June 7, 1932. K. F. GALLIMORE 1,862,215

GRINDING MACHINE

Original Filed July 22, 1925 10 Sheets-Sheet 1

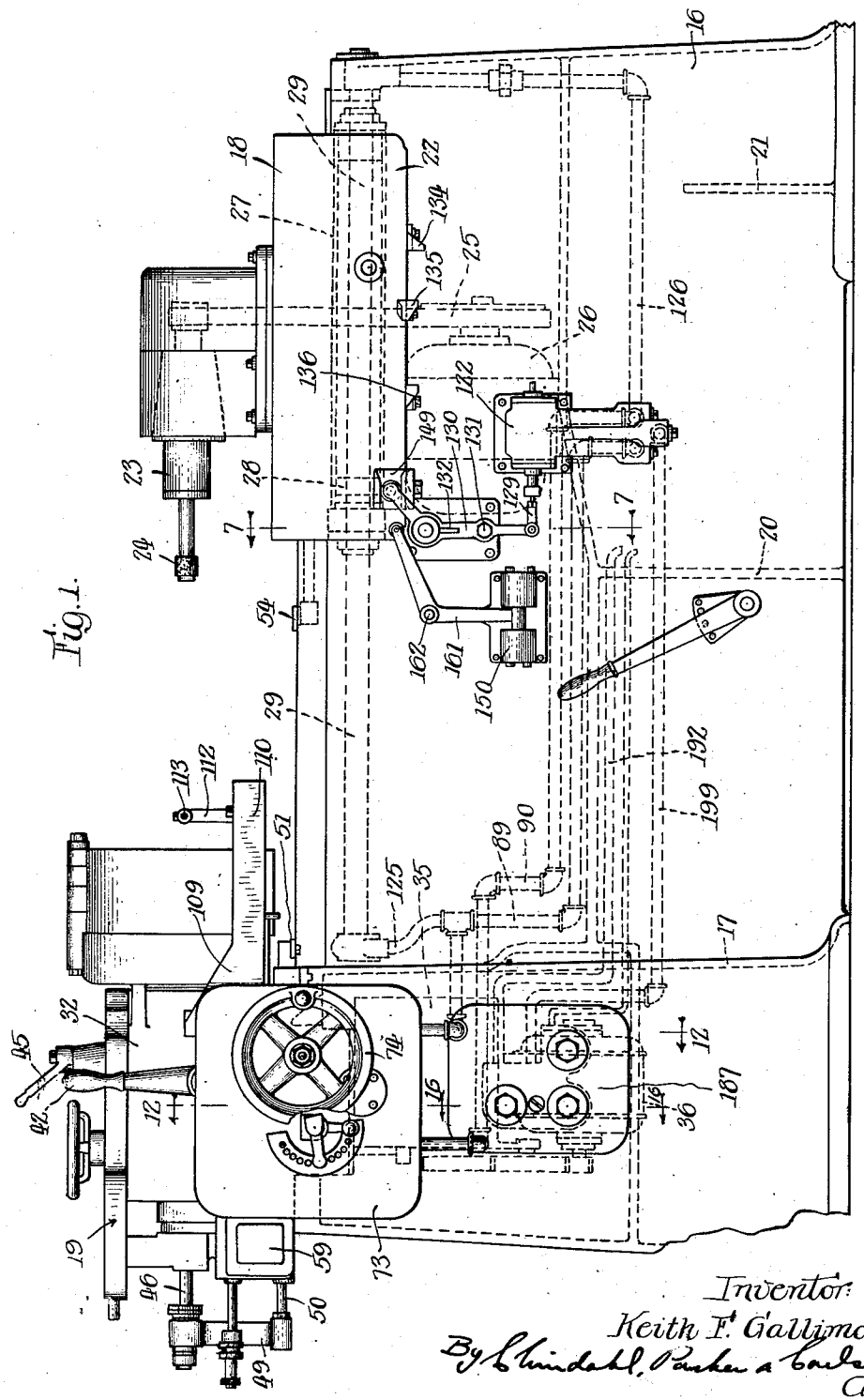


Fig. 1.

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GRINDING MACHINE

Original Filed July 22, 1925 10 Sheets-Sheet 2

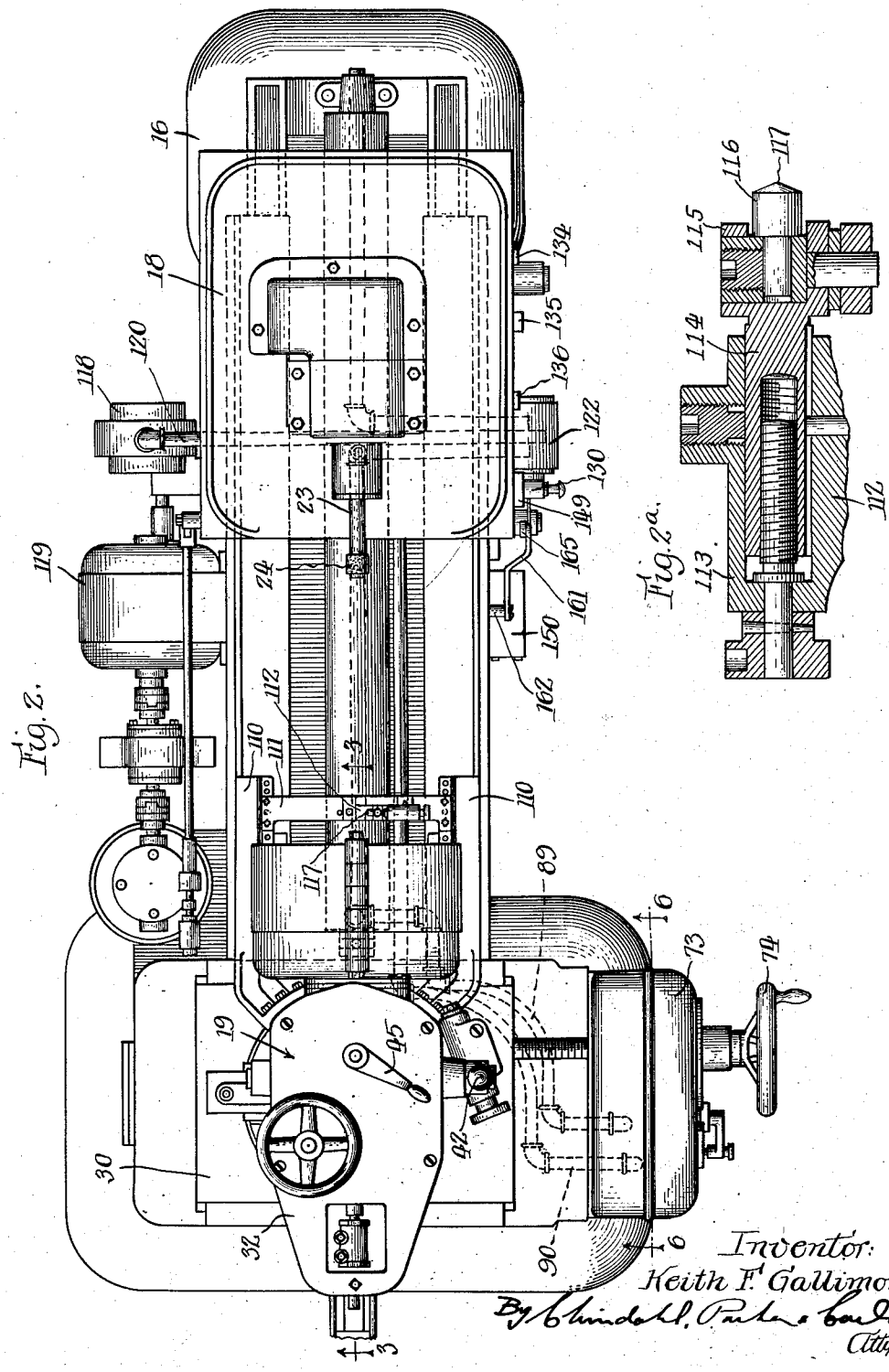


Fig. 2.

Fig. 2a.

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June 7, 1932. K. F. GALLIMORE 1,862,215

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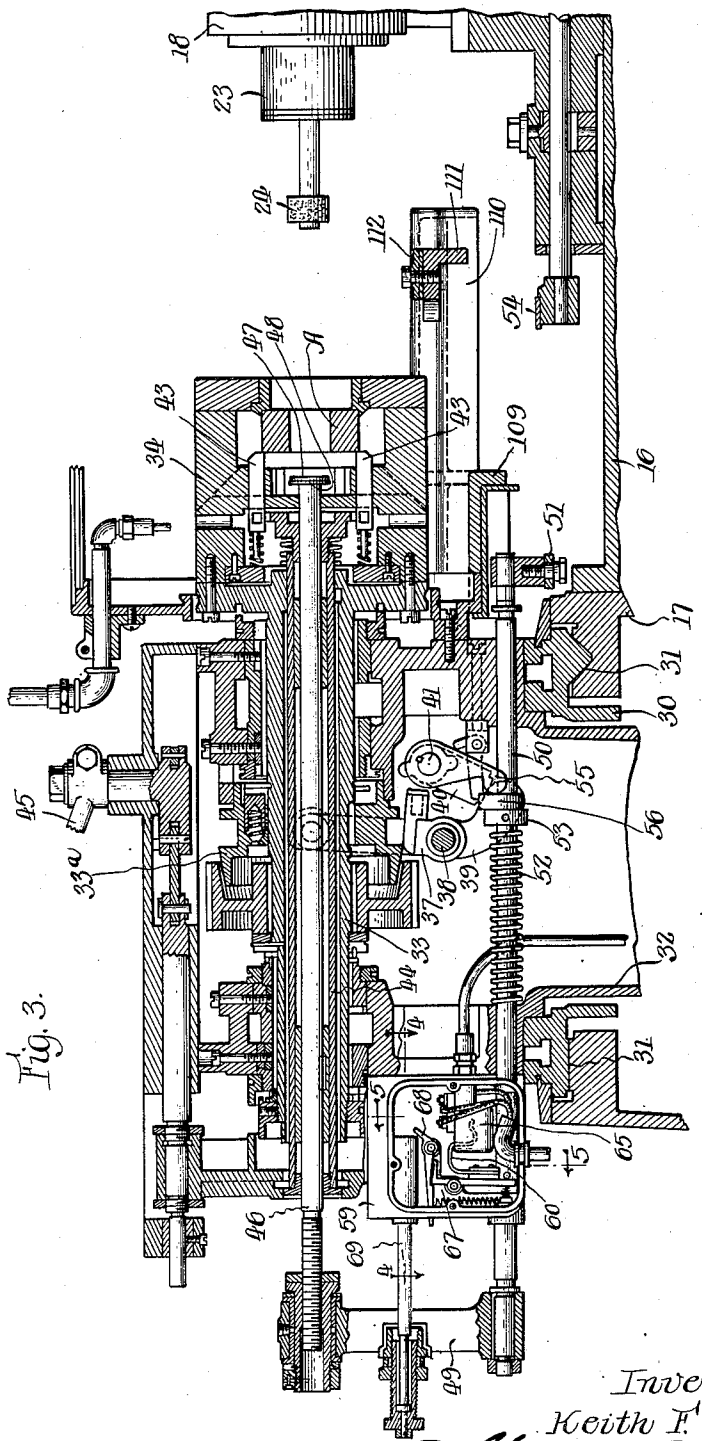


Fig. 3.

Inventor:
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June 7, 1932. K. F. GALLIMORE 1,862,215

GRINDING MACHINE

Original Filed July 22, 1925 10 Sheets-Sheet 4

Fig. 4.

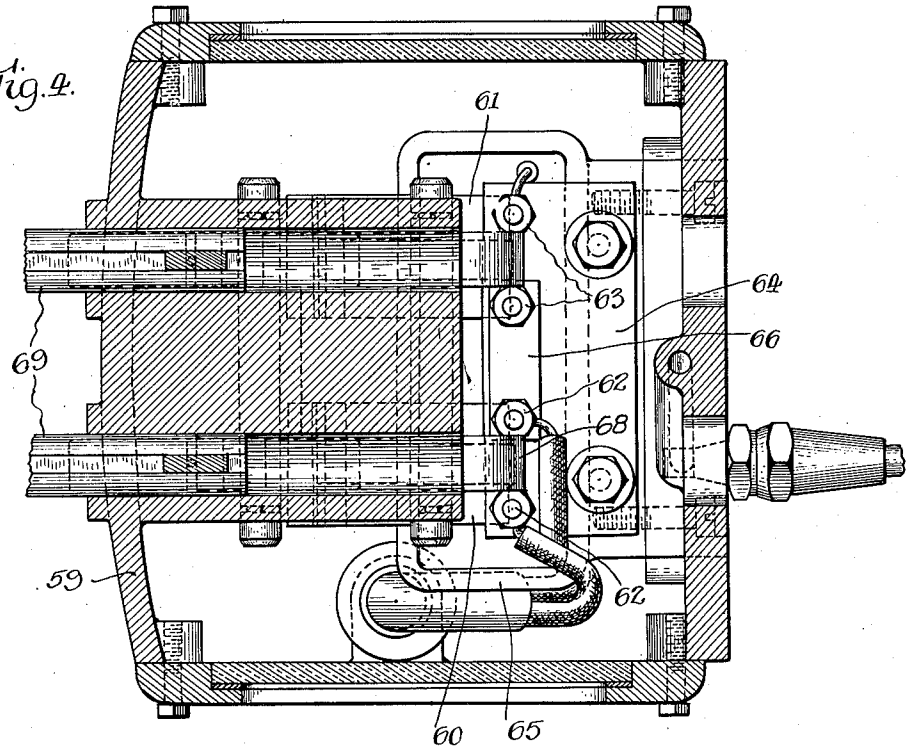
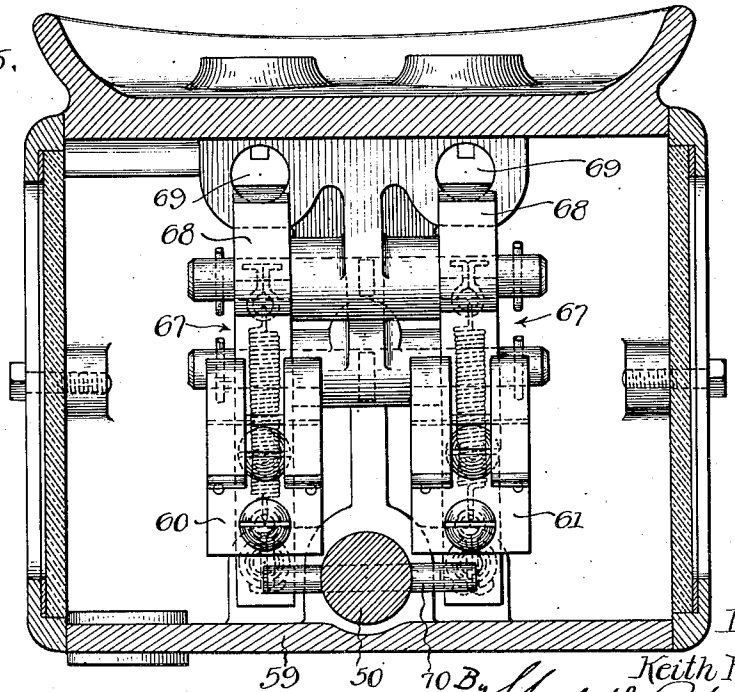


Fig. 5.



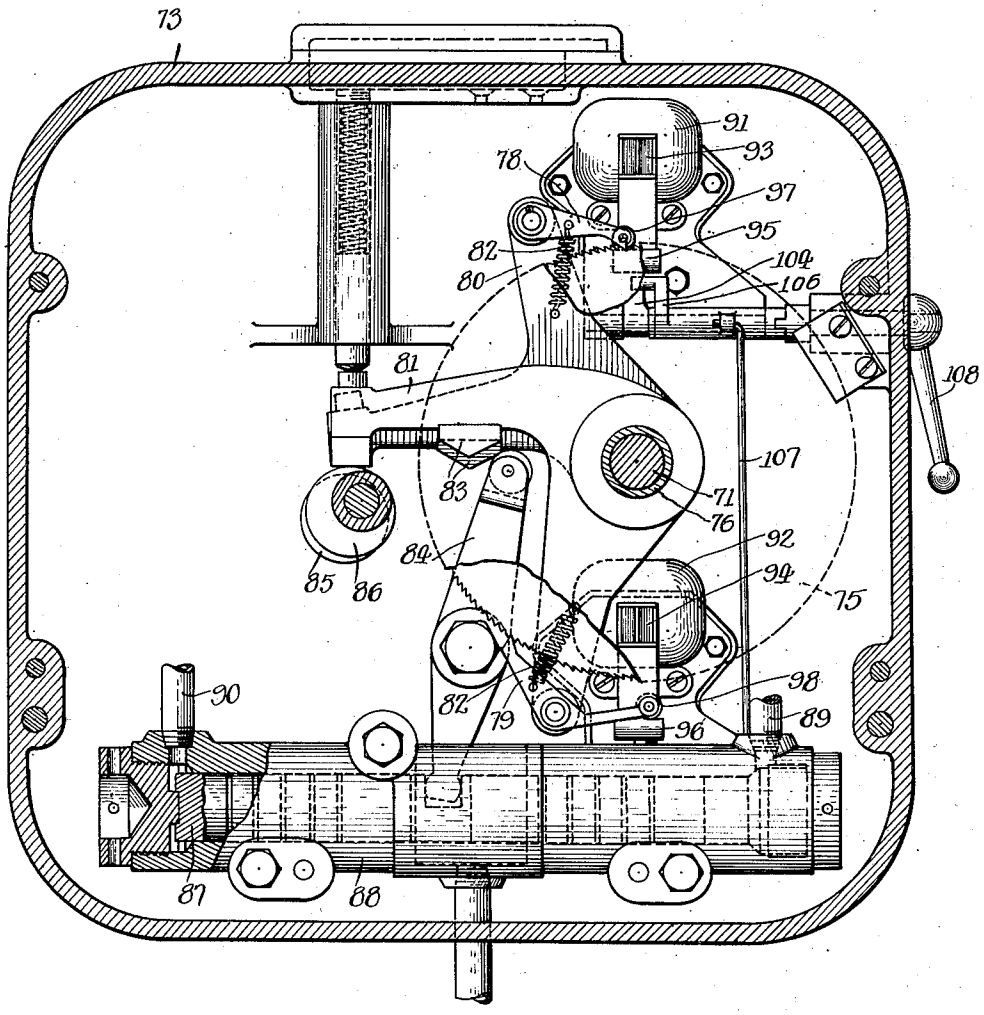
Inventor:
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June 7, 1932. K. F. GALLIMORE 1,862,215

GRINDING MACHINE

Original Filed July 22, 1925 10 Sheets-Sheet 5

Fig. 6.



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June 7, 1932. K. F. GALLIMORE 1,862,215

GRINDING MACHINE

Original Filed July 22, 1925 10 Sheets-Sheet 6

Fig. 7.

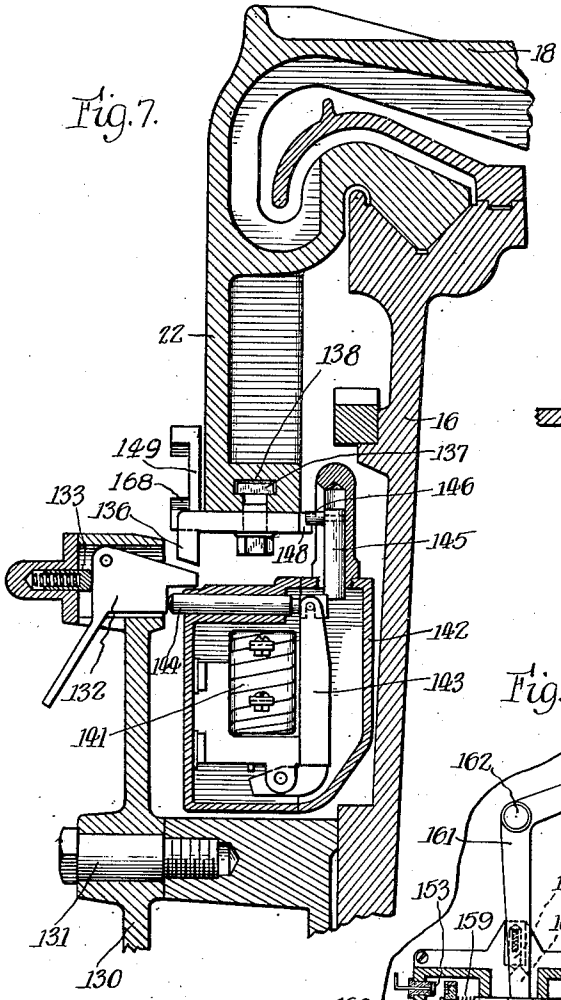


Fig. 9.

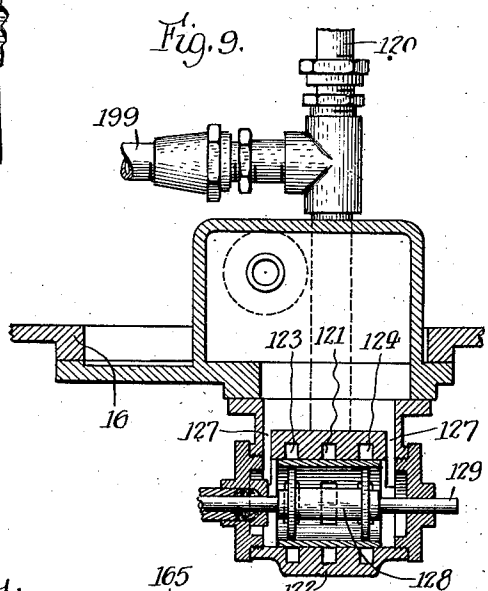
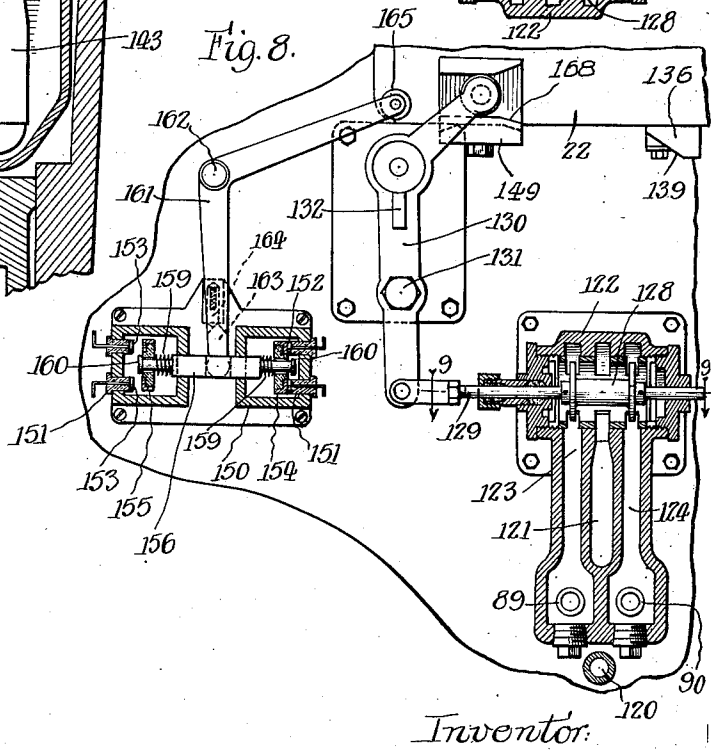


Fig. 8.



Inventor:
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Fig. 12.

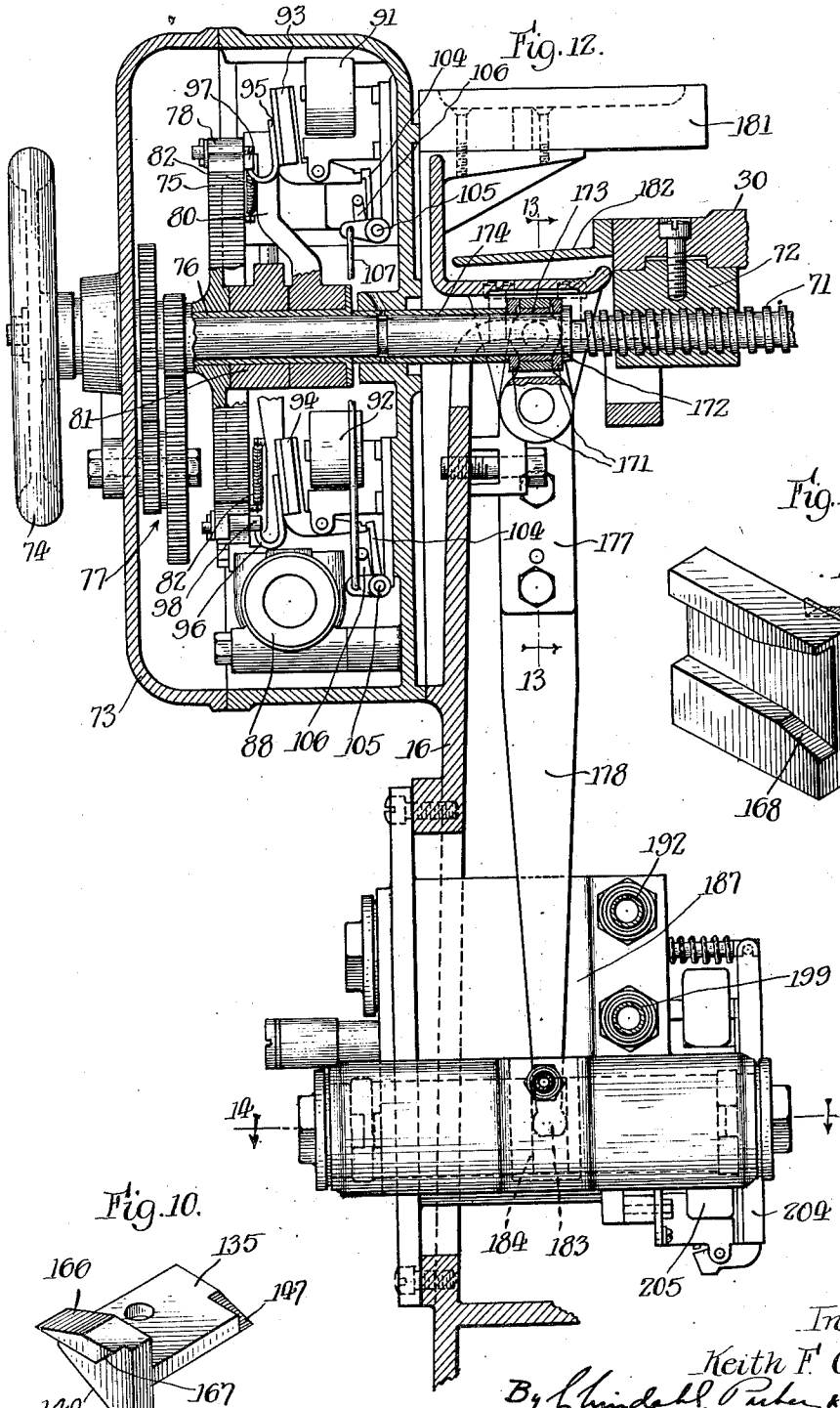


Fig. 11.

Fig. 10.

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Fig. 13.

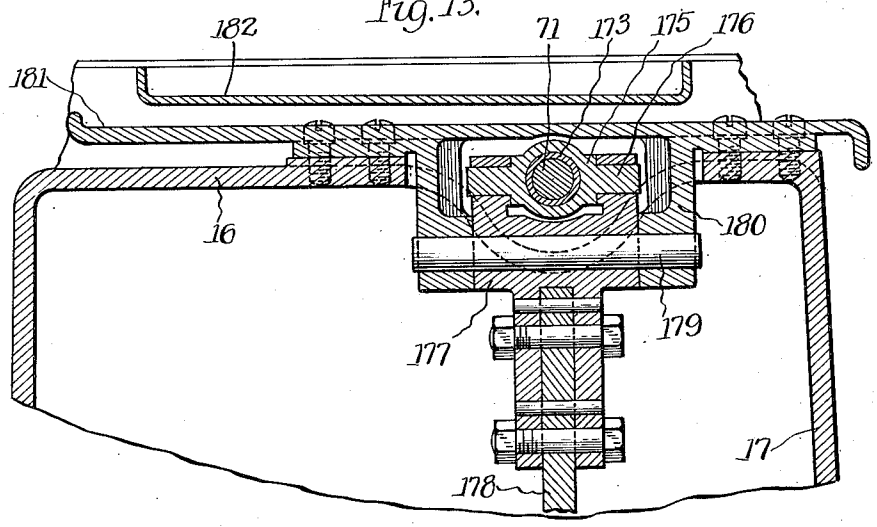
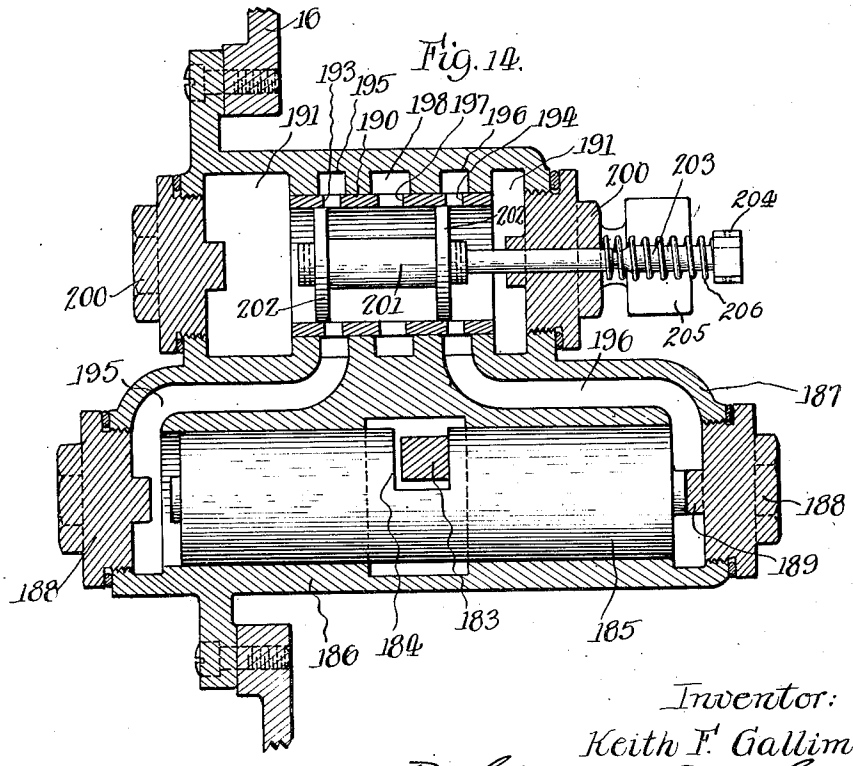


Fig. 14.



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GRINDING MACHINE

Original Filed July 22, 1925 10 Sheets-Sheet 9

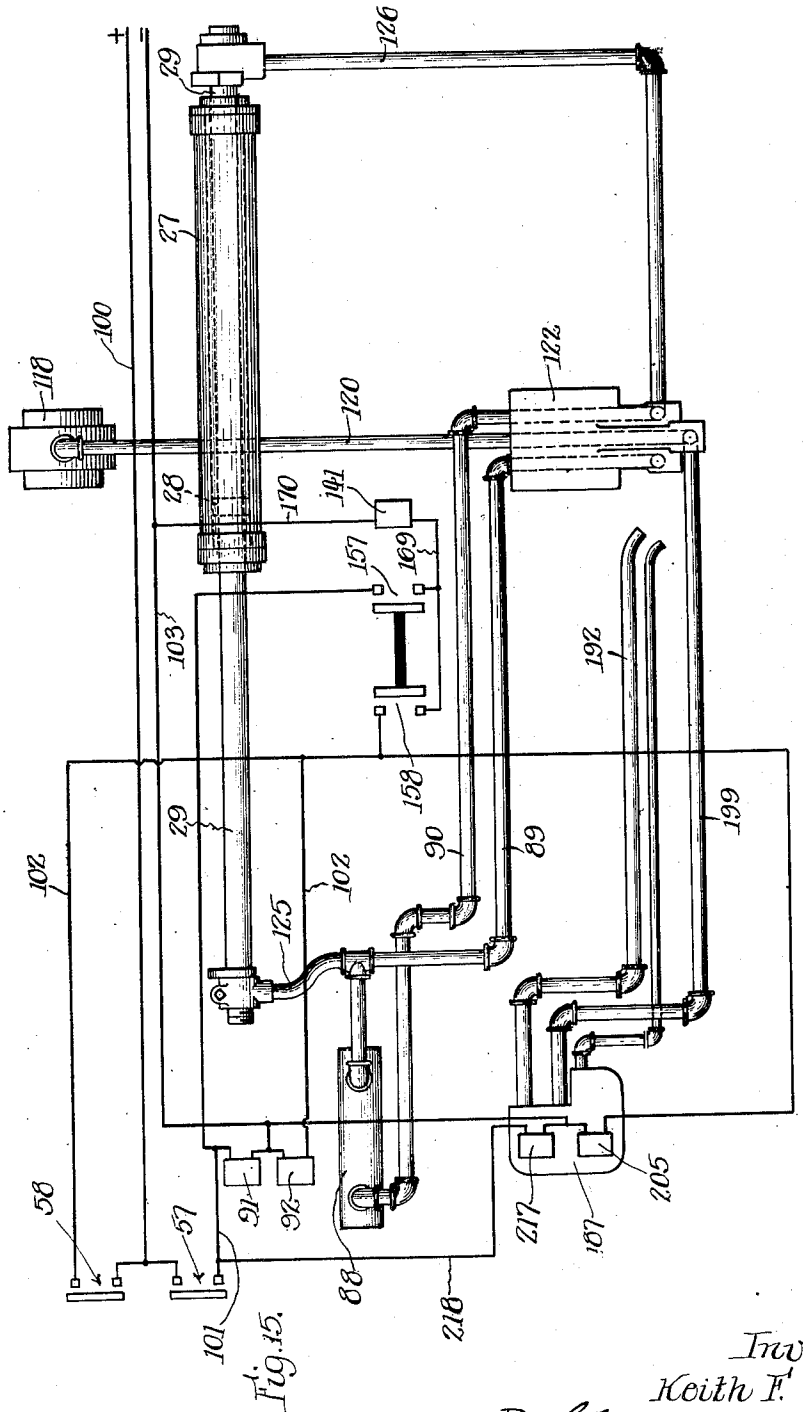


Fig. 15.

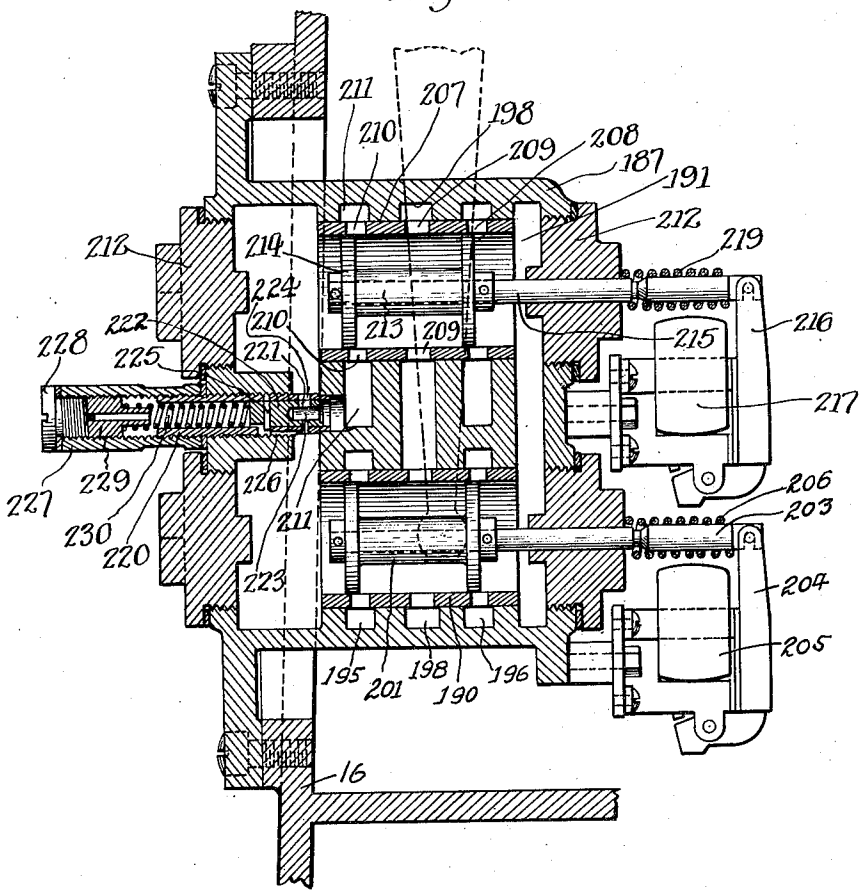
Inventor:
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June 7, 1932. K. F. GALLIMORE 1,862,215

GRINDING MACHINE

Original Filed July 22, 1925 10 Sheets-Sheet 10

Fig. 16.



Inventor:
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Patented June 7, 1932 1,862,215

UNITED STATES PATENT OFFICE

KEITH F. GALLIMORE, OF FOND DU LAC, WISCONSIN, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HEALD MACHINE COMPANY, OF WORCESTER, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS

GRINDING MACHINE

Application filed July 22, 1925, Serial No. 45,164. Renewed November 23, 1929.

The present invention relates to improvements in grinding machines, and has particular reference to automatic internal grinders in which the grinding wheel is automatically brought from a remote inoperative position into an operative position relative to the work, is reciprocated in contact with the work, and at the completion of the grinding operation is automatically returned to its inoperative position.

The primary object of the invention is to provide a fixed wheel truing device which will automatically dress the grinding wheel at the completion of the rough grinding operation, i. e. a predetermined time after the beginning and before the completion of the grinding operation.

A more specific object is to provide in combination with a fixed wheel truing device mounted on the headstock carriage for movement therewith, means for automatically effecting the temporary withdrawal of the grinding wheel from the work at a predetermined point in the grinding operation, and means for automatically effecting a separation of the grinding wheel and the finished surface of the work in a direction perpendicular to the latter at the completion of the grinding operation, the first movement serving to carry the grinding wheel past the truing device to engage therewith, and the second movement serving to permit the grinding wheel to be drawn into its inoperative position without again engaging the finished surface of the work or the truing device.

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

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

Fig. 2 is a plan view of the machine.

Fig. 2ª is a fragmentary sectional view of the dressing tool support.

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 of the feeding mechanism taken along line 6—6 of Fig. 2.

Fig. 7 is a fragmentary vertical sectional view taken along line 7—7 of Figure 1.

Fig. 8 is an enlarged fragmentary view of the front of the machine, said view showing the main control valve and the reversing switch in section, and the control dogs and levers.

Fig. 9 is a sectional view of the valve taken along line 9—9 of Fig. 8.

Fig. 10 is a perspective view of one of the reversing dogs.

Fig. 11 is a perspective view of another dog.

Fig. 12 is a vertical sectional view taken substantially along line 12—12 of Fig. 1.

Fig. 13 is a fragmentary sectional view taken substantially along line 13—13 of Fig. 12.

Fig. 14 is a sectional view taken along line 14—14 of Fig. 12.

Fig. 15 is a diagrammatic representation of the hydraulic operating system and of the electric circuits for operating and controlling the operation of the machine carriages.

Fig. 16 is a sectional view taken substantially in the plane of line 16—16 of Fig. 1.

While the invention is susceptible of various modifications and alternative constructions and adaptations, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I 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 16 having an internal transverse wall 17 which separates the base into a long bed on which a grinding spindle carriage 18 is mounted and a side portion on which a headstock carriage 19 is mounted. Between the wall 17 and another transverse wall 20 is a chamber adapted to

contain a coolant fluid for the work, and between the wall 20 and a third transverse wall 21 is a reservoir adapted to contain a pressure fluid, such as oil for actuating the carriages 18 and 19.

Hydraulic operating mechanism is provided for actuating the carriages. This mechanism includes a main control valve which is automatically operable by movements of the grinding spindle carriage 18 to direct pressure fluid to a feeding mechanism for effecting a relative transverse feed between the grinding wheel and the work, and to direct pressure fluid to a hydraulic motor on the grinding spindle carriage to cause the latter to move from an inoperative position remote from the headstock carriage into operative position in which the grinding wheel and the work are positioned in operative relation, to reciprocate the grinding spindle carriage in its operative position, to temporarily move said carriage partly toward its inoperative position and immediately return the same to its operative position thereby effecting a temporary withdrawal of the grinding wheel from the work, and when the grinding operation is completed to return the grinding spindle carriage to its inoperative position. The feeding mechanism initially provides a coarse cross feed for the roughing cuts, and finally provides a fine cross feed for the finishing cuts. A gage is provided which coacts with the work and which is effectual to institute the reduction in the cross feed and the temporary and permanent withdrawals of the grinding wheel from the work. A fixed wheel dressing device is mounted on the headstock carriage to dress the grinding wheel as it moves past on its temporary withdrawal movement from the work. Hydraulic means having a supplemental valve under the control of the gage serves to effect a separation of the grinding wheel and the work in a direction perpendicular to the surface of the latter when the grinding operation is completed and before the grinding wheel is withdrawn beyond the end of the ground surface, thereby preventing the grinding wheel from engaging the end of the ground surface and the dressing tool on its final withdrawal.

While hydraulic means is employed to actuate the carriages and while each of the carriages is given certain specific movements, it is to be understood that for the purposes of the invention any suitable power means may be employed, and the machine movements broadly outlined may be given to either of the carriages since the movements between the carriages are required only to be relative.

The grinding spindle carriage

The grinding spindle carriage 18 (see Figs. 1 and 2) is mounted to reciprocate on suitable ways extending longitudinally of the base 16, and is provided with sides 22 overhanging the side walls of the base. Rotatably mounted in the carriage 18 is a spindle 23 which carries a grinding wheel 24, and which is driven by a belt 25 from an electric motor 26 mounted on the underside of the carriage to travel therewith. The carriage 18 is arranged to be reciprocated by a piston and cylinder unit, one element of which is mounted on the carriage to travel therewith. Preferably the cylinder 27 is rigidly secured to the underside of the carriage 18, and the piston 28 is stationarily supported by hollow rods 29 having their remote ends mounted in the machine base. These rods communicate with the cylinder 27 at opposite sides of the piston 28 to introduce and discharge the pressure fluid from and to the main control valve to be hereinafter described.

The headstock carriage

The headstock carriage 19 (see Figs. 2 and 3) comprises a body section 30 which is slidably mounted on transverse ways 31 on the machine base 16, and a top section 32 which is rotatably mounted on the body section and extends therethrough into the base. Journaled in the top section 32 is a rotary work spindle 33 which carries a suitable chuck or work fixture 34 on one end for holding the work to be ground, such as the blank A, and which is driven through suitable connections including a movable clutch member 33a and a change speed gearing 35 by an electric motor 36 mounted together with the gearing on the underside of the top section to move and rotate therewith. The clutch member 33a is provided with a yoke 37 pivotally mounted on a rod 38 and having a depending arm 39. A cam 40 is rigidly mounted on a shaft 41 having a suitable hand lever 42, and is adapted to engage the arm 39 upon being actuated to throw the clutch member 33a.

The chuck 34 in the present instance is provided with a plurality of clamping members 43 normally spring pressed into engagement with the work, and adapted to be withdrawn therefrom by means of a suitable draw bar 44 operatively connected with a hand lever 45.

The gaging mechanism

The gaging mechanism (see Figs. 3 to 5) consists of a gage rod 46 extending slidably and axially through the work spindle 33 into the chuck 34, and having a pair of gages 47 and 48, designated respectively as a "roughing gage" and a "finishing gage", mounted on its forward end. The roughing gage 47 is smaller in diameter than the finishing gage 48, 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 46 is connected by a bracket 49 to that of a parallel push rod 50 reciprocable in the top section

32 and carrying an abutment roller 51 at its forward end. A coil spring 52 engaging a collar 53 on the push rod 50 tends to move the gages forward into yielding engagement with the inner edge of the bore in the blank A, and an adjustable abutment 54 on the grinding spindle carriage is adapted to strike the roller 51 to withdraw the gages from the work blank A as the grinding wheel 24 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 a U. S. Patent No. 1,534,302, issued on April 21, 1925, to Prentice Conradson, Herbert E. Kempton and myself.

An arm 55 rigidly mounted on the shaft 41 is adapted to engage a block 56 loosely mounted on the push rod 50 against the collar 53, and thereby to move the gages into inoperative position away from the work when the clutch member 33ª is thrown to stop the spindle 33.

In moving initially past the inner edge of the work being ground, the gages 47 and 48 cause the successive closing of two switches 57 and 58 respectively. Preferably switches of the type disclosed in a copending application Serial No. 15,849, filed March 16, 1925, by Herbert E. Kempton and myself, now Patent No. 1,751,204, issued March 18, 1930, are employed. These switches are housed in a casing 59 secured to the left end of the body section 32 of the headstock carriage, and comprise two forked spring contacts 60 and 61 associated respectively with two sets of fixed contacts 62 and 63. The fixed contacts are supported on an insulating plate 64 over an oil reservoir 65 into which the spring contacts 60 and 61 extend, and two of the fixed contacts, one for each set, are connected by a conducting plate 66 to which a common lead wire is attached.

The two spring contacts 60 and 61 are movably supported by a pair of tripping mechanisms 67 which at the beginning of the grinding operation are locked to hold the contacts open, and which when released will move the contacts into engagement with the fixed contacts. The tripping mechanisms are adapted to be actuated through two trip dogs 68, one for each mechanism, which are positioned when said mechanisms are set, to be engaged by a pair of plungers 69 slidably extending into the casing 59. These plungers are adjustably mounted in the bracket 49 for movement with the gages 47 and 48, and are independently so adjusted that as the gage rod 46 moves in increments sufficiently to the right they will trip the two mechanisms 67 successively to close the switches 57 and 58 in a predetermined sequence with reference to the progress of the grinding operation.

The switches 57 and 58 after once being closed will be unaffected by the slight temporary withdrawals of the gages from the work by the abutment 54. A pin 70 carried by the push rod 50, which extends through the casing 59 between the two tripping mechanisms, is adapted to re-set both mechanisms, thereby opening the switches 57 and 58 when the clutch member 33ª is thrown into open position.

Feeding mechanism

The headstock carriage 19 is arranged to be fed along the ways 31 to move the work blank A against the grinding wheel 24 as the latter is reciprocated, by means of a feed screw 71 mounted in the base 16 and engaging a nut 72 (see Fig. 12) on the underside of the body section 30 of the carriage. The outer end of the feed screw 71 extends through a feed box 73 (see Figs. 6 and 12) on the front side of the machine, and is provided with a hand wheel 74 whereby it may be manually rotated. Within the feed box, a ratchet wheel 75 is mounted on a sleeve 76 on the feed screw 71, and is operatively connected through a train of gears 77 to the screw. The ratchet wheel 75 is adapted to be rotated intermittently by either one or both of two feed pawls 78 and 79. These pawls are pivotally mounted on the oppositely extending arms of two bell crank levers 80 and 81 respectively, loosely mounted on the sleeve 76, and are resiliently held in engagement with the ratchet wheel 75 by coiled springs 82. The other arms of the bell crank levers extend horizontally side by side, and are provided with cams 83 on their lower sides adapted to be engaged by a lever 84 to reciprocate the pawls. The degree of oscillation of these arms may be independently adjusted by means of two adjustable eccentrics 85 and 86 underlying them and limiting the downward movement of each of the cams 83. In practice, the eccentrics 85 and 86 are so adjusted that the feed pawl 78, designated as the "coarse feed pawl" is given a relatively long reciprocation, and the pawl 79 designated as the "fine feed pawl" is given a relatively short reciprocation.

The lever 84 is adapted to be oscillated by means of a floating piston 87 reciprocable in a stationary horizontal cylinder 88. Pressure fluid is successively and alternately received by and discharged from opposite ends of the cylinder 88 through pipes 89 and 90 connected with the main control valve.

Mounted in the feed box 73 are two electromagnates 91 and 92 provided with armatures 93 and 94 having curved tracks 95 and 96 respectively. The latter underlie rollers 97 and 98 on the pawls 78 and 79, and upon excitation of the electromagnets will raise the corresponding pawls out of engagement with the

ratchet wheel 75. The electromagnets are connected in the following circuits controlled by the switches 57 and 58; from the positive terminal through the wire 100, thence branching through the switch 57, wire 101 and the electromagnet 91, and through the switch 58, wire 102, and the electromagnet 92 to the wire 103 and the negative terminal. Since the switches 57 and 58 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 71 by means of the hand wheel 74, the pawls 78 and 79 after excitation of the electromagnets are automatically locked in inoperative position by a pair of latches 104 engaging the heels of the armatures 93 and 94. The latches 104 are mounted on a pair of shafts 105 together with releasing levers 106 which are connected by a suitable linkage 107 and which can be oscillated simultaneously by a lever 108 to disengage said latches and thereby release said pawls.

The dressing mechanism

Mounted on the top section 32 of the headstock carriage 19 for movement therewith is a fixed wheel dressing tool (see Figs. 1, 2ª, 2 and 3). This tool may be supported in any suitable manner but preferably the mechanism disclosed in my copending application, Serial No. 715,359, filed May 23, 1924 is employed. That mechanism comprises a base bracket 109 which is rigidly bolted to the top section 32 and which is formed with a pair of parallel spaced arms 110 extending over the bed 16 of the grinding machine. A cross member 111 bridges the arms 110, and is adjustable longitudinally thereof. Mounted on the cross member 111 and adapted to be adjusted longitudinally and laterally thereof is an upstanding bracket 112 which is formed on its upper end with a tubular socket 113. Adjustably mounted in the socket 113 is a tool holder 114 (see Fig. 2ª) having a bifurcated head 115 in which a mounting 116 carrying a diamond 117 is supported for angular adjustment. By this construction, the diamond 117 can be positioned at the proper distance from the outer end of the work, and in proper relation to the surface of the work to be ground. In the present instance, the diamond is set at a point which is in substantial alinement with the ground surface of the work but which will at the completion of the roughing operation be a trifle nearer the axis of rotation of the work than said surface.

The operating mechanism

The hydraulic pressure fluid, which is preferably oil is drawn from the oil reservoir in the machine base 16 by an oil pump 118 driven by an electric motor 119, said pump and said motor being mounted on the rear side of the base. The oil is discharged from the pump 118 through a pipe 120 which communicates with the inlet port, 121 of a main control valve 122 (see Figs. 8 and 9) mounted on the front side of the machine. This valve is formed with ports 123 and 124 connected through the pipes 89 and 90 with the cylinder 88, and through pipe 125 and 126 branching from said first mentioned pipes to the remote ends of the hollow piston rods 29. Spent oil flowing back to the valve 122 through either of the ports 123 and 124 is returned through outlet ports 127 to the oil reservoir.

The flow of oil through the valve 122 is controlled by a reciprocable valve member 128 adapted to connect the ports 123 and 124 successively and alternately with the ports 121 and 127. When the valve member 128 is in a central or neutral position, the oil will be by-passed directly from the inlet port 121 to the outlet ports 127. The volume of the oil passing through the valve can be changed to vary the speed at which the carriages 18 and 19 are moved, by changing the speed of the pump 118.

The valve member 128 is provided with a stem 129 pivotally connected with the lower end of an actuator which is in the form of an upright lever 130 pivoted between its ends at 131 on the machine base. Movement of the upper end of the lever 130 to the right or left will reciprocate the valve member 128 to cause movement of the spindle carriage 18 toward or from the chuck 34. A pivotal dog 132 is mounted in the upper end of the lever 130 and is normally maintained by a spring follower 133 in operative position in the path of three dogs 134, 135 and 136 (see Figs. 1, 8 and 10) which are adjustably secured to the front depending side 22 of the carriage 18 by bolts 137 engaging in a T-slot 138. The dogs 136 and 135 are beveled at their left ends to provide cam faces 139 and 140 respectively which upon movement of the carriage 18 from its inoperative position shown in Figure 1 to the left will successively engage and depress the pivotal dog 132 out of the way to permit the latter to snap into position between the dogs 134 and 135. Upon continued movement of the carriage 18, the dogs 134 and 135 would automatically oscillate the lever 130 to reciprocate the carriage in its operative position. The distance through which the carriage will reciprocate depends upon the spacing of the dogs 134 and 135, and is determined by the length of the bore or surface to be ground, the dogs being so positioned that the grinding wheel 24 will reciprocate from one end of the work to the other.

The pivotal dog 132 is adapted to be automatically tripped when the coarse feed gage 47 and also when the fine feed gage 48 moves past the inner edge of the ground surface. Preferably the means (see Fig. 7) for ac-

complishing this comprises an electromagnet 141 mounted in a suitable housing 142 on the base, and having a pivotal armature 143 to the free end of which a slidable pin 144 is attached. The pin 144 is arranged to engage the dog 132, and thereby to swing it out of the path of the dogs 135 and 136, but not far enough to be out of the path of the dog 134. A catch 145 mounted in the housing 142 is adapted to fall behind the pin 144 when the armature 143 is attracted by the magnet coil, to hold the dog in tripped position. The catch 145 is provided with a pin or projection 146 which is adapted to ride upon a cam face 147 on the dog 135 and also upon two cam faces 148 on opposite sides of a dog 149 (see Fig. 11) mounted on the left end of the carriage 18, and which is thereby adapted to release the pivotal dog 132 after the electromagnet 141 is deenergized.

Excitation of the electromagnet 141 is controlled by a suitable switch mechanism (see Fig. 8) which comprises a casing 150 mounted on the front of the machine base. Mounted on insulating sleeve 151 in opposite ends of the casing 150 are two fixed contacts 152 and two fixed contacts 153 respectively. Two movable contacts 154 and 155 are slidably mounted on the reduced opposite ends of a reversing plunger 156 reciprocable in the casing 150, and are adapted to selectively close the contacts 152 and 153 with which they constitute switches 157 and 158 respectively. A pair of coiled springs 159 on the plunger 156 tends to press the contacts 154 and 155 outwardly against a pair of heads 160 on the extreme ends of said plunger.

The plunger engages and is adapted to be reciprocated by the downwardly extending arm of a switch lever 161 pivotally mounted at 162 to the front of the machine base. Formed on the lower end of the lever 161 is a wedge shaped projection 163 which engages either side of a pointed spring detent 164 mounted in the casing 150 to hold the plunger 156 resiliently in one extreme position or the other. The lever 161 is formed with an inclined arm which supports a cam roller 165 at its extreme end over the control lever 130 and in the path of the dogs 135 and 149.

When the carriage 18 is in its inoperative position, the plunger 156 is positioned to the right thereby closing the switch 157. In the initial movement of the carriage to operative position, the cam roller 165 will engage an upper inclined face 166 on top of the dog 135 which will raise the roller out of its normal position and thereby move the plunger 156 still further to the right relatively to the contacts 152 and against the force of the adjacent spring 159. After passing over the dog 135, the roller under the influence of the spring 159 will snap back into operative position, and the switch 157 will still be closed and will remain closed during the roughing operation. In movement of the carriage 18 toward its inoperative position, when the switch 57 is closed, a sharp cam face 167 on the reversing dog 135 will engage and depress the cam roller 165, thereby opening the switch 157 and closing the switch 158. Upon a return movement of the carriage 18 to operative position, the roller 165 will pass under the cam face 166 and the switch 158 will be unaffected. In the final movement of the carriage 18 to inoperative position, the cam roller 165 will ride onto a cam face 168 on the dog 149, and will thereby move the plunger 156 to the right to close the switch 157.

Closure of the switches 57 and 157 completes a circuit through the electromagnet 141 as follows: from the positive terminal through the wire 100, the switch 57, the wire 101, the switch 157, wire 169, the electromagnet 141, and wire 170 to the negative terminal, Closure of the switches 58 and 158 closes a circuit through the electromagnet 141 as follows: from the positive terminal, through the wire 100, the switch 58, the wire 102, the switch 158, the wire 169, the electromagnet 141, the wire 170, to the negative terminal.

The back-off mechanism

Means (see Figs. 12 to 14) is provided for separating the grinding wheel 24 and the surface of the work perpendicularly to said surface. This movement is instituted in the present instance just before the grinding wheel is withdrawn axially from the work. While either of the carriages 18 or 19 may be moved to effect this separation, preferably the headstock carriage 19 is shifted through the feed screw 71. To this end, a pair of collars 171 are mounted on the feed screw 71 next to a shoulder 172, and are separated by a spacer 173. The collars 171 are held in place by a spacer sleeve 174 positioned between the front collar and the sleeve 76 in the feed box. Mounted on the spacer 173 between the collars 171 is a yoke 175 having two lateral cylindrical extensions 176 which extend pivotally through the arms of a bifurcated head 177 on the upper end of a lever 178. The head 177 is pivotally supported on a pin 179 in a bracket 180 rigidly secured to the base 16. The bracket 180 is formed integral with a water guard 181 which is also secured to the base 16, and which overlaps a shield 182 on the headstock carriage to protect the parts underneath.

The lower end of the lever 178 is formed with a nob 183 which engages in a milled slot 184 in a reciprocable piston 185. The piston is mounted in a cylinder 186 formed in a casing 187, and closed at its opposite ends by plugs or caps 188 having stops 189 formed thereon. The position of the piston is controlled by a valve comprising a cylindrical valve sleeve 190 mounted in the casing 187 and opening at its opposite ends into an ex-

haust chamber 191 in the casing. Pressure fluid from the exhaust chamber 191 is discharged into a pipe 192 leading to the oil reservoir. The sleeve 190 is formed with two sets of end ports 193 and 194 communicating with passages 195 and 196 leading to opposite ends of the cylinder 186, and a set of central ports 197 communicating with an inlet passage 198 connected through a pipe 199 to the pipe 120. Two plugs 200 are threaded into opposite ends of the casing 187 in line with the sleeve 190.

Reciprocably mounted in the valve sleeve 190 is a valve member 201 having two enlargements 202 adapted upon reciprocation to successively and alternately connect the end ports 193 and 194 with the exhaust chamber 191 and the inlet ports 197. The valve member 201 is provided with a stem 203 (see Fig. 14) which extends slidably through one of the end caps 200, and the free end of which is pivotally secured to the free end of the pivotal armature 204 of an electromagnet 205. The electromagnet 205 is rigidly supported on the casing 187, and the circuit therethrough is as follows: from the positive terminal, through the wire 100, the switch 58, the wire 102, the electromagnet 205, and the wire 103 to the negative terminal. A coiled spring 206 on the stem 203 between the armature 204 and the cap 200 tends to maintain the valve member 201 to the right to maintain the ports 194 and 197 in communication. It will be evident that when the gage 48 moves past the inner edge of the finished work surface, thereby closing the switch 58, the electromagnet 205 will be excited, and will cause the feed screw 71 to be shifted longitudinally to the left to separate the grinding wheel 24 and the finished work surface.

Slow traverse mechanism

To obtain a relatively slow traverse of the grinding wheel 24 in its working reciprocation during the finishing cut and in its movement past the dressing tool 117 on the temporary withdrawal from the work, a part of the pressure fluid normally passing through the main control valve 122 is, upon entry of the gage 47 into the bore of the work, automatically by-passed to the oil reservoir in the base. To this end the casing 187 is formed with a cylindrical valve chamber 207 in which is mounted a valve sleeve 208. The inlet passage 198 communicates through a plurality of ports 209 with the interior of the sleeve 208, and the latter is formed in one end with a plurality of ports 210 opening into an outlet passage 211. Opposite ends of a sleeve 208 open into the exhaust chamber 191. A pair of plugs 212 are removably threaded into the ends of the casing 187 in alinement with the valve sleeve 208.

Reciprocably mounted in the sleeve 208 is a valve member 213 having a pair of spaced enlargements 214 controlling the ports 209 and 210. The valve member is provided with a stem 215 extending through the inner plug 212. The outer end of the stem is pivotally secured to the free end of the armature 216 of an electromagnet 217 rigidly mounted on the casing. The circuit through the electromagnet 217 is as follows: from the positive terminal through the wire 100, the switch 57, a wire 218, the electromagnet 217 and the wire 103 to the negative terminal. A coil spring 219 on the stem 215 between the inner plug 212 and the armature 216 tends to move the valve member 213 to cut off the ports 210 from the ports 209.

The pressure fluid from the outlet passage 211 is passed to the exhaust chamber 191 through a self-adjustable valve which serves to pass a constant volume of pressure fluid therethrough irrespective of fluctuations in the pressure. These fluctuations may be brought about by variations in the resistance to the movement of the grinding spindle carriage 18. For example, at the end of its inward stroke, the carriage assumes the added burden of moving the gages 47 and 48 away from the work. This valve comprises a cylinder 220 threaded into the wall of the casing 187 and having one or more ports 221 opening into the exhaust chamber 191. A piston 222 is slidably mounted in the cylinder 220, and is formed with a central passage 223 opening into the outlet passage 211 and communicating through ports 224 with the ports 221. Movement of the piston 222 is controlled and limited by a pin 225 mounted therein and engaging a slot 226 in the cylinder 220. The slot 226 extends along the outside of the cylinder 220 to the exhaust chamber 191, and permits fluid from the cylinder to be exhausted when the piston 222 moves to the left. A sleeve 227 is threaded onto the front end of the cylinder 220 and is closed by a plug 228. Threaded into the sleeve 227 is an adjusting nut 229 between which and the inner end of the piston 222 a coiled spring 230 is positioned to counterbalance the pressure required to move the carriage at a predetermined speed. The ports 221 and 224 normally are in full register to provide the largest possible openings between the outlet passage 211 and the exhaust chamber 191. If the pressure increases, the piston 222 will move the ports 221 and 224 partly out of register to reduce the effective area of the openings therethrough. If the pressure falls, the piston 222 will move to the right to enlarge the openings through the ports 221 and 224.

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 34, and the

lever 42 is actuated to throw the clutch member 33ª and start operation of the spindle 33. By actuating the lever 42, the cam 55, releases the push rod 50, thereby permitting the gages 47 and 48 to move into engagement with the inner end of the work. The lever 130 at the front of the machine is thrown to the right thereby instituting movement of the grinding spindle carriage 18 to the left to operative position. At this stage of the machine operation, the switch 157 is closed.

As the grinding spindle carriage moves toward its operative position, the dogs 136 and 135 will successively depress the pivotal dog 132 to permit the latter to snap into position between the dogs 134 and 135 to institute and effect an automatic reciprocation of the grinding wheel in its operative position. At the inner end of each stroke of the reciprocation, the abutment 54 will withdraw and hold the gages 47 and 48 away from the work. Meanwhile the work is moved into engagement with the grinding wheel 24 by turning the hand wheel 74, and the automatic cross feed is then instituted by actuating the lever 108 to release the feed pawls 78 and 79.

The grinding wheel 24 continues to reciprocate in the work, 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 will move past the inner edge of the surface being ground. The dressing tool 117 is positioned substantially in line with but a trifle nearer the axis of rotation than the resulting surface of the work.

Movement of the gage 47 past the inner edge of the work results in the closure of the switch 57 which closes the circuits through the electromagnets 91, 141 and 217. The electromagnet 91 raises the pawl 78, and effects a reduction in the rate of the cross feed. The electromagnet 141 trips the pivotal dog 132 and prevents a reversal of the lever 130 by the dog 135, thereby causing the grinding wheel to be withdrawn axially from the bore of the work. The electromagnet 217 moves the valve member 213 to the left, thereby by-passing a portion of the pressure fluid normally directed to the main valve 122, and consequently effecting a reduction in the speed of traverse of the grinding wheel 24. In the withdrawal movement of the carriage, the roller 165 of the lever 161 is depressed by the cam face 167 thereby opening the switch 157 and closing the switch 158. This results in a deenergization of the electromagnet 141. The pin 146 engages the cam surface 147 thereupon releasing the pivotal dog 132 which is positioned between the dogs 135 and 136. The carriage 18 continues its movement toward inoperative position until the dog 136 reverses the lever 130, and causes a return of the carriage to its operative position.

In the temporary withdrawal of the grinding wheel from the work, the grinding wheel 24 is moved past the fixed wheel dressing tool 117 which trues its surface. Since a portion of the pressure fluid is by-passed through the casing 187, this movement of the grinding wheel 24 past the dressing tool 117 will be relatively slow to permit the wheel to be accurately dressed.

In the return of the carriage to its operative position, the pivotal dog 132 is again depressed by the dog 135, and snaps into position between the dogs 134 and 135. Reciprocation of the carriage continues at the slow speed until the gage 48 moves past the inner edge of the surface, whereupon the switch 58 is closed thereby resulting in the excitation of the electromagnets 92, 141 and 205. Excitation of the electromagnet 92 raises the feed pawl 79 and stops the cross feed. Excitation of the electromagnet 141 again trips the pivotal dog 132 and permits a withdrawal of the grinding wheel from the bore of the work. In this instance the position of the lever 161 is unaffected by the dog 135, and the switch 158 remains closed thereby causing the electromagnet 141 to remain energized and permitting the carriage to move to its inoperative position. Just before the carriage 18 reaches its inoperative position, the lever 161 is oscillated by the cam face 168 thereby opening the switch 158 and closing the switch 157. The electromagnet 141 is then deenergized, and the pivotal dog 132 is released by the cam surface 148. Simultaneously with the beginning of the withdrawal movement, excitation of the electromagnet 205 causes the piston 185 to oscillate the lever 178 and shift the headstock carriage 19 along the ways 31 thereby effecting a separation of the grinding wheel 24 and the finished surface of the work before the withdrawal of the grinding wheel beyond the end of the work. This movement causes the grinding wheel to be withdrawn toward its inoperative position without engaging the finished surface of the work or the dressing tool. After withdrawal of the grinding wheel 24 from the work and past the dressing tool 117, the clutch lever 42 is operated to stop the spindle 33, thereby moving the gage rod to the left to open the switches 57 and 58. This results in a deenergization of all the electromagnets. As a result the headstock carriage 19 is returned to its initial position, and the carriage 18 completes its movement to inoperative position at high speed.

By applying a fixed wheel truing device to the headstock carriage for movement therewith, and by effecting a lateral separation between the grinding wheel and the work before a separation of the grinding wheel and the work axially of the former, contact between the grinding wheel and the surface is avoided on the final withdrawal movement,

and dressing of the grinding wheel is permitted only between the roughing and finishing cuts. The dressing is entirely automatic, and results incidentally from the general machine operation.

I claim as my invention:

1. A grinding machine having, in combination, a headstock for supporting the work, means supporting a grinding wheel, control means governed by the progress of the grinding operation, operating means under the control of said control means for moving the work and said grinding wheel relatively to each other to bring said grinding wheel from an inoperative position remote from said work into operative position, to reciprocate said grinding wheel across the work in said operative position, to effect a temporary axial separation of the work and said grinding wheel at an intermediate stage in the grinding operation, and a final axial separation therebetween at the completion of said grinding operation, a truing device mounted in fixed relation to said headstock and having a dressing tool positioned to engage and dress said grinding wheel upon said temporary separation, and means under the control of said control means for effecting a lateral separation of the ground work surface and said grinding wheel when the grinding operation has been completed to cause said grinding wheel to clear said surface and said dressing tool on said final separation.

2. A grinding machine having, in combination, means for supporting the work, a grinding wheel and support therefor, control means governed by the progress of the grinding operation, means for effecting a relative reciprocation between the work and said grinding wheel, said means being controlled by said control means to automatically effect an axial separation of the work and said grinding wheel first temporarily at a predetermined intermediate stage of the grinding operation and finally at the completion of the grinding operation, and being operable to automatically return said grinding wheel to the work after said first separation, a dressing tool fixed in substantial alinement with the work surface and hence adapted to engage said grinding wheel as the latter is moved past said tool in said temporary separation, and means under the control of said control means operable at the completion of the grinding operation to automatically separate the finished work surface and said grinding wheel laterally of said grinding wheel before said final axial separation.

3. A grinding machine having, in combination, a headstock for supporting the work, a carriage having a grinding wheel, means for moving said carriage to move said grinding wheel from inoperative position remote from the work into operative position, reciprocating said grinding wheel in said last mentioned position, withdrawing said grinding wheel temporarily from the work at a predetermined stage in the grinding operation, continuing said reciprocation, and withdrawing said grinding wheel finally from the work to inoperative position at the completion of the grinding operation, a dressing tool positioned to engage the surface of said grinding wheel as the latter is moved past said truing tool in the temporary separating movement, and means for automatically separating said grinding wheel and the finished surface of the work at the completion of the grinding operation to cause said grinding wheel to clear said surface and said dressing tool on the final withdrawal movement.

4. A grinding machine having, in combination, a headstock for supporting the work, a carriage having a grinding wheel, control means governed by the progress of the grinding operation, means for moving said carriage relatively to said headstock to reciprocate said grinding wheel across the surface of said work to separate said grinding wheel from the work at a predetermined stage in the grinding operation, to return said grinding wheel to the work and continue said reciprocation, and to again separate said grinding wheel from the work at the completion of the grinding operation, a dressing tool mounted in fixed relation to the headstock and positioned to engage said grinding wheel as it is withdrawn from the work in the first separation, and means under the control of said control means automatically operable at the completion of the grinding operation to effect a separation of the finished surface of the work and said grinding wheel to cause said grinding wheel on its final withdrawal to clear said surface and said dressing tool.

5. A grinding machine having, in combination, a headstock for supporting the work, a grinding wheel and support therefor, means for moving said headstock and said grinding wheel relative to each other to reciprocate said grinding wheel across the surface of the work and effect an axial separation therebetween at a predetermined stage in the grinding operation and also at the completion of the grinding operation, a dressing tool mounted in fixed relation to the headstock and positioned to engage the grinding wheel upon said first separation, and means automatically operable upon the completion of the grinding operation to separate the finished surface of the work and said grinding wheel so as to cause said grinding wheel to clear said surface and said dressing tool on the final separating movement.

6. A grinding machine having, in combination, a headstock for supporting the work, a carriage having a grinding wheel, means

automatically operable to move said carriage and said headstock relative to each other so as to reciprocate said grinding wheel across said work and to extend one stroke of the reciprocation so as to separate the work and said grinding wheel at a predetermined stage in the grinding operation, a dressing tool mounted in fixed relation to the headstock and positioned to engage said grinding wheel as the latter is separated from the work, and means automatically operable subsequent to said separation to separate the finished surface of the work and said grinding wheel to permit withdrawal of said grinding wheel from the work without contacting with said dressing tool.

7. A grinding machine having, in combination, a headstock for supporting the work, a carriage having a grinding wheel adapted to engage the work, control means governed by the progress of the grinding operation, operating means under the control of said control means for separating the work and said grinding wheel axially at a predetermined stage in the grinding operation and returning said grinding wheel to the work, and again separating the work and said grinding wheel at the completion of the grinding operation, a dressing means mounted in fixed relation to the headstock and positioned to engage said grinding wheel in said first separation, and means under the control of said control means for automatically shifting said headstock upon completion of the grinding operation to separate the finished surface of the work and said grinding wheel laterally before the final withdrawal of said grinding wheel from the work past said dressing means.

8. A grinding machine having, in combination, a headstock for supporting the work, a grinding wheel and a support therefor, control means governed by the progress of the grinding operation, means under the control of said control means for effecting a relative graduated cross feed between the work and said grinding wheel, said cross feed being automatically reduced at the completion of the roughing operation and being automatically discontinued at the completion of the entire operation, operating means under the control of said control means automatically operable to withdraw said grinding wheel beyond the end of said work at the completion of the rough grinding operation, immediately returning said grinding wheel to the work, and again withdrawing said grinding wheel beyond the end of the work at the completion of the finish grinding operation, a dressing tool positioned to engage the surface of said grinding wheel as the latter is initially withdrawn from the work, said dressing tool being positioned in substantial alinement with the ground surface of the work at the completion of the roughing operation, and means under the control of said control means automatically operable upon completion of the grinding operation to separate the finished work surface and said grinding wheel laterally of said wheel before completion of the final withdrawal of the latter so that said grinding wheel will clear the ground surface and said dressing tool in said final withdrawal.

9. A grinding machine having, in combination, a headstock for supporting the work, a grinding wheel and a support therefor, means for moving said headstock and said grinding wheel relative to each other to reciprocate said grinding wheel across the surface of the work and to effect an axial separation therebetween at a predetermined stage in the grinding operation and also at the completion of the grinding operation, a dressing tool mounted in fixed relation to said headstock and positioned to engage said grinding wheel upon said first separation, means automatically operable upon the completion of the grinding operation to separate the finished surface of the work and said grinding wheel so as to cause said grinding wheel to clear said surface and said dressing tool on said final separating movement, and means automatically operable at said predetermined stage to slow down the speed of relative axial movement between said grinding wheel and the work so as to cause said grinding wheel to move slowly past said dressing tool in the course of said first separation.

10. A grinding machine having, in combination, a headstock for supporting the work, a grinding wheel and support therefor, control means governed by the progress of the grinding operation, operating means under the control of said control means for withdrawing said grinding wheel beyond the end of said work at a predetermined stage in the grinding operation, a dressing tool mounted in fixed relation to the headstock and positioned in substantial alinement with the ground surface of the work at the time of said withdrawal, and means under the control of said control means for separating the finished work surface and said grinding wheel at the completion of the grinding operation to permit said grinding wheel to be withdrawn beyond the end of the work and past said dressing tool without contacting therewith.

11. A grinding machine having, in combination, a headstock for supporting the work, means supporting a grinding wheel, a truing device mounted on said headstock and positioned in alinement with a preliminary work surface to be ground, control means governed by the progress of the grinding operation, operating means operable to automatically institute a working reciprocation between the work and said grinding

wheel in movement of said grinding wheel relatively to the work from a remote inoperative position into operative position, and operable to automatically reciprocate the work and said grinding wheel relatively to each other in said operative position, said control means controlling said operating means to temporarily extend the working stroke of said reciprocation when said preliminary surface has been ground so as to move said grinding wheel across said truing device, and again to extend the working stroke at the completion of the grinding operation so as to effect a final axial separation of the work and said grinding wheel, and means under the control of said control means for effecting a separation of the finished work surface and said grinding wheel laterally of said wheel when the grinding operation has been completed to cause said grinding wheel to clear said finished surface and said truing device in said final separation.

12. A grinding machine having, in combination, a headstock for supporting the work, means supporting a grinding wheel, a truing tool mounted on said headstock and positioned in substantial alinement with the surface to be ground, means for automatically reciprocating the grinding wheel relatively across the work surface and said truing tool, and means automatically operable at the completion of the grinding operation to effect a lateral separation of the finished work surface and said grinding wheel to cause said grinding wheel to clear said finished surface and said truing tool on further reciprocatory movement.

In testimony whereof I have hereunto affixed my signature.

KEITH F. GALLIMORE.