Thereupon the springs 158 and 202 move the valve members 153 and 197 to the right so as to close the by-pass valve and shift the feed screw 108 back to initial position. The grinding spindle carriage 20 then continues to move at fast speed toward its inoperative position in which it is automatically stopped by the cam 106. After the chuck 28 has been reloaded, the above operation is repeated.

By slowing down the speed of reciprocation of the grinding wheel during the finishing cut and by separating the grinding wheel and the ground surface before withdrawal of the former from the work, an improved finish is obtained. It is to be understood that while the specific movements of the carriages and other parts are described in detail, such movements are required merely to be relative to obtain the desired results.

We claim as our invention:

1. A grinding machine having, in combination, a carriage having a grinding wheel, a headstock adapted to support the work, a gage arranged to coact with the work, hydraulic operating means for effecting a relative working reciprocation between said grinding wheel and said work, means set in operation by said gage for prolonging one stroke of said reciprocation to separate said grinding wheel and said work in one direction, and means set in operation by said gage for automatically effecting a separation between said grinding wheel and said work in another direction to permit said first mentioned separation without permitting said grinding wheel to engage the end of the ground surface.

2. A grinding machine having, in combination, a carriage having a grinding wheel, a headstock adapted to support the work, a gage arranged to coact with the work, means for effecting a relative intermittent approaching movement, a relative reciprocation and a separation at the completion of said reciprocation between said grinding wheel and the work, said separating movement being instituted by said gage, means set in operation by said gage for slowing down the speed of said reciprocation during the last part of the grinding operation, and means set in operation by said gage for effecting a separation between said grinding wheel and the work surface before said first mentioned separation between said grinding wheel and the work is completed.

3. A grinding machine having, in combination, a grinding wheel, a headstock adapted to support the work to be ground, a carriage supporting one of said parts, fluid pressure means for moving said carriage and thus relatively reciprocating said grinding

wheel axially across the surface of said work, means automatically operable when the grinding has proceeded to a predetermined point to slow down the speed of said reciprocation, and self adjusting means for changing the pressure of the fluid to compensate for changes in the resistance to said reciprocating movement, said last mentioned means serving to maintain a constant speed during the slow reciprocation.

4. A grinding machine having, in combination, a grinding wheel, a headstock adapted to support the work to be ground, a carriage supporting one of said parts, fluid pressure means for reciprocating said carriage and thus effecting a relative reciprocation of said grinding wheel with respect to the work, and means for slowing down the speed of reciprocation, said last mentioned means including means for maintaining a constant speed of said reciprocation after the latter is reduced.

5. A grinding machine having, in combination, a carriage having a grinding wheel, a headstock for supporting a workpiece, for the grinding of a bore therein by said wheel, fluid pressure operating means for producing a relative axial reciprocation between said wheel and the workpiece bore in the grinding of the latter, a gauge arranged to enter said workpiece bore when the grinding thereof has proceeded to a predetermined point, and a by-pass valve controlled by said gauge and adapted to by-pass a portion of the pressure fluid normally directed to said operating means when the grinding has proceeded to said predetermined point, thereby to slow down the speed of said reciprocation.

6. A grinding machine having, in combination, a carriage having a grinding wheel, a headstock adapted to support the work to be ground, a gage arranged to coact with the work, hydraulic operating means for effecting an approaching movement between said grinding wheel and the work to bring them into operative relation, a relative reciprocating movement therebetween axially of said grinding wheel, and an automatic separation therebetween axially of said grinding wheel when the work has been ground to a predetermined point, means automatically operable to by-pass a part of the pressure fluid directed to cause said above movements to slow down said reciprocation when the grinding has progressed to a predetermined point, said last mentioned means including means for maintaining a constant speed of reciprocation irrespective of variations in the pressure of said pressure fluid.

7. A grinding machine having, in combination, a carriage having a grinding wheel, a headstock adapted to support the work, means for effecting a relative intermittent cross feed between said grinding wheel and said work, means for effecting a relative

movement axially of said grinding wheel between said grinding wheel and said work to grind the latter and for automatically separating them axially of said grinding wheel, said separation occurring only at the completion of the grinding operation, means automatically operable to successively reduce the magnitude of individual cross feed actuations and discontinue said cross feed, and means automatically operable at the completion of the grinding operation to effect a lateral separation between said grinding wheel and the work in the direction of said cross feed to permit the first mentioned separation of the grinding wheel and the work without engagement of said grinding wheel with the finished work surface.

8. A grinding machine having, in combination, a carriage having a grinding wheel, a headstock adapted to support the work, means including a feed screw for moving said headstock transversely of said grinding wheel to effect a relative feeding movement between said work and said grinding wheel, means for effecting a relative movement axially of said grinding wheel and the work, and means automatically operable to shift said feed screw bodily and longitudinally to effect a lateral separation between said grinding wheel and said work.

9. A grinding machine having, in combination, a carriage having a grinding wheel, a headstock carriage adapted to support the work, means for moving said grinding wheel and said work relative to each other to grind the latter, one of said carriages having a cross feed screw, a lever rotatably engaging said cross feed screw, means automatically operable when the grinding has proceeded to a predetermined point to oscillate said lever and shift said feed screw bodily thereby effecting a separation between said grinding wheel and said work laterally of said grinding wheel.

10. A grinding machine having, in combination, a support for a grinding wheel, a support for the work to be ground, means for effecting a relative movement between said grinding wheel and said work to grind the latter, a gage arranged to coact with the work, a piston and cylinder unit, a lever engaging one of said supports at its upper end, and one of the elements of said piston and cylinder unit at its lower end, and means under the control of said gage for directing pressure fluid to said piston and cylinder unit to oscillate said lever and thereby shift said grinding wheel and said work laterally relatively to each other to separate them.

11. A grinding machine having, in combination, a carriage having a grinding wheel, a carriage for supporting the work, said carriages being mounted for a relative cross-feed, a gage arranged to coact with the work, a lever engaging one of said carriages and

adapted to move the same in the line of said cross-feed, a piston and cylinder unit for actuating said lever to shift said last mentioned carriage, a valve for controlling the admission of pressure fluid to said piston and cylinder unit, and an electromagnet controlled by said gage for actuating said valve.

12. A grinding machine, having in combination, a carriage having a grinding wheel, a carriage for supporting the work, hydraulic operating means for effecting a relative reciprocation between said grinding wheel and said work axially of the grinding wheel, a gage arranged to coact with the work, a by-pass valve for by-passing a portion of the pressure fluid normally passing to said operating mechanism, and an electromagnet controlled by said gage for actuating said valve to by-pass said pressure fluid and effect a reduction in the speed of said reciprocation.

13. A grinding machine having, in combination, a carriage having a grinding wheel, a carriage for supporting the work, means for effecting a relative reciprocation between said grinding wheel and said work axially of the grinding wheel, intermittently operated means for feeding said carriages one in relation to the other, so that the grinding wheel will make successively deeper cuts in the work, said means being brought into operation substantially at the reversals of the aforesaid reciprocating movements, automatic means for causing ultimate separation of said carriages in a direction parallel to the axis of said grinding wheel, whereby to draw said grinding wheel by the edge of a workpiece being ground, and further automatic means brought into operation only upon operation of said first-mentioned automatic means, to cause separation of said carriages in a direction substantially at right angles to the axis of the grinding wheel, whereby to remove said wheel from contact with a workpiece before any part of said wheel moves past the edge of said workpiece, during the movement of axial separation of said carriages.

14. A grinding machine having, in combination, a grinding wheel, a head stock, means for procuring a relative reciprocating motion of one of said parts in relation to the other through a given range of travel, and for causing a movement of separation between them along the direction of the aforesaid range of travel but beyond it, means governed by the progress of the grinding operation, means set in operation by said last named means to procure the said movement of separation, and further means also set in operation by the means governed by the progress of the grinding operation to procure a lateral separation between the grinding wheel and the head stock, on a line divergent from the aforesaid line of travel,

and before the aforesaid movement of separation on said line, whereby to procure automatic determination of a grinding operation and separation between a grinding wheel and
 5 workpiece without running the wheel off the workpiece and thus eliminating scratch marks due to the wheel pressure on a gradually diminishing surface.

15. A grinding machine having, in combination, a grinding wheel, a head stock adapted to support the work to be ground, a carriage supporting one of said parts, fluid pressure means for reciprocating said carriage, thus to effect a relative motion between the grinding wheel and a workpiece,
 15 controlling means for the pressure fluid adapted to slow down the speed of reciprocation of said carriage, means governed by the progress of a grinding operation to automatically bring into operation said controlling means, and means coincidently brought into operation for varying the pressure of the fluid, during the slow reciprocation of the carriage, to compensate for changes of
 20 resistance to movement of said carriage.

16. In a grinding machine, a head stock adapted to hold a workpiece, a grinding wheel, means for reciprocating said grinding wheel relative to the work to produce a
 30 grinding traverse through a given range and for withdrawing said grinding wheel relative to the work in an axial direction to separate them, work sizing means to set in operation the withdrawal movement axially,
 35 cross feeding mechanism to feed the workpiece in cutting relation to the grinding wheel, means to effect a lateral separation between the work and wheel, and controlling means operated by said work sizing mechanism for causing said lateral separation to take place before the wheel has left the workpiece.

17. In a grinding machine, a head stock adapted to hold a workpiece, a grinding
 45 wheel, means for reciprocating said grinding wheel relative to the work to produce a grinding traverse through a given range and for withdrawing said grinding wheel relative to the work in an axial direction to separate them, work sizing means to set in operation the withdrawal movement axially,
 50 cross feeding mechanism to feed the workpiece in cutting relation to the grinding wheel, means additional to said cross feeding means to effect a slight lateral separation along the line of the cross feed between the work and wheel, and controlling means operated by said work sizing mechanism for causing said lateral separation to take place
 60 before the wheel has left the workpiece.

18. In a grinding machine, the combination with a grinding wheel, a workhead, a reciprocatory table for producing a relative axial traverse between said parts, and means
 65 for effecting a cross feed of one of said parts

relative to the other, of automatic means for causing said table to move beyond its normal traverse, to substantially separate said wheel and workhead along the line of said reciprocation, and means responsive to said automatic means for causing said wheel and workhead to separate along the line of said cross feed.

19. In a grinding machine, the combination with a grinding wheel, a workhead, a reciprocatory table for producing a relative axial traverse between said parts, and means for effecting a cross feed of one of said parts relative to the other, of automatic means for causing said table to substantially separate
 75 said wheel and workhead along the line of said reciprocation, and hydraulic means responsive to said automatic means for causing a separation of said wheel and workhead along the line of said cross feed.

20. In a grinding machine, the combination with a grinding wheel, a workhead, means for producing a relative axial reciprocatory traverse between said parts, and means for effecting a cross feed of one of said parts relative to the other, of automatic means for causing said wheel and workhead to separate along the line of said relative reciprocatory traverse, other means adapted, when actuated, to cause said workhead and wheel to separate along the line of said cross feed, and hydraulic means brought into operation coincident with said automatic means to actuate said other means.

21. In a grinding machine, a table or carriage, means for giving said table or carriage a reciprocatory motion, a cross slide, a cross feed screw adapted, when turned, to effect a progressive cross feed movement of said cross slide relative to said table or carriage transversely to the line of the latter's reciprocation, automatic means for extending the reciprocatory motion of said table or carriage, and means responsive thereto for effecting a retraction of the cross feed movement of said slide relative to said table or carriage without turning said cross feed screw.

In testimony whereof we have hereunto affixed our signatures.

HERBERT E. KEMPTON.
 KEITH F. GALLIMORE.