Aug. 20, 1935. H. L. BLOOD ET AL 2,011,705

GRINDING MACHINE

Filed July 20, 1933 6 Sheets-Sheet 1

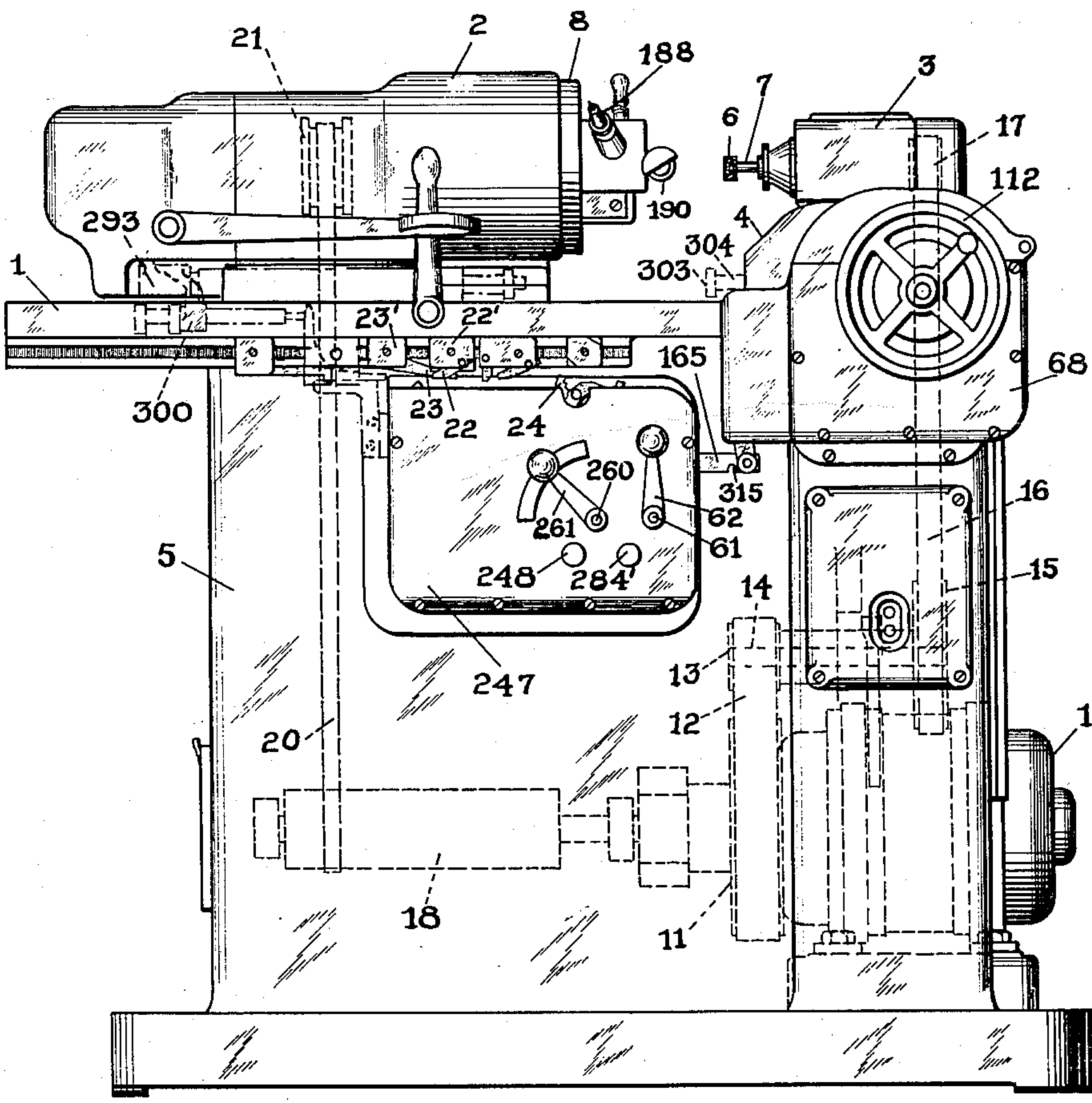

Fig.1

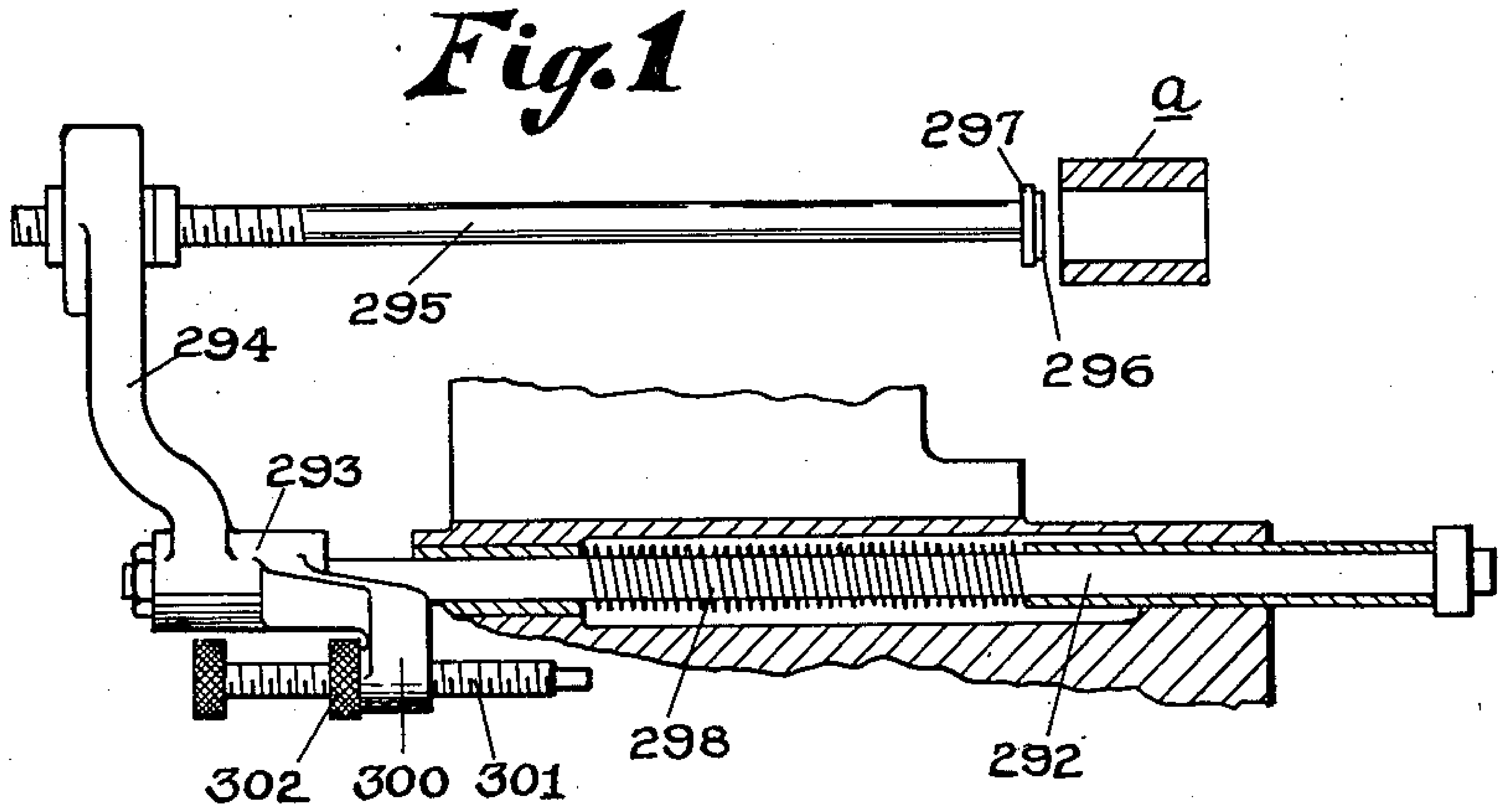

Fig.12

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GRINDING MACHINE

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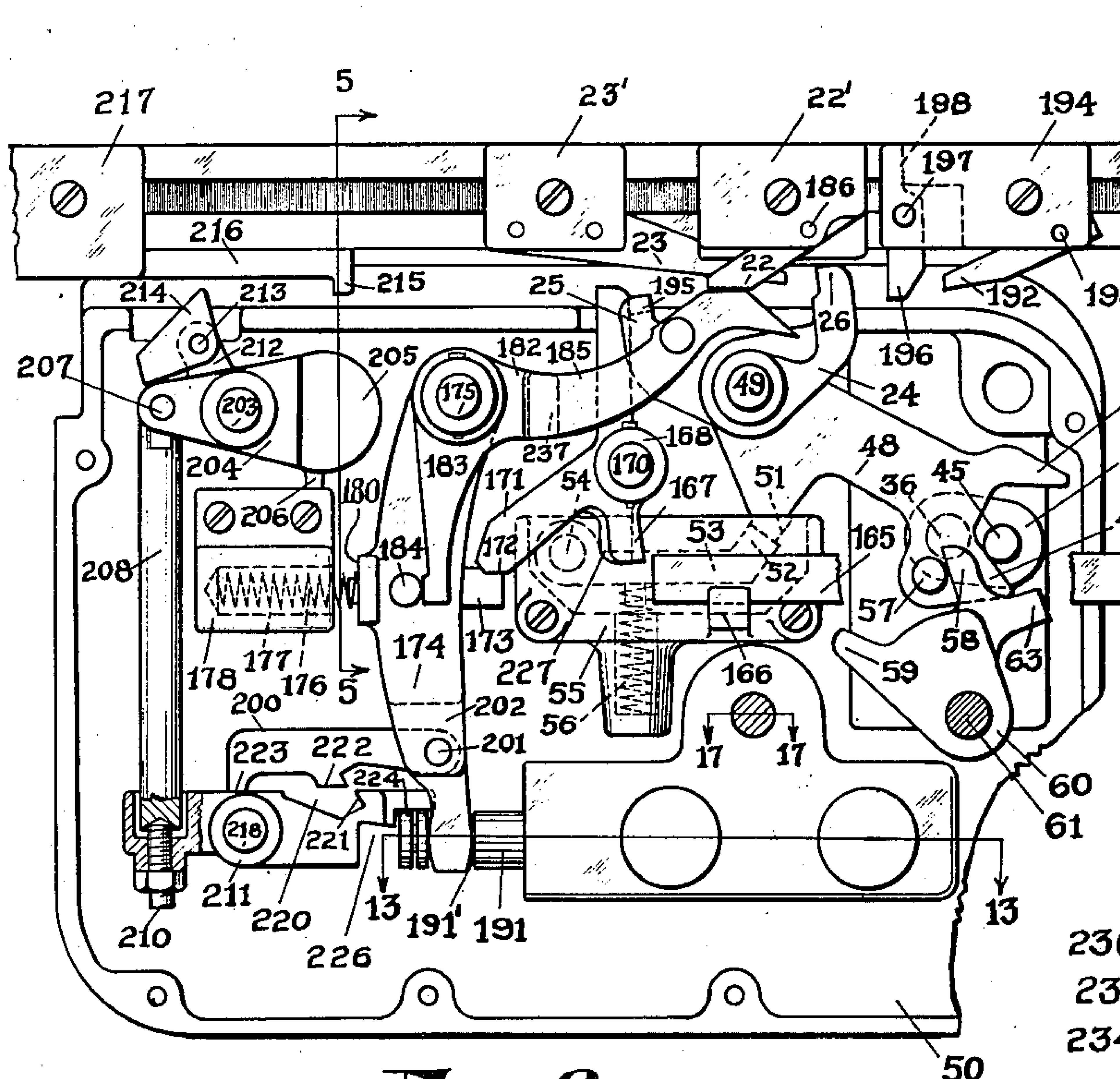

Fig. 2

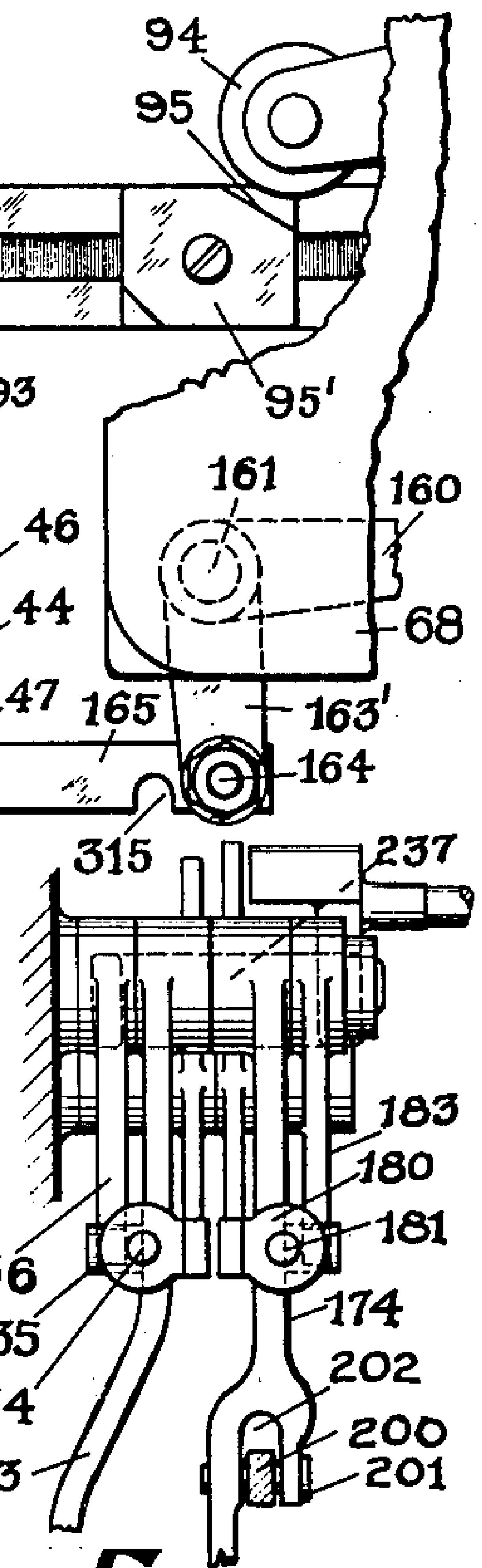

Fig. 5

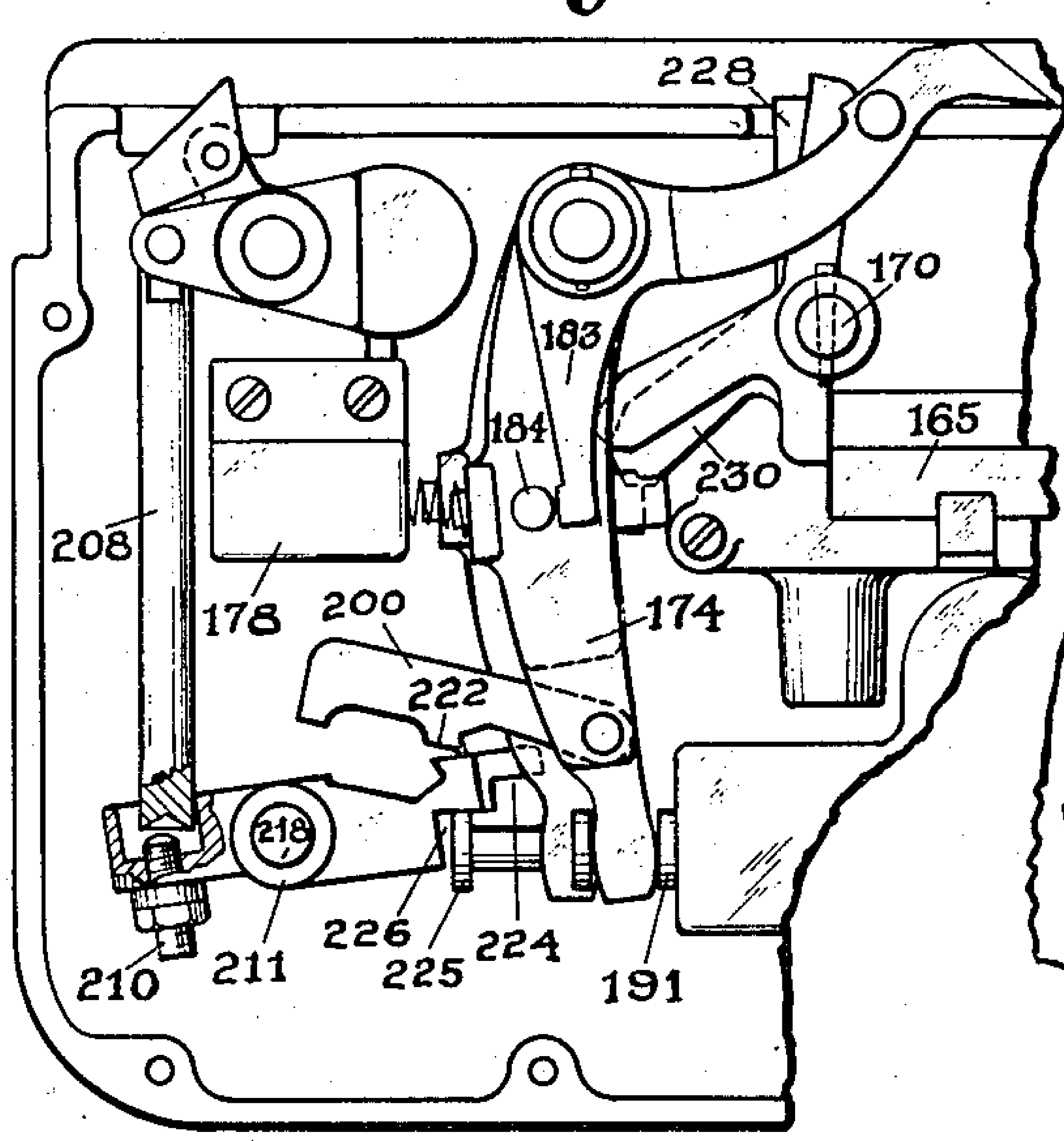

Fig. 3

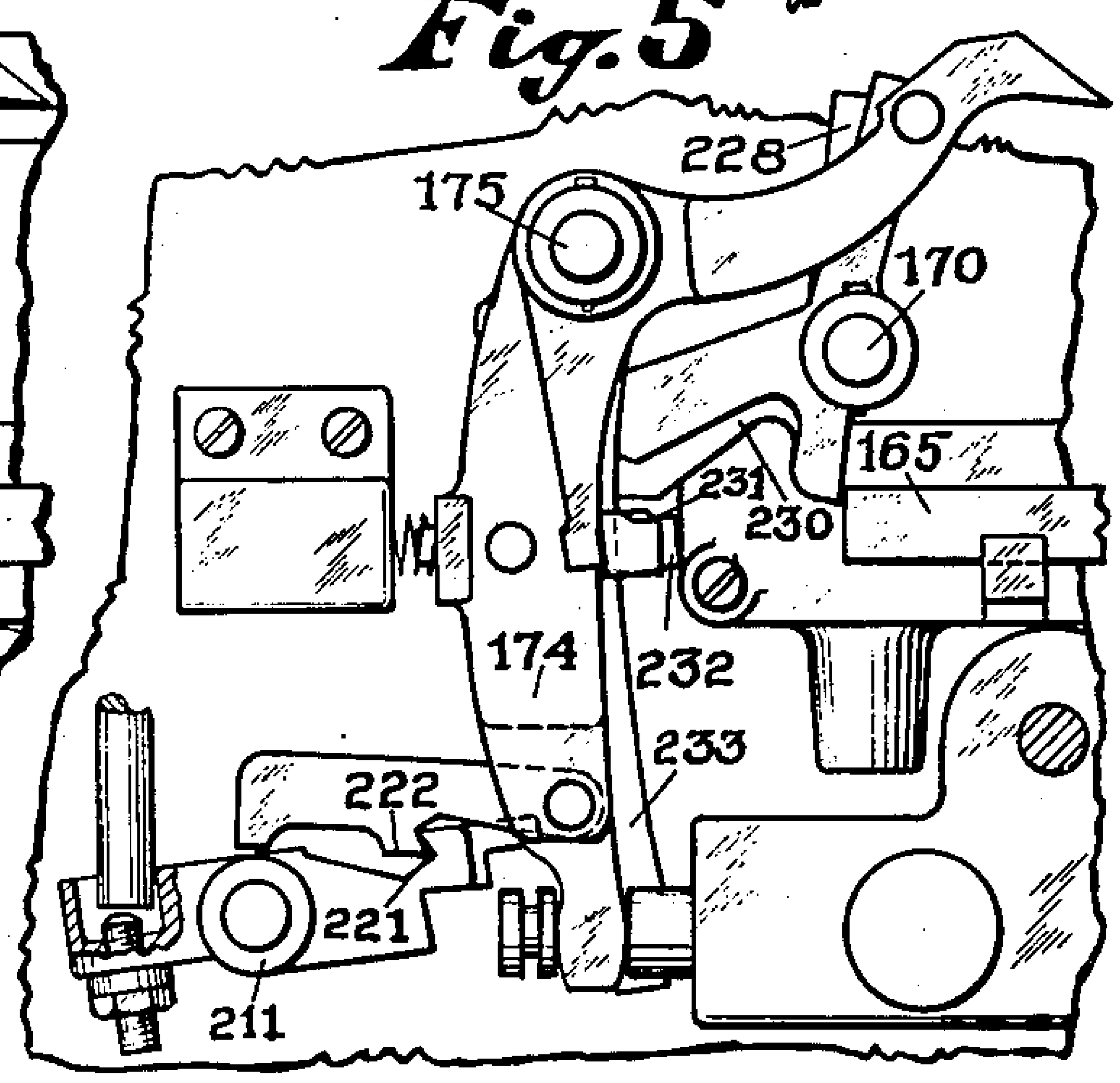

Fig. 4

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GRINDING MACHINE

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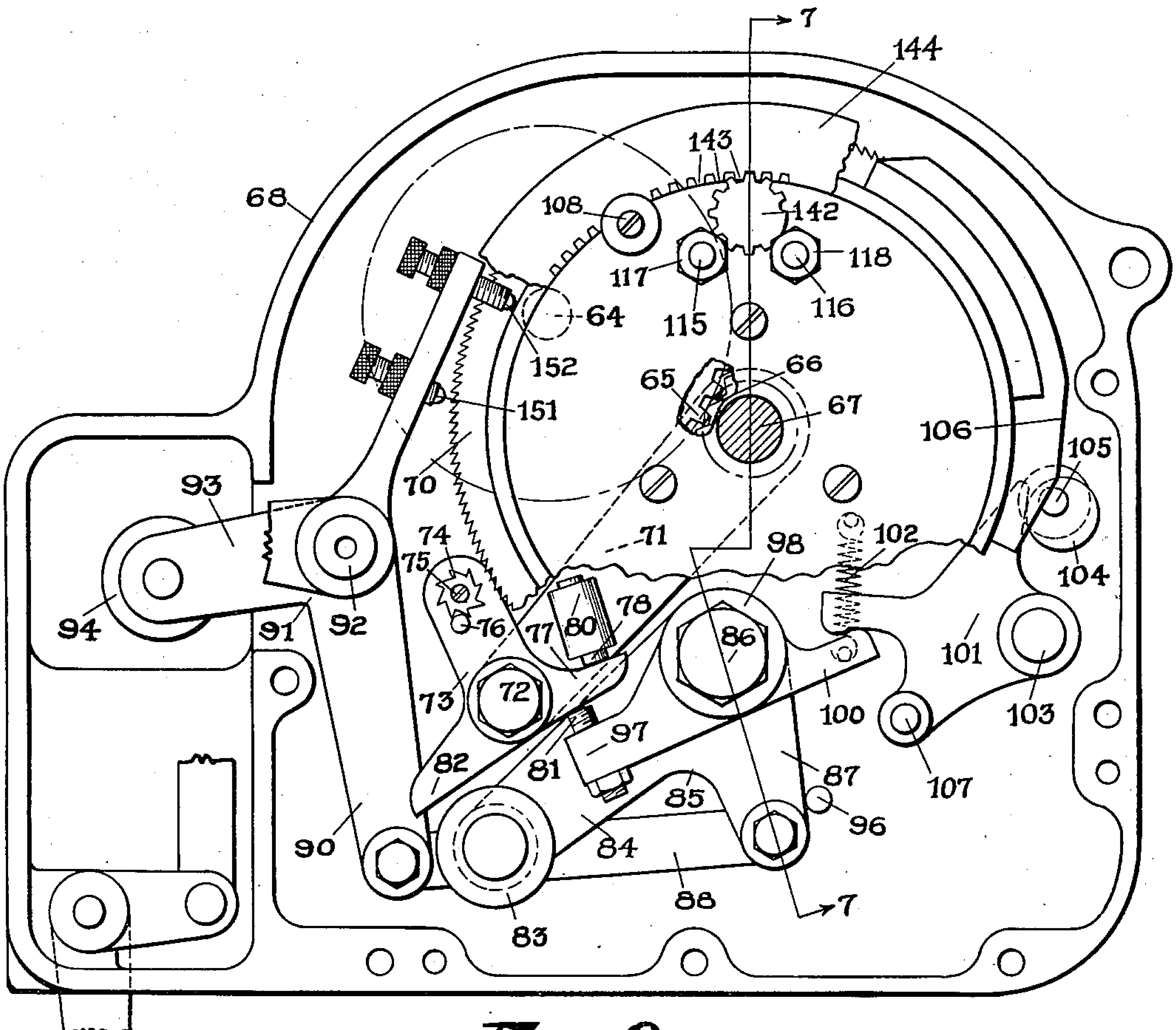

Fig. 6

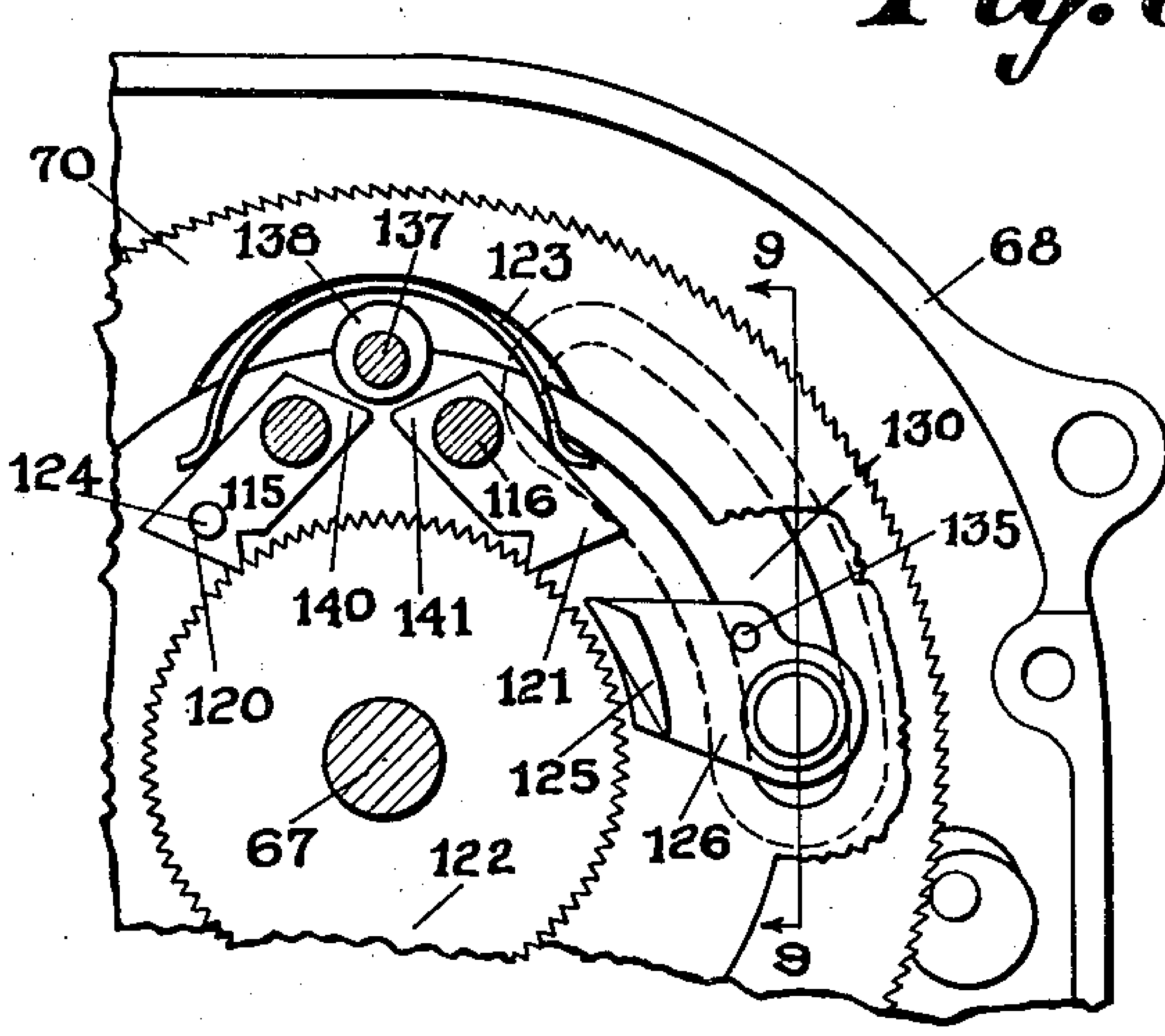

Fig. 8

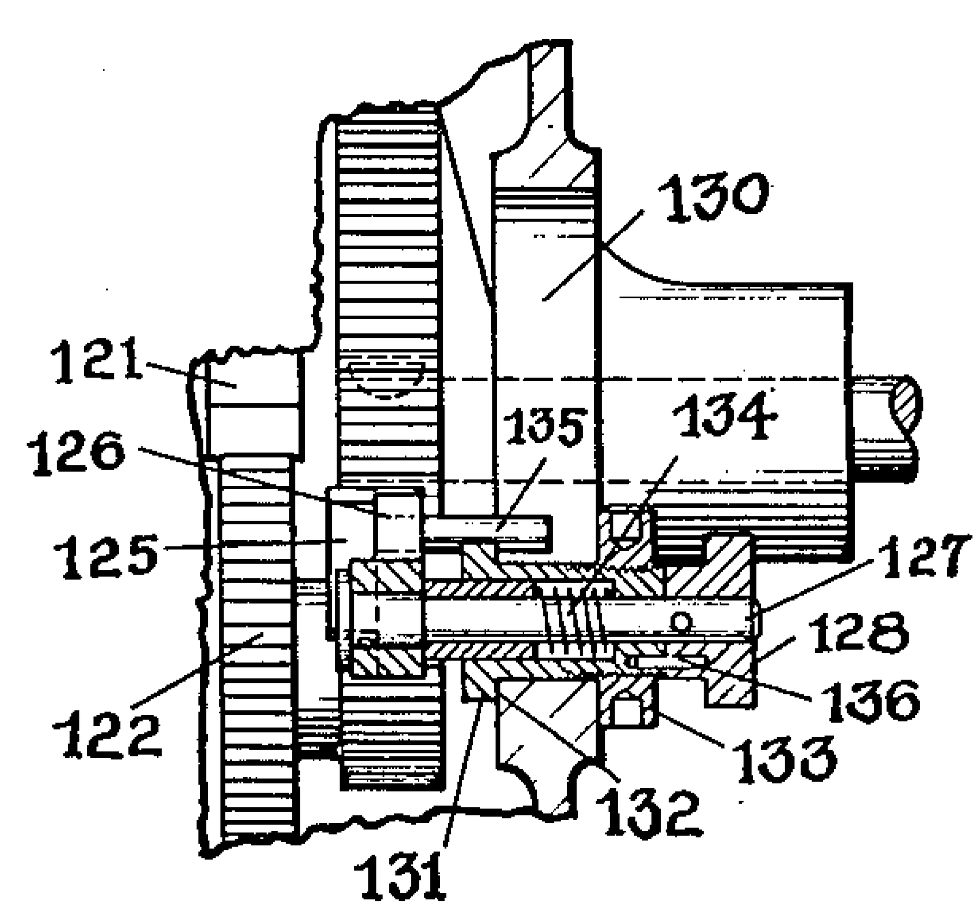

Fig. 9

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GRINDING MACHINE

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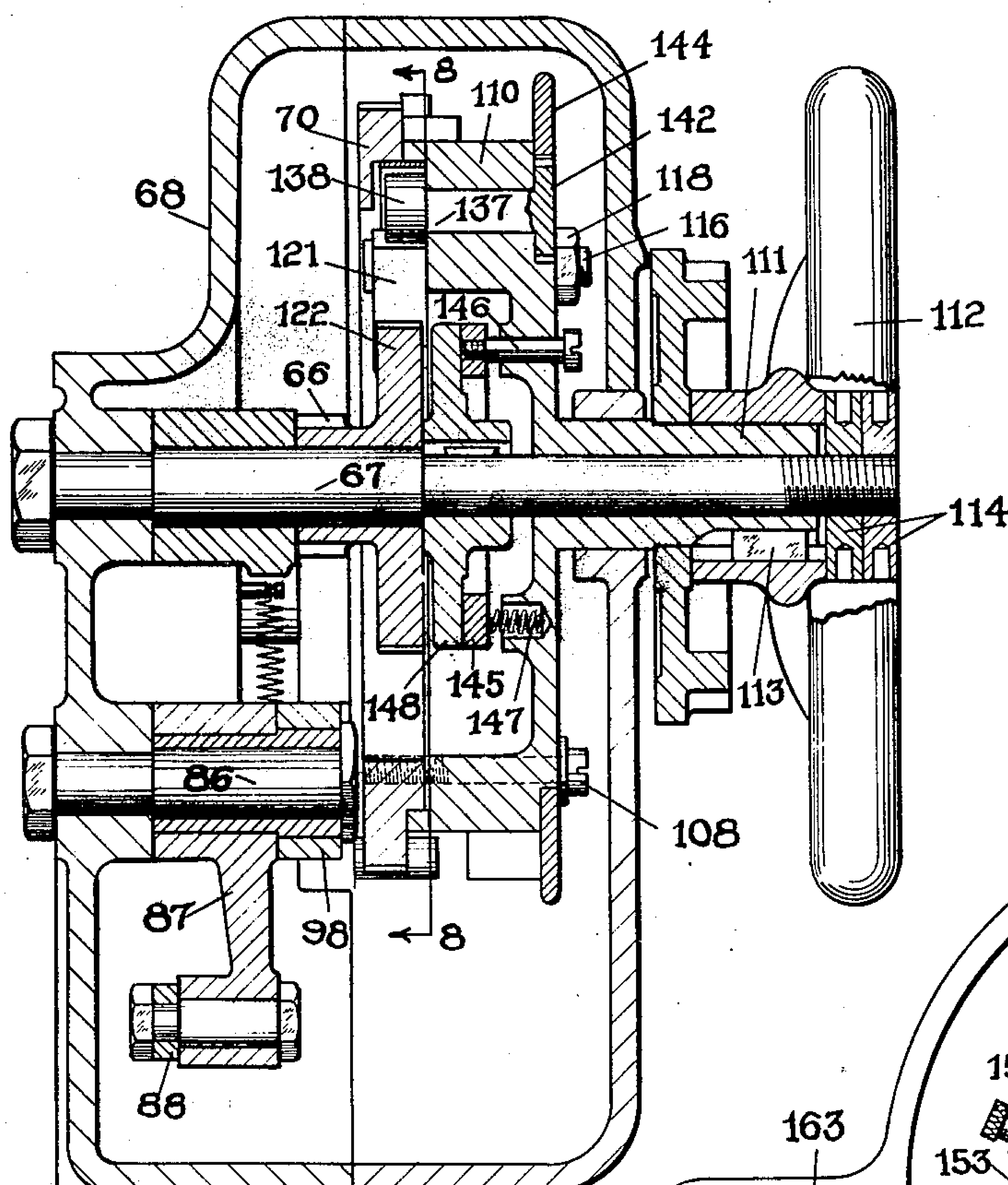

Fig. 7

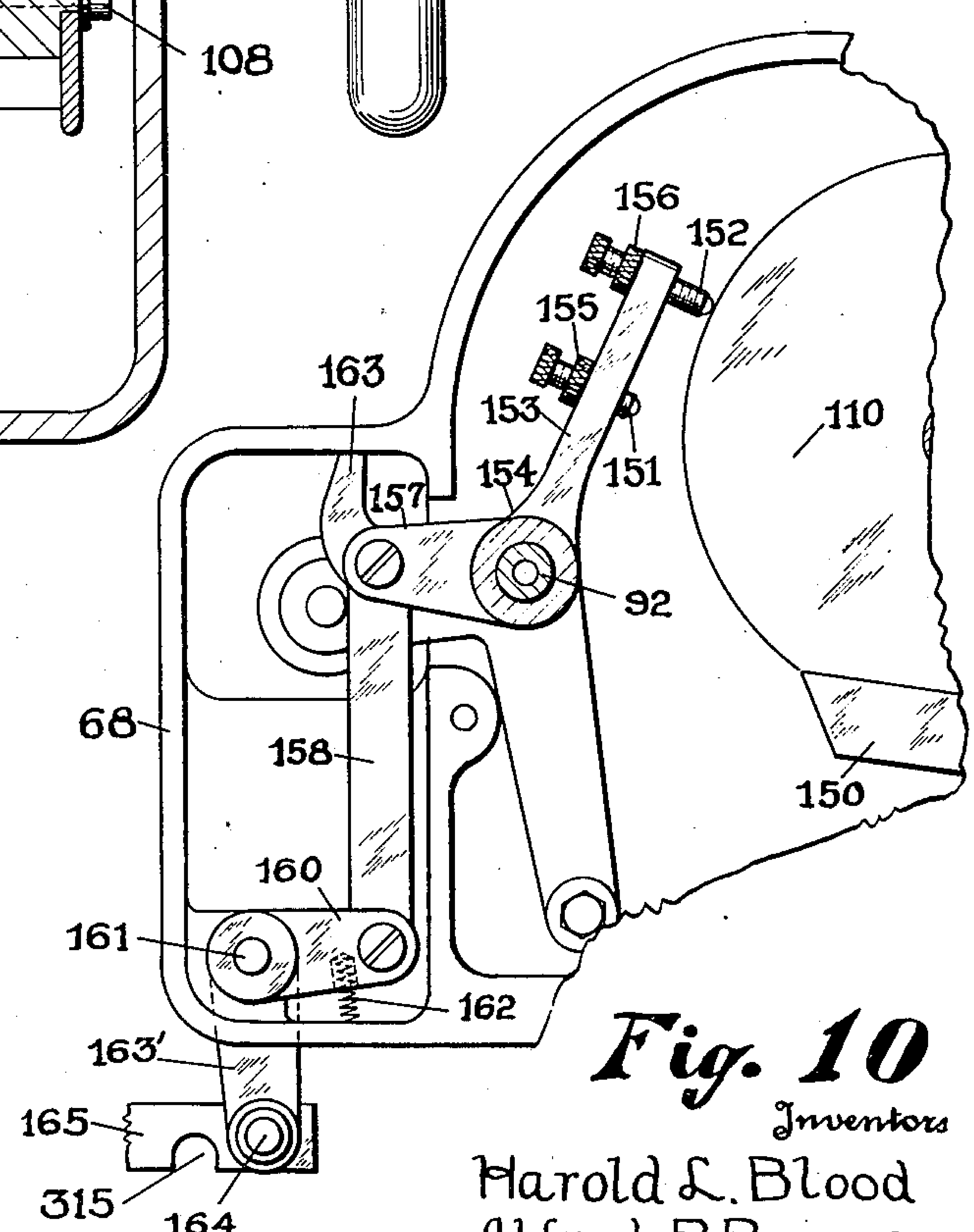

Fig. 10

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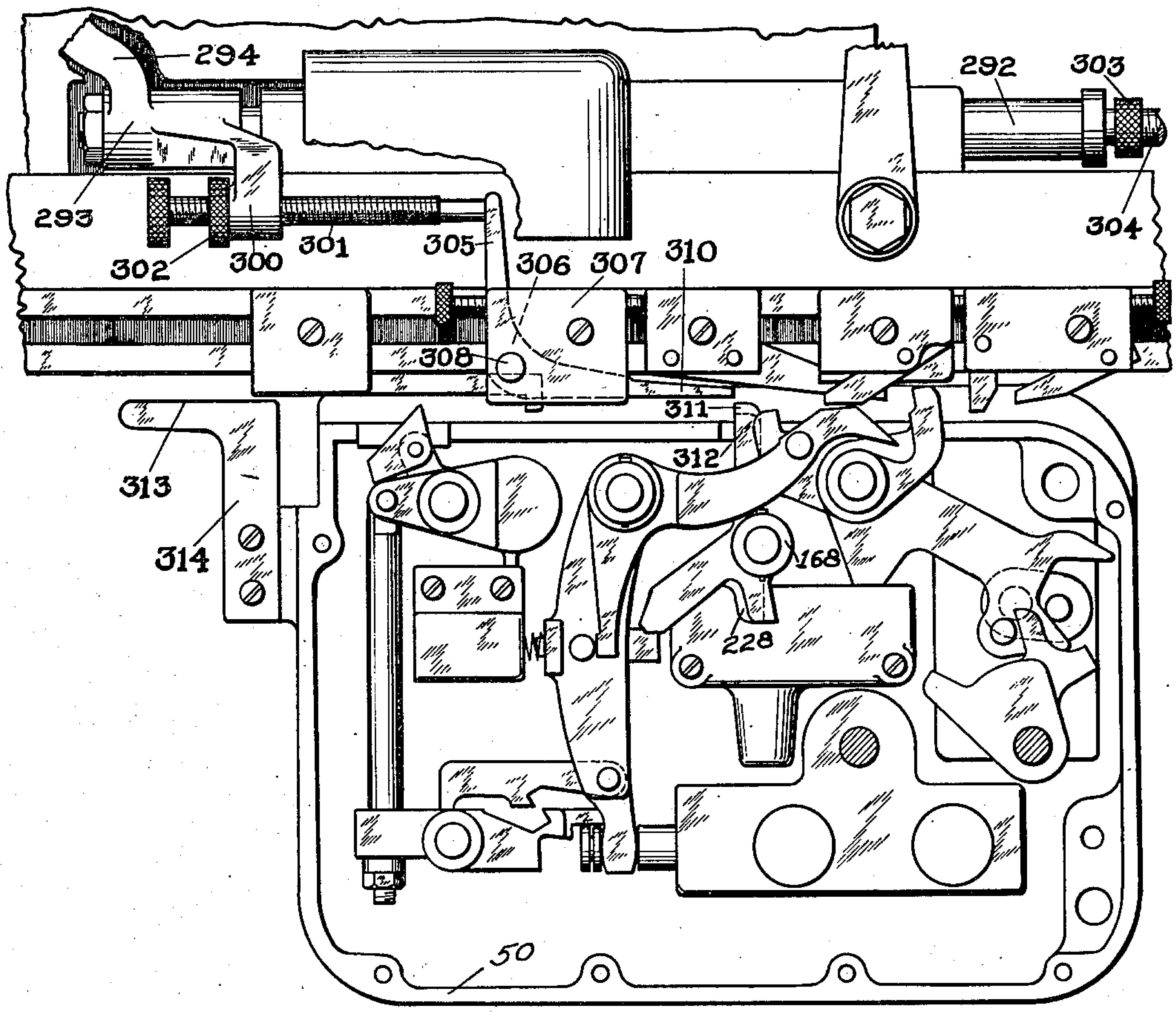

Fig. 11

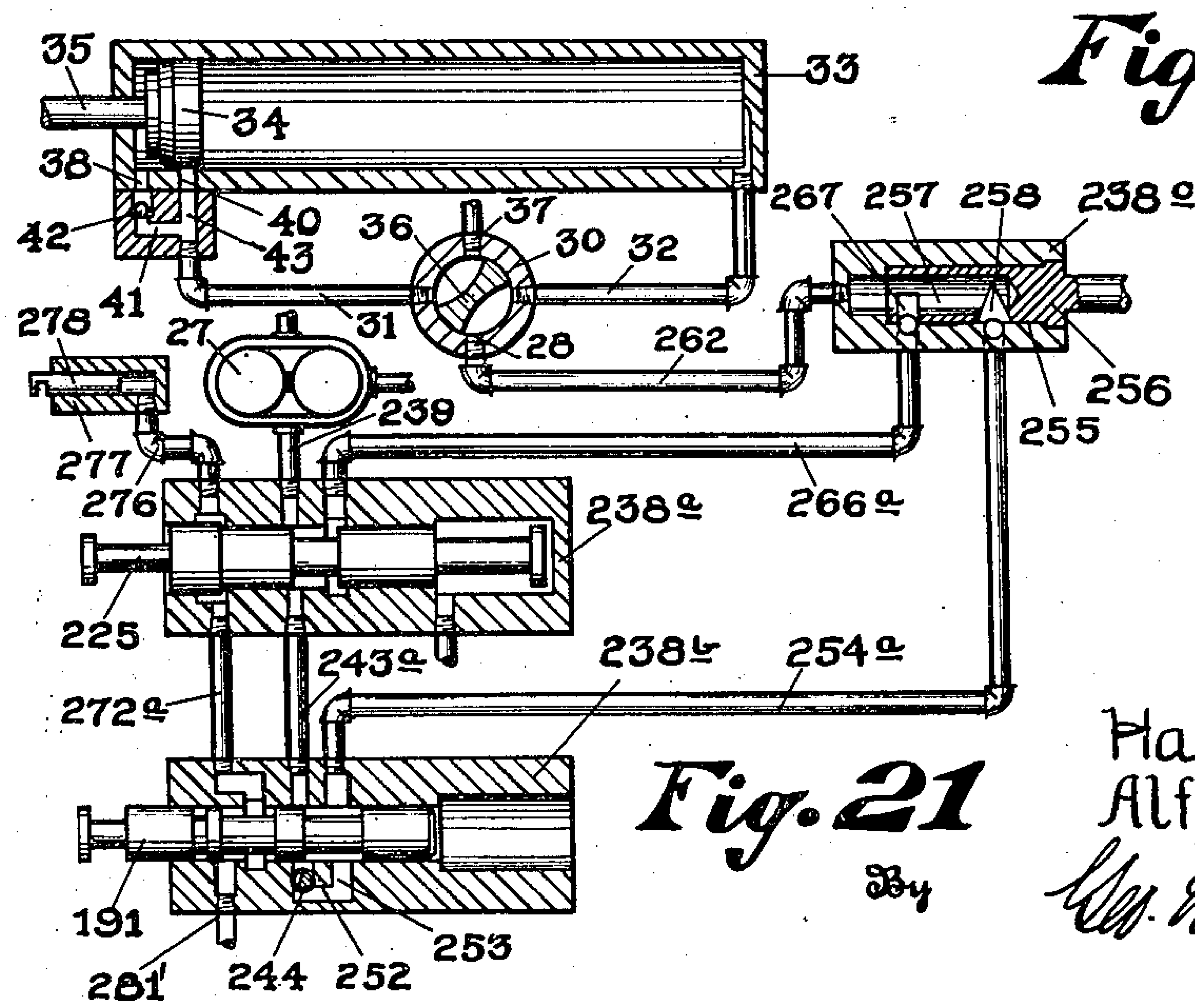

Fig. 21

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GRINDING MACHINE

Filed July 20, 1933 6 Sheets-Sheet 6

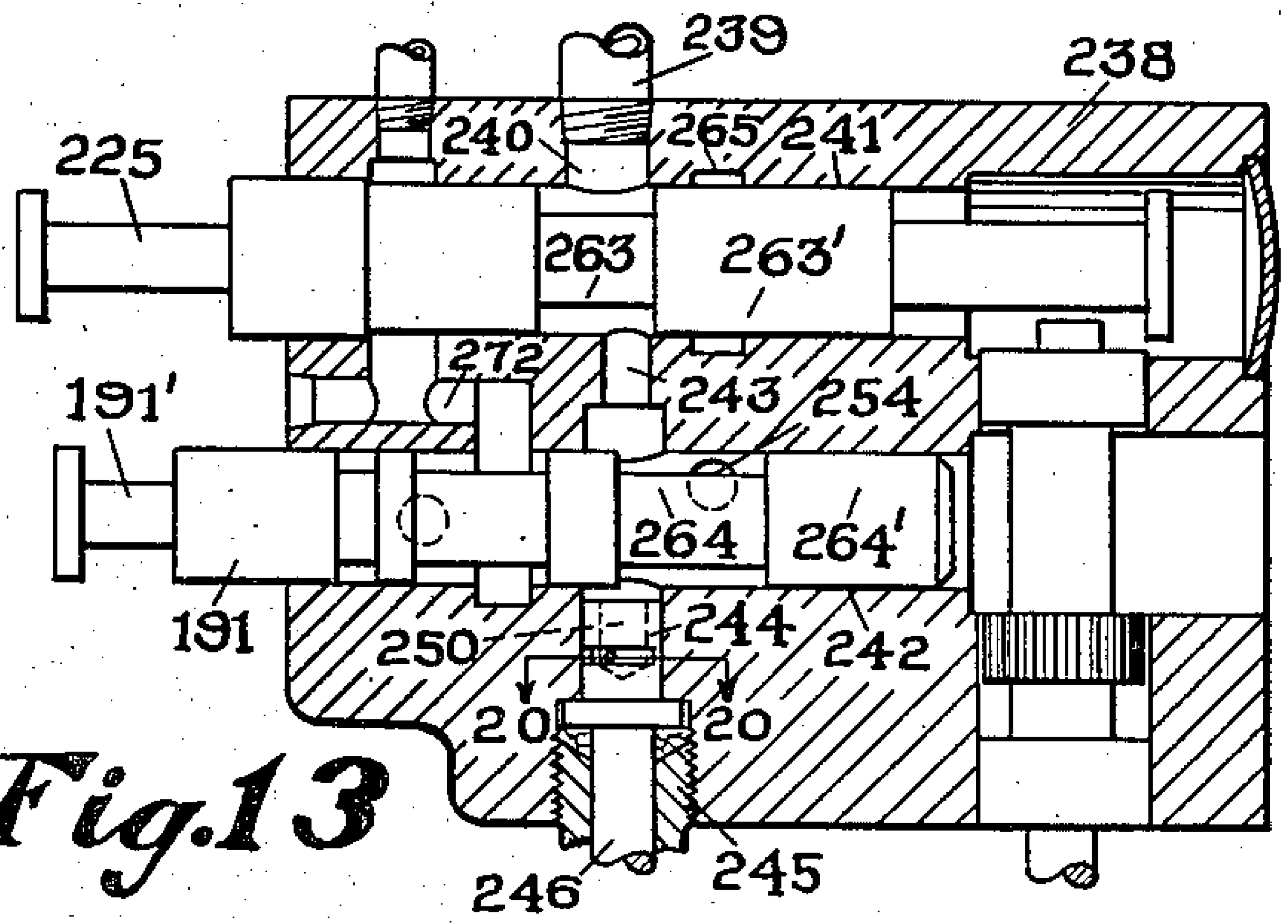


Fig.13

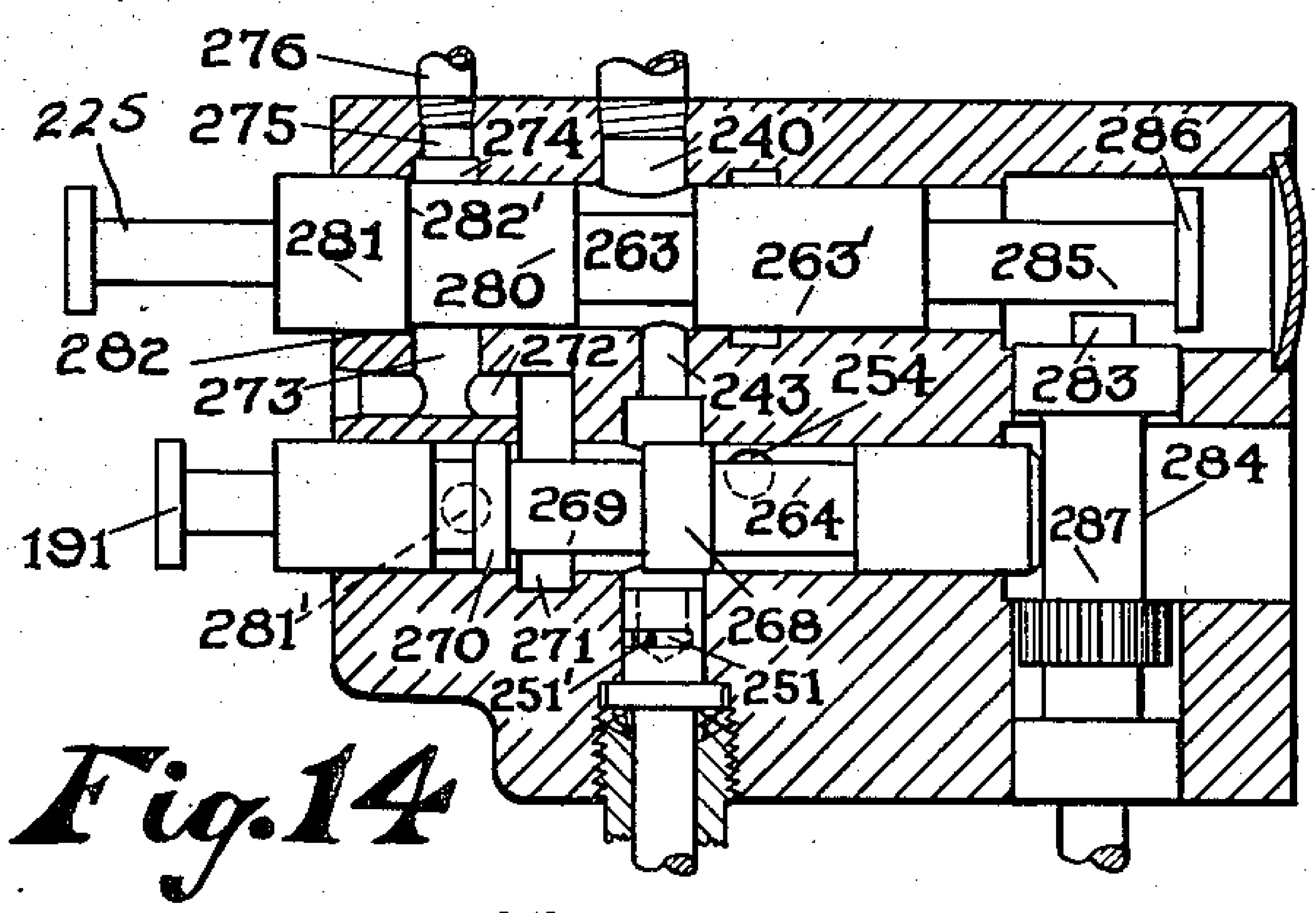


Fig.14

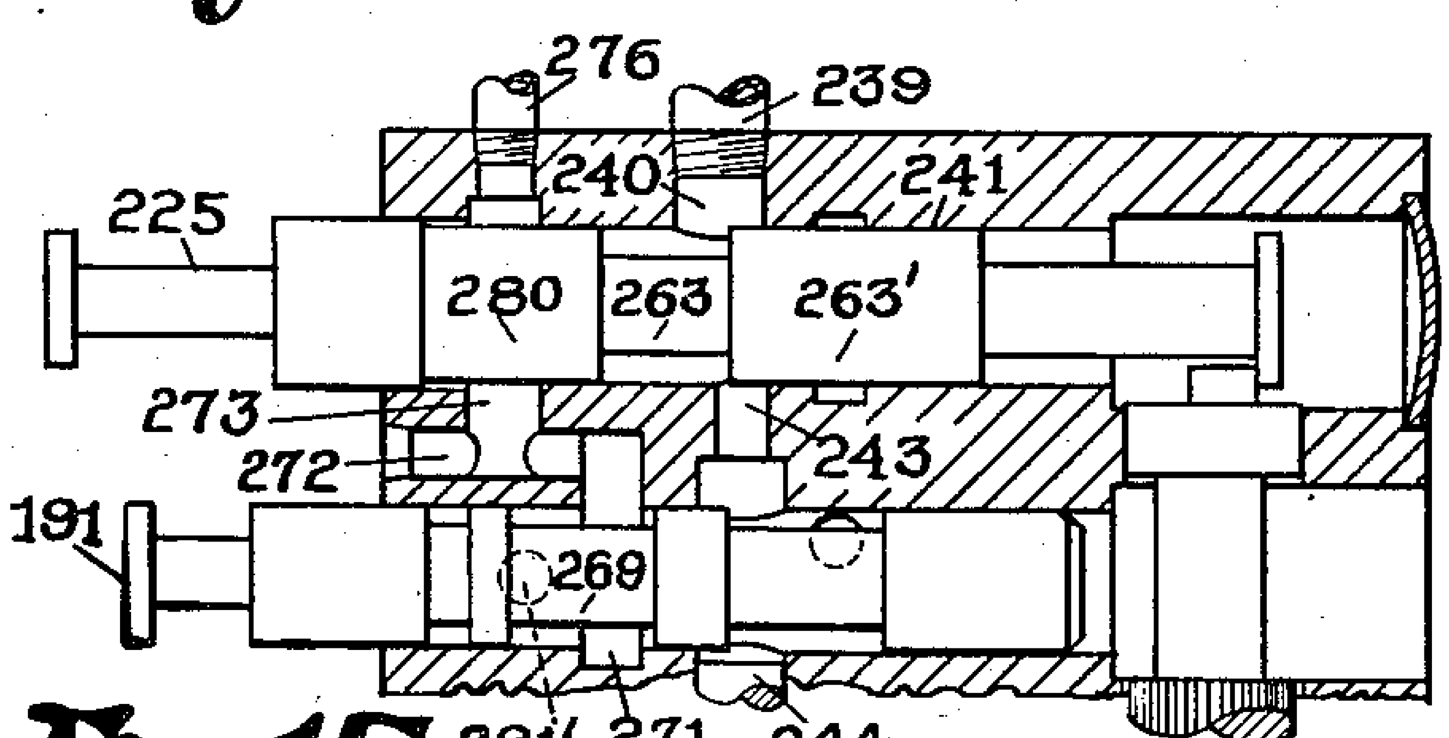


Fig.15

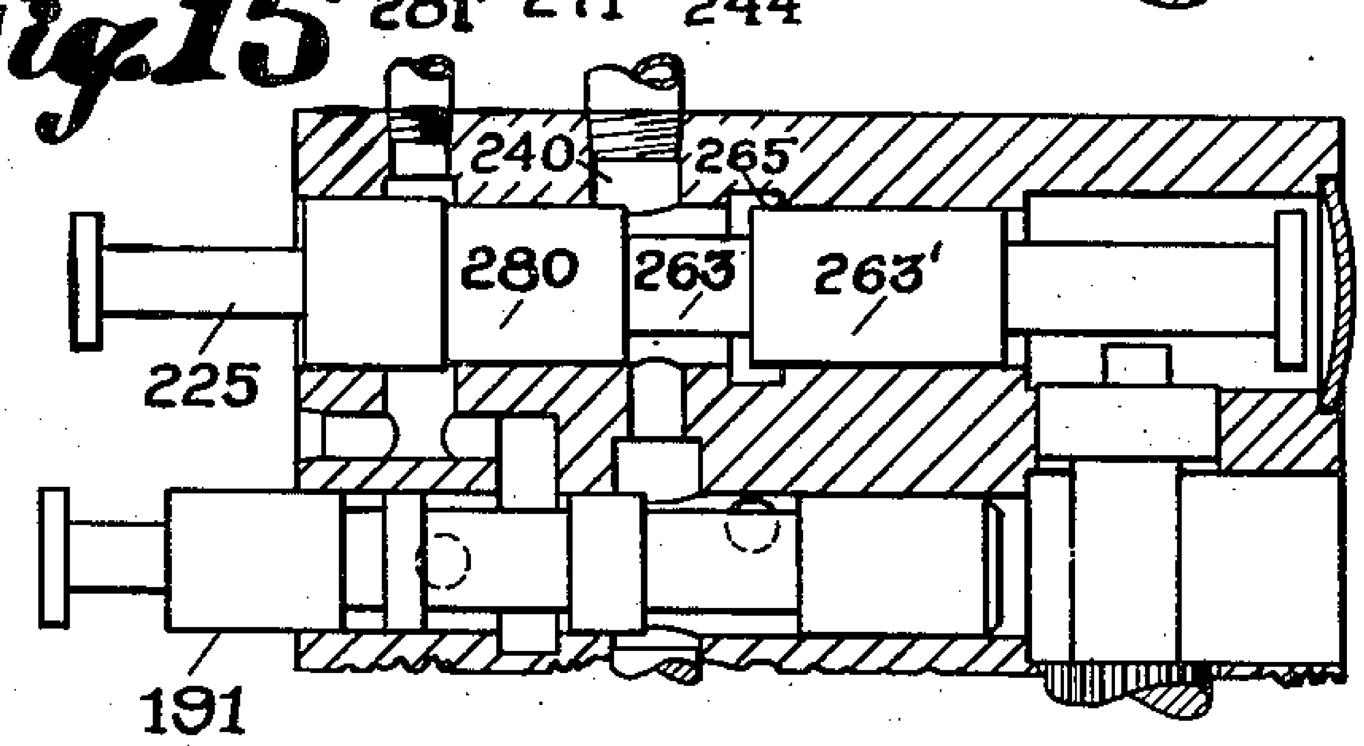


Fig.16

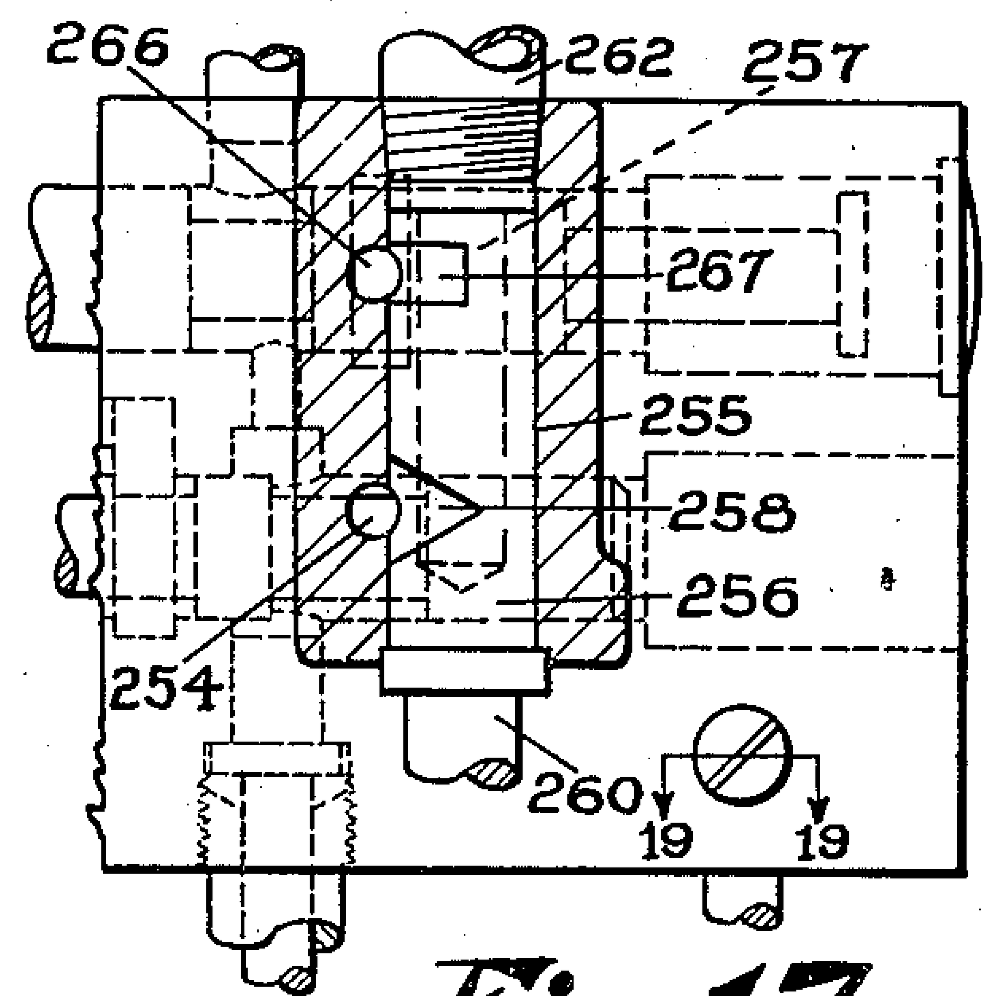


Fig.17

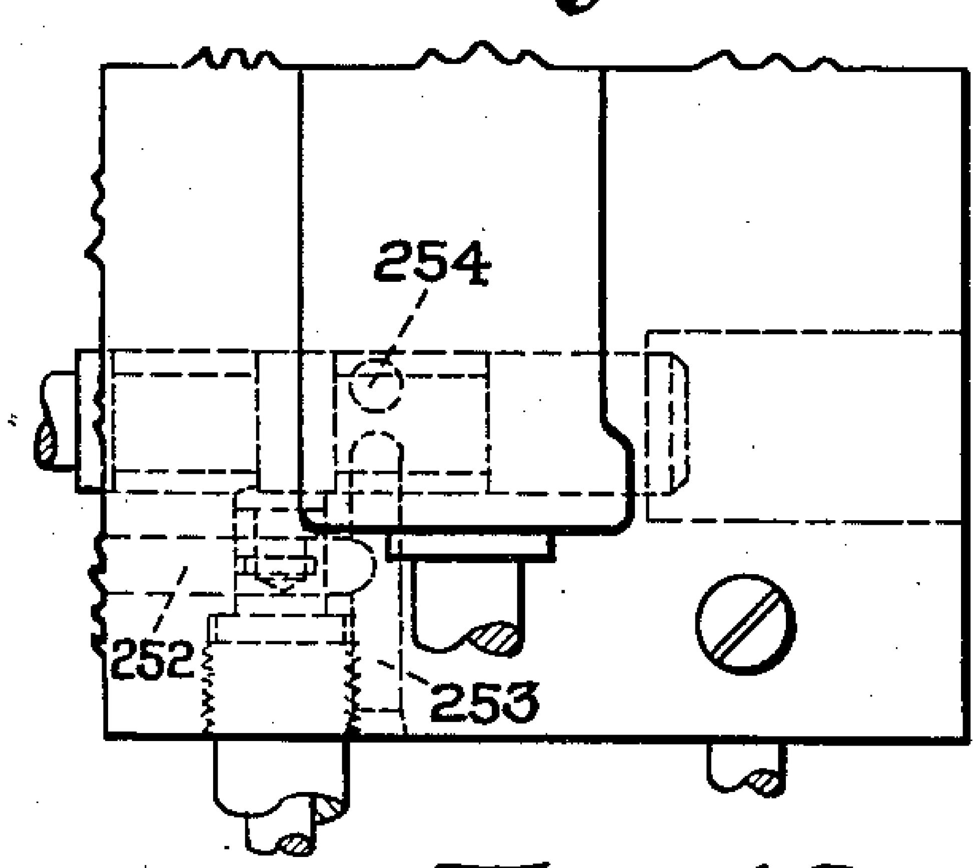
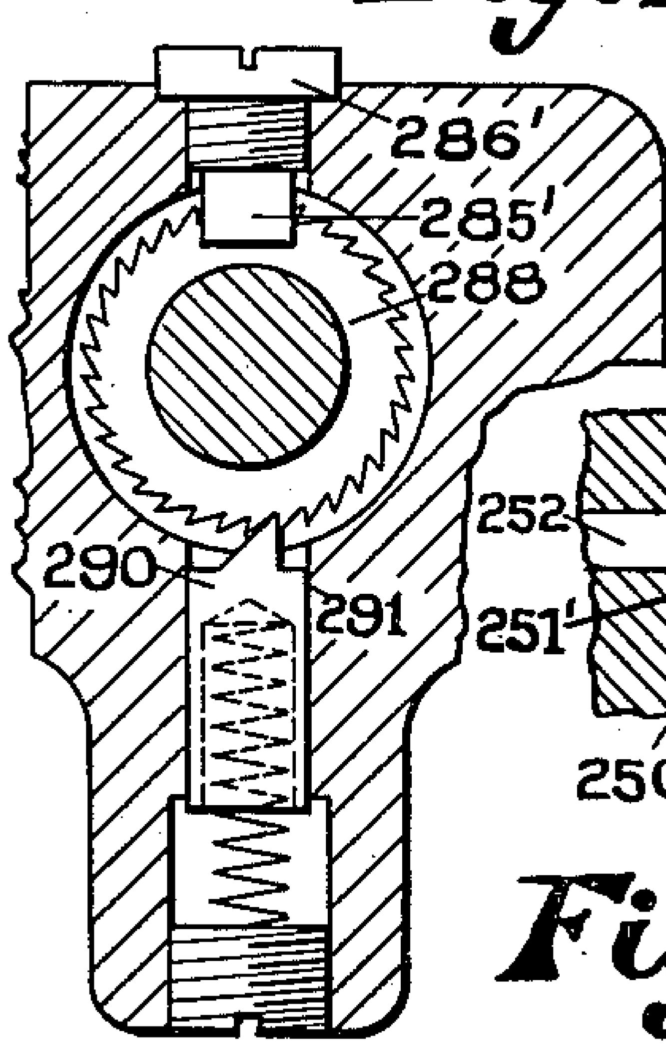


Fig.18



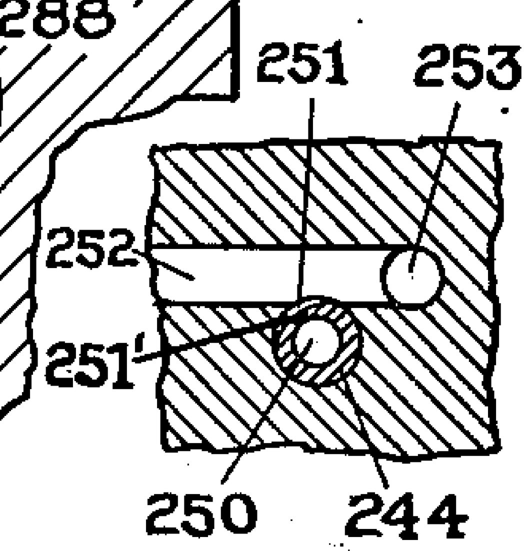


Fig.20

Fig.19

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Patented Aug. 20, 1935

2,011,705

UNITED STATES PATENT OFFICE

2,011,705

GRINDING MACHINE

Harold L. Blood and Alfred P. Burns, Worcester, Mass., assignors to The Heald Machine Company, Worcester, Mass., a corporation of Massachusetts

Application July 20, 1933, Serial No. 681,334

31 Claims. (Cl. 51—95)

The present invention relates to a grinding machine for the reduction of workpieces to a predetermined size, and it is particularly applicable to machines for grinding the internal surfaces of sleeves, bushings and like articles.

In grinding machines of the type disclosed in U. S. Letters Patent No. 1,682,672, issued August 28, 1928 to Guild, and No. 1,682,673, issued August 28, 1928 to Taylor, the progress of the grinding operation is under the control of the crossfeed mechanism, and the control mechanism which is responsive to the movement of the crossfeed mechanism involves a plurality of electrical circuits which are successively energized as the workpiece approaches the desired size. The electrical circuits necessarily require a source of electrical energy for actuation thereof and the proper operation for a plurality of extended movements involves a plurality of electrical connections resulting in a complex circuit. One of the principal objects of the present invention is to eliminate the electrical circuits so that the control mechanism may be actuated directly through mechanical elements from the crossfeed mechanism.

In grinding machines of the type disclosed in U. S. Letters Patent No. 1,534,302 issued April 21, 1925 to Conradson, et al., the grinding operation is controlled by electrical circuits successively energized by the entry of gages within the bore of the workpiece as the latter approaches and reaches the desired size. This type of machine also presents the objection of a mechanism which, for proper operation, and by reason of the several electrical connections, involves a complex electrical circuit. Another object of the present invention is accordingly to provide a control mechanism which is positively actuated by the gage mechanism through mechanical elements so that the electrical circuits under the control of the gage may be entirely eliminated. The grinding operation is nevertheless entirely automatic and successive workpieces will all be reduced to the desired size.

In the construction of a universal type of grinding machine which may be operated selectively by mechanism of the type disclosed in the above cited Guild and Taylor patents or by mechanism of the type disclosed in the above cited Conradson, et al. patent, it has been necessary, in order that either type of control might operate separately, to provide one complete electrical circuit for the Guild or Taylor mechanism and an independent electrical circuit for the Conradson, et al. mechanism. The necessity for a plurality of independent electrical circuits results in a complicated machine which may readily become inoperative by reason of its complexity; a further object of the present invention is to provide a single control mechanism which may be actuated selectively either in response to movement of the crossfeed mechanism or under the control of gages.

According to the present invention, the control mechanism is connected directly through mechanical elements to the actuating mechanism. The invention also involves the provision of connecting elements for actuation of the control mechanisms selectively either in response to movement of the crossfeed mechanism or under the control of gage structures, either of said actuating mechanisms being rendered inoperative while the other actuating mechanism is operative.

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

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

Fig. 2 is a front elevation on a larger scale of the mechanism within the control box, the cover of said box having been removed.

Fig. 3 is a fragmentary elevation of the mechanism of Fig. 2 showing the parts in a different position.

Fig. 4 is a view corresponding to Fig. 3 showing the parts in another position.

Fig. 5 is a side elevation of parts of the mechanism within the control box as seen substantially along the line 5—5 of Fig. 2.

Fig. 6 is a front elevation of the crossfeed mechanism, with parts broken away to show the construction.

Fig. 7 is a vertical section substantially along the line 7—7 of Fig. 6.

Fig. 8 is a vertical section substantially along the line 8—8 of Fig. 7.

Fig. 9 is a vertical section substantially along the line 9—9 of Fig. 8.

Fig. 10 is an elevation of part of the actuating mechanism for the control mechanism of Fig. 2.

Fig. 11 is a view corresponding to Fig. 2 showing the connecting elements when the control mechanism is actuated by gage mechanisms.

Fig. 12 is a diagrammatic view showing the gage mechanism.

Fig. 13 is a horizontal section through the control valves substantially along the line 13—13 of Fig. 2.

Fig. 14 is a sectional view corresponding to Fig. 13 showing the valves in another position.

Fig. 15 is a section corresponding to Fig. 13 showing the valves in another position.

Fig. 16 is a sectional view corresponding to Fig. 13 showing the valves in a fourth position.

Fig. 17 is a sectional view of the throttle valve substantially along the line 17—17 of Fig. 2.

Fig. 18 is a plan view of a part of the valve mechanism.

Fig. 19 is a vertical sectional view substantially along the line 19—19 of Fig. 17.

Fig. 20 is a sectional view substantially along the line 20—20 of Fig. 13.

Fig. 21 is a fluid pressure diagram.

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

Referring first to Fig. 1, the machine provides the usual reciprocatory table 1 provided in an internal grinding machine; either the grinding wheel or the work to be ground is carried on said table, the reciprocations of the latter operating in either case to produce a relative translatory movement between said grinding wheel and the workpiece. In the construction shown, the table supports and carries a workhead 2, and the wheelhead 3 is mounted on a bridge 4 which spans the guideways, not shown, provided by the base 5 of the machine, for the movements of the table 1. The grinding wheel 6 is carried on a spindle 7 journaled in the wheelhead 3, and the workpiece, not shown, is mounted in a suitable work-supporting member 8 carried on the end of a spindle journaled in the workhead.

Both the grinding wheel and the workpiece are rotated from a driving motor 10 mounted on the base of the machine. The shaft of said motor carries a large diameter pulley 11 connected by a belt 12 to a pulley 13 on a countershaft 14 journaled in the base. The countershaft also carries a pulley 15 connected by a belt 16 to a pulley 17 on the grinding wheel spindle 7, thereby providing a high rate of rotation for the grinding wheel. The drive shaft of the motor is also connected to a drum 18 journaled in the base of the machine, and a belt 20 which passes around said drum, and around a pulley 21 on the spindle on which the chuck 8 is mounted, procures rotation of said chuck at a slow rate of speed in response to rotation of the motor. The arrangement of belts and pulleys provides for rotation of the grinding wheel at a much higher speed than that of the chuck.

The reciprocations of the table 1 which cause the rotating grinding wheel to make the desired traverse over the surface of the workpiece mounted in the chuck are imparted in any well known manner, as by the use of fluid pressure controlling and reversing mechanism, one type of which is described in Patent No. 1,582,468, issued to Heald and Guild April 27, 1926. It is sufficient to note, for the purpose of the present application, that the driving means employed for the reciprocations of the table 1 procure the reversal of said table at each end of the normal working stroke, by the use of spaced reversing dogs 22 and 23, carried by blocks 22′ and 23′ adjustably secured to the table, and adapted alternately to engage and move a reversing member 24. The latter provides spaced upwardly projecting lugs 25 and 26, Fig. 2, which, during the grinding operation, when the work piece is being reciprocated back and forth over the grinding wheel, are situated in a position to be engaged by the dogs 22 and 23 respectively. The movement of said member 24 resulting from the engagement of said lugs with the dogs effects the reversal of the movements of the table 1 through suitable mechanism which will be described hereinafter.

The fluid pressure mechanism for actuating the carriage is shown in Fig. 21. In this figure, fluid under pressure, which is supplied by a pump 27 enters the inlet port 28 of a reversing valve casing 30 through throttle valve mechanisms which will be described later. The valve casing 30 has outlet ports connected by pipes 31 and 32 to the left and right hand ends respectively of a cylinder 33. The latter is mounted in the base of the machine and receives a piston 34 having a projecting piston rod 35 secured to a lug, not shown, on the under side of the table. With the reversing valve 36 in the valve casing 30 in the position shown, fluid under pressure is admitted to the right hand end of the cylinder for urging the table to the left into the rest position shown in Fig. 1, fluid from the left hand end of the cylinder exhausting past said reversing valve and out an exhaust opening 37 in the valve casing.

The machine provides a slow-down arrangement to prevent a sudden stopping of the table during its movement to the left into rest position. Referring again to Fig. 21, the left hand end of the cylinder is provided with spaced ports 38 and 40. The port 38 at the extreme end of the cylinder is connected by a channel 41, in which a ball check valve 42 is positioned, to a channel 43 which connects the end of the pipe 31 to the port 40. The latter is spaced from the left hand end of the cylinder sufficiently to be covered and closed by the piston 34 just before said piston reaches the left hand end of the cylinder. Thus, as the piston is moving to the left into the position shown in Fig. 21, it closes the port 40 and, as the ball check valve prevents discharge of fluid through the port 38, no further exhaust of fluid from the left hand end of said cylinder takes place and the table is brought to rest under the cushioning action of the fluid remaining in the end of the cylinder. When the reversing valve is shifted to procure movement of the table to the right, fluid enters past the check valve 42 into the cylinder although the port 40 is still closed by the piston.

As above stated, the reversing member 24 is connected to the reversing valve 36 for actuating the same. As best shown in Fig. 2, the forward end of the reversing valve 36 has secured thereto an arm 44 which supports a pin 45 in spaced relation to the valve. Said pin is positioned between spaced projecting lugs 46 and 47 on the end of an arm 48 secured to a shaft 49 journaled in the control box 50. The reversing member 24 is also secured against turning movement on the shaft 49 so that said member and the arm 48 move as a unit. The arm 48 has a V-shaped projecting portion 51 which engages with a corresponding V-shaped portion 52 on the end of an arm 53 pivotally mounted on a pin 54 carried by a bracket 55 secured within the control box. The arm 53 is urged upwardly into engagement with the V-shaped portion 51 by a spring 56. The cooperating V-shaped portions tend to maintain the arm 48 either in the position shown or, upon engagement of the reversing dog 23 with the reversing member 24, to procure positive movement of said arm 48 clockwise for shifting the valve 36 into its opposite position. As will be apparent from the drawings, the spacing between the lugs 46 and 47 is materially greater than the diameter of the pin 45 to provide a lost motion between said arm and the reversing valve. As the arm 48 is rocked clockwise by the reversing dog 23, the V-shaped portion 51 slides along the side of the V-shaped portion 52 with which it is in engagement until the points of said V-shaped portions pass each other. The arm 48 is then moved positively clockwise a further distance by the action of the spring 56, and shifts the valve 36. Oscillation of the reversing member 24 by the reversing dogs thus procures, through oscillation of the reversing valve, a positive reciprocation of the table.

In setting up the machine, it is often desirable to shift the reversing valve manually. To this end, the arm 48 carries a pin 57 which is positioned between spaced arms 58 and 59 on a plate 60. The latter is secured to a shaft 61 journaled in the control box, and said shaft projects through the cover of the control box and carries a lever 62, Fig. 1, on the forward end thereof to provide for manual turning movement of said shaft. Counterclockwise oscillation of the plate 60 from the position shown in Fig. 2 will shift the reversing valve into its opposite position by a clockwise swinging movement of the arm 48 and similarly a clockwise turning movement of the plate 60 when the reversing valve is in its opposite position will procure shifting movement of the valve by engagement between the arm 59 and the pin 57. The plate 60 carries a projecting lug 63 which engages with the side of the control box to prevent excessive clockwise oscillation of said plate.

The crossfeed movement between the workpiece and the grinding wheel is obtained by movement of the wheelhead 3 transversely on the bridge 4 in response to the reciprocations of the table. The wheelhead is mounted on a cross-slide, not shown, and movement thereof is obtained by rotation of a crossfeed screw 64, Fig. 6, which engages an internally threaded portion, not shown, of the cross-slide. Said crossfeed screw carries a gear 65 adjacent the forward end thereof which meshes with a pinion 66 rotatably mounted on a shaft 67, the latter being secured against rotation in a casing 68 within which the crossfeed mechanism is positioned. The casing 68 is secured to the forward end of the bridge. The pinion 66 during the crossfeed movement of the slide is rotated in unison with a ratchet wheel 70 which is actuated in response to the reciprocations of the table. The rotation of the pinion procures, through rotation of the crossfeed screw 64, a movement of the grinding wheel transversely of the machine to cause the wheel to cut successively deeper and deeper into the workpiece.

Referring again to Fig. 6, an arm 71 is pivotally mounted on the shaft 67 and has secured in its outer end a bolt 72 on which a lever 73 is pivotally mounted. One arm of said lever carries a pawl 74 which is rotatably mounted on a stud 75 in the end of said arm, said pawl being held against rotation by a pin 76. This structure provides for use, selectively, of any one of a plurality of points provided by said pawl, the pin supporting one of said points in a position for engagement with the ratchet wheel. A second arm 77 of the lever 73 is engageable with an adjustable stop 78 carried by a lug 80 on the arm 71 and said stop is arranged to support the lever against counterclockwise rotation beyond the position shown. The arm 77 of the lever 73 also engages an abutment 81, normally held against movement, which limits counterclockwise oscillation of the arm 71 beyond the position shown.

A third arm 82 on the lever 73 is in a position for engagement with a roller 83 on the end of one arm 84 of a bell crank lever 85 pivotally mounted on a stud 86 secured to the casing 68. The other arm 87 of the lever 85 is connected by a link 88 to an arm 90 of a lever 91 journaled on a stud 92 in the casing 68. The opposite arm 93 of the lever 91 carries a roller 94 (see also Fig. 2) which is in a position for engagement with a cam 95 on a block 95′ adjustably secured to the table. During each reciprocation of the carriage while the grinding wheel and workpiece are in operative position, the cam engages beneath said roller and procures an oscillation thereof. A clockwise turning movement of the lever 91 responsive to engagement between the cam and roller procures a corresponding clockwise turning movement of the lever 85 to bring the roller 83 into engagement with the arm 82, with a resultant turning movement of the lever 73 to bring the pawl into engagement with the ratchet wheel. In response to continued elevation of the roller 83, a clockwise turning movement of the arm 71 is procured with a resulting turning movement of the ratchet wheel 70. A pin 96 carried by the casing 68 engages the arm 87 to prevent excessive counterclockwise rotation of the bell crank levers 73 and 85 and to support the roller 94 in a position for engagement by the cam 95.

As will be apparent, the roller 83 is given a predetermined oscillation during each reciprocation of the carriage. The resultant turning movement of the ratchet wheel is varied, however, by adjusting the position of the abutment 81. Referring again to Fig. 6, the abutment comprises a stud adjustably mounted in one arm 97 of a lever 98 which is mounted for turning movement on the stud 86. The opposite arm 100 of the lever 98 engages one arm of a lever 101 against which the arm 100 is held by a spring 102. One end of the spring engages the arm 100 and the other end of said spring is suitably connected to a part of the casing 68. The abutment 81 accordingly limits the downward swinging movement of the arm 71 and also the pawl carrying lever 73, thereby determining the extent of advance of the crossfeed slide for each reciprocation of the table. The lever 101, which is normally stationary, is arranged for turning movement for adjusting the rate of crossfeed movement. To this end, the lever 101 is mounted for oscillation on a pin 103 supported by the casing 68, and an arm of said lever is held against an eccentric disc 104 secured to a pin 105 which is manually adjustable in the casing. Turning movement of said eccentric disc rocks the lever 98 and adjusts the position of the abutment 81 for varying the rate of crossfeed movement.

The rate of crossfeed movement is also automatically diminished during the grinding operation by a turning movement of the lever 101. During the clockwise advance of the ratchet wheel 70 by which the crossfeed movement is procured, a cam 106 which is rotatable as a unit with said ratchet wheel engages a pin 107 mounted on an arm of the lever 101 to procure a counterclockwise turning movement of said lever and a corresponding elevation of the abutment 81. The extent to which the arm 71 is elevated by the roller 83 during each reciprocation of the table is thus decreased, thereby reducing the rate of crossfeed movement.

As above stated, the ratchet wheel 70 is connected to the shaft 64 to procure a turning movement of said shaft in response to a turning movement of the ratchet wheel, and the structure by which the ratchet wheel and shaft are connected is best shown in Figs. 7 and 8. Referring to these figures, the ratchet wheel 70 is connected as by bolts 108 to an annular member 110 journaled on the shaft 67 and said member 110 has an integral forwardly extending sleeve 111 to which a hand wheel 112 is secured as by a key 113. Locking nuts 114 on the end of the shaft 67 support the annular member 110 against sliding movement on said shaft. The annular member 110 provides spaced studs 115 and 116 secured by nuts 117 and 118 to said member, and said studs provide pivotal supports for pawls 120 and 121, Fig. 8, respectively. Said pawls are arranged to engage a ratchet wheel 122 which is integral with the pinion 66 and said pawls are normally maintained resiliently in engagement with said ratchet wheel by a spring 123. The pawl 121 procures clockwise turning movement of the ratchet wheel 122 in response to corresponding clockwise rotation of the ratchet wheel 70 and the pawl 120 procures counterclockwise turning of the ratchet wheel 122 when the ratchet wheel 70 is turned in a counterclockwise direction. Thus, when both pawls are in engagement with the ratchet wheel 122, both ratchet wheels and the pinion 66 normally rotate as a unit.

During the crossfeed movement of the grinding wheel, the ratchet wheel 70 is advanced clockwise as above stated, and the pawl 121 procures a corresponding advance of the ratchet wheel 122. As the grinding operation continues, a pin 124 on the pawl 120 is brought into engagement with a shield 125 secured against movement in the casing 68. Said shield procures retraction of the pawl 120, which is inoperative during the clockwise movement, out of engagement with the ratchet wheel 122. The crossfeed movement continues, however, under the action of pawl 121 until the workpiece reaches the desired size at which time the machine is brought to rest by a mechanism which will be described hereinafter. During the subsequent retraction of the crossfeed movement by counterclockwise rotation of the hand wheel 112, the annular member 110 on which the pawls 120 and 121 and the ratchet wheel 70 are mounted, carries said pawls counterclockwise therewith without a corresponding clockwise turning movement of the ratchet wheel 122, the pawl 120 being held in inoperative position by the shield 125. The ratchet wheel 122 is not rotated until the pin 124 on the pawl 120 is carried counterclockwise out of engagement with the shield 125, thus allowing the pawl to again engage the ratchet wheel. Continued counterclockwise rotation of the hand wheel procures a corresponding counterclockwise rotation of the ratchet wheel 122 and a resultant retraction of the crossfeed movement, at the same time providing a compensation for the reduction in size of the grinding wheel.

The compensatory movement between the ratchet wheel 122 and the ratchet wheel 70 to provide a compensation for the reduction in size of the grinding wheel is dependent, as will be apparent, upon the position of the shield 125 relative to the pawl 120 (or the pin 124) at the end of each grinding operation. The shield 125 is adjustably positioned in the casing 68 so that the extent of the compensatory movement may be varied to correspond approximately to the reduction in size of the grinding wheel. Referring now to Fig. 9, the shield 125 is carried by a plate 126 secured against rotation on a shaft 127, the latter having secured to its opposite end a knurled nut 128. The casing 68 is provided with an arcuate slot 130 concentric to the shaft 67, and this slot receives a sleeve 131 having a shoulder 132 which engages the inner surface of the casing. A nut 133 on a threaded portion of the sleeve engages the outer surface of the casing for clamping the sleeve in fixed position in the arcuate slot. The shaft 127 is slidable within the sleeve and a spring 134 urges said shaft toward the left, Fig. 9, to urge the knurled nut against the end of said sleeve, thereby maintaining the shield 125 in a position for engagement with the pin 124 on the pawl 120. The plate 126 has a projecting stud 135 which engages with one edge of the slot 130 to aid in maintaining the shield in proper position.

The knurled nut 128 which is positively secured to the shaft 127 has a projecting pin 136 engaging a recess in the sleeve 131. The shield 125 is withdrawn from operative position by movement of the nut 128 to the right, Fig. 9, thereby drawing the shield to the right therewith, and subsequent turning of said nut to cause the pin 136 to engage the end of said sleeve in a position spaced from the recess which normally receives said pin. The shield is thus retained in inoperative position and in this manner it is possible to avoid any compensatory movement and cause the ratchet wheel 122 to rotate as a unit with the ratchet wheel 70 at all times. The operative position of the shield 125 is readily adjusted by loosening the clamping nut 133 to permit shifting of the sleeve 131 in the slot 130.

In setting up the machine for the grinding of a predetermined size of workpiece, it is desirable to provide for rotation of the ratchet wheel 70 and the annular member 110 secured thereto without a corresponding rotation of the ratchet wheel 122. For this purpose, the annular member 110 has a shaft 137, Figs. 7 and 8, journaled therein, to the inner end of which is secured an eccentric disc 138 in a position for engagement with projecting lugs 140 and 141 on the pawls 120 and 121 respectively. The forward end of the shaft 137 is provided with a pinion 142 for engagement with a series of gear teeth 143, Fig. 6, provided by a ring 144 which is rotatable on the annular member 110 and held against removal therefrom by the heads of the bolts 108. A manual turning of the ring 144 urges the eccentric disc into engagement with the lugs 140 and 141, thereby withdrawing both of the pawls 120 and 121 out of engagement with the ratchet wheel 122.

To prevent undesired movement of the annular member 110 while the pawls 120 and 121 are in inoperative position, said member supports a ring 145, Fig. 7, which is secured against rotation relative to said member by bolts 146 passing through said annular member and engaging said ring. The ring 145 is normally urged by springs 147 into engagement with a flange 148 secured against rotation on the shaft 67. Said annular ring 145 acts as a brake for the hand wheel and the annular member 110 movable therewith.

The above described mechanism is fully disclosed in prior patents or copending applications and is not, of itself, a part of the present invention. The latter involves the attainment in connection with the above or similar machine instrumentalities of the novel and useful results herein set forth. According to the present invention, the progress of the grinding operation is controlled by mechanism actuated directly from the crossfeed mechanism without the interposition of any electrical elements.

As indicated in Fig. 10, the annular member 110 forming a part of the crossfeed mechanism carries a cam 150 which, during the crossfeed movement of the grinding wheel, is advanced clockwise and into engagement successively with the ends of adjustable screws 151 and 152 carried by an arm 153 of a bell crank lever 154 journaled on the stud 92, the screws 151 and 152 being locked in adjusted position by locking nuts 155 and 156. The other arm 157 of the bell crank lever 154 is connected by a lever 158 to an arm 160 secured to a shaft 161 journaled in the casing 68. A spring 162 which engages the arm 160 urges the bell crank lever 154 clockwise into the position shown in Fig. 10, further clockwise movement of said lever being prevented by a lug 163 projecting from the arm 157 and engaging a part of the casing 68.

During the crossfeed movement, as the workpiece approaches the desired size, the cam 150 engages and elevates the screw 151 and thus procures a slight counterclockwise movement of the lever 154 which movement operates to procure a change in the grinding operation. In the construction shown, the movement of the lever procures a separation of the grinding wheel from the workpiece and a change in the rate of travel of the table during the time that the grinding wheel is moving past the dressing tool. The grinding wheel and workpiece are returned to operative position after the grinding wheel is dressed and the grinding operation continues until the cam 150 passes beneath, and elevates, the screw 152, thereby procuring a further counterclockwise turning movement of the lever 154. This further movement of the lever 154 operates to procure cessation of the grinding operation and a runout of the table to rest position.

As best shown in Figs. 2 to 5 inclusive, the shaft 161 projects beyond the casing 68 (see also Fig. 10) and has on the end thereof a depending arm 163′ which carries a bolt 164 by which a horizontally slidable bar 165 is secured to said arm. The left hand end of the bar 165 projects into the control box and is supported at the left hand end by a lug 166 on the bracket 55 within said box. Engagement of the cam 150 with the screw 151 procures movement of the horizontal bar 165 to the left into engagement with a depending arm 167 of a lever 168 rotatably mounted on a shaft 170 in the control box and forming a part of the control mechanism.

The control mechanism, which is shown in detail in Figs. 2 to 5 inclusive, controls the grinding operation and is actuated in response to the crossfeed movement as above pointed out. The lever 168 has a second arm 171 which normally engages a notch 172 provided in a lug 173 on a depending arm 174. Said arm is journaled on a shaft 175 in the control box and is urged counterclockwise by a spring 176 which is positioned within a recess 177 in a bracket 178 mounted in the control box. One end of said spring engages the inner end of the recess and the opposite end of said spring engages a flat surface 180 on the arm 174. The spring is held in position on said surface 180 by a pin 181, Fig. 5, projecting from said surface.

A bell crank lever 182 which is journaled on the shaft 175 has a depending arm 183 which engages a pin 184 on the arm 174. The opposite arm 185 of the bell crank lever 182 projects upwardly between the lugs 25 and 26 on the reversing member 24, and is provided with a cam surface for engagement with the reversing dog 22 to elevate said dog. When the cam 150 elevates the screw 151, the horizontal bar 165 rocks the lever 168 clockwise and elevates the arm 171 of said lever out of engagement with the notch 172 permitting the arm 174 to swing counterclockwise in response to the pressure of the spring 176 into the position of Fig. 3. This movement of the arm 174 procures a corresponding elevation of the upwardly projecting arm 185 of the lever 182 into alinement with the reversing dog 22. During movement of the table to the left, the reversing dog 22 rides over the end of the arm 185 without engaging the lug 25 of the reversing member so that the table moves to the left beyond its normal position for a dressing operation on the grinding wheel. The reversing dog 22 is pivotally mounted on a pin 186 in the block 22′ secured on the front of the table to permit elevation of the dog by the lever.

As the table moves to the left beyond its normal position, the pivotally mounted dressing tool 188, Fig. 1, is moved by fluid under pressure into operative position in alinement with the grinding wheel for engagement therewith. The fluid pressure mechanism for actuating the dressing tool, which is fully disclosed in Patent No. 1,779,094, issued to Heald and Guild October 21, 1930, will be described later in connection with the fluid pressure mechanism of the present machine. On the return movement of the table to the right into operative position following the dressing operation, a roller 190, carried by the support for the dressing tool, engages a cam, not shown, on the back of the bridge 4 for returning the dressing tool into the inoperative position shown.

The counterclockwise swinging movement of the arm 174, above referred to, in addition to procuring the extended movement of the table, also reduces the rate of movement of the table during the extended movement for dressing by shifting of a valve member 191, Fig. 2, which is provided with a notch 191′ engaged by the lower end of the arm 174. The operation of the valve 191 will be pointed out in connection with the fluid pressure mechanism hereinafter described.

After the dressing tool has passed the grinding wheel during the movement of the table to the left, a reversing dog 192 pivotally mounted on a pin 193 in a block 194 secured to the table engages a portion 195 of the lug 25. The portion 195 projects above and forwardly of the main portion of the lug engaged by the dog 22, and the upper end of the arm 185 in raised position, as a result of the swinging movement of the arm 174, does not elevate the dog 192 sufficiently to prevent engagement of said dog with the portion 195. Engagement between the dog 192 and the lug on the reversing member shifts the reversing valve and thus reverses the direction of movement of the table to return the workpiece to operative position for the completion of the grinding operation.

During the return movement of the table to the right, the arm 185 is restored to the original position of Fig. 2 out of alinement with the reversing dog 22 to prevent a repetition of the dressing operation. To this end, the block 194 carries a depending dog 196 pivotally mounted on a pin 197 in said block. A portion of said dog engages a shoulder 198 on the block 194 to prevent clockwise movement of said dog from the position shown. During the extended movement of the table to the left, the depending dog 196 engages the end of the arm 185 and is swung counterclockwise on the pin 197 without affecting the position of said arm; on the return movement of the table to the right, however, said dog engages the upper end of said arm 185 and returns said arm to the position shown in Fig. 2 with the upper end of said arm out of alinement with the reversing dog 22. Downward movement of the arm 185 also returns the arm 174 to its original position where it is retained by a latch 200. The latter is pivotally mounted on a pin 201 supported by a bifurcated portion 202 of the arm 174.

Referring again to Fig. 2, a stud 203 mounted in the control box provides a support for a lever 204 having a counterweight 205 at one end, and a projecting lug 206 which engages with the bracket 178 to support said lever in the position shown. A pin 207 in the end of the lever opposite the counterweight is connected to a rod 208, the lower end of which engages the end of a set screw 210 adjustably mounted in one arm of a lever 211. The lever 204 has a second projecting lug 212 which supports a pin 213 on which a member 214 is mounted. A portion of said member engages the lever 204 to prevent counterclockwise turning movement of said member beyond the position shown, although permitting free clockwise turning movement. During the extended movement of the table to the left for the dressing operation, a projection 215 on the end of a bar 216 carried by a block 217 on the table engages the upwardly extending end of said member 214 with which said projection is in alinement and procures a turning movement of the lever 204 and thus a downward movement of the rod 208. During the return movement of the table to the right, the projection 215 engages and rocks the member 214 without affecting the position of the rod 208.

Downward movement of the rod 208 procures turning movement of the lever 211 on the stud 218 on which said lever is mounted and corresponding elevation of the right hand end of said lever. The latter has a notch 220 in the upper surface thereof which provides a locking surface 221 for engagement with a projecting portion 222 on the latch 200. Said latch has a depending end portion 223 engaging with the lever 211 just above the stud 218. In addition to the notch 220, the lever 211 has a notch 224 on the under side thereof which engages the end of a valve member 225 to prevent movement of said valve to the left. Upon elevation of the right hand end of the lever 211, said valve 225 moves automatically to the left, as will be pointed out, and the end of said valve engages a second and lower notch 226 in said lever which limits the movement of said valve toward the left. Said lever 211 is supported by the end of the valve member 225 in the position shown in Fig. 3 when said valve member has been shifted to the left. Return movement of the arm 174 to original position in response to engagement between the dog 196 and the lever 185 positions the projecting portion 222 of the latch in engagement with the surface 221 provided by the notch 220 in the lever (see Fig. 4) and the arm 174 is accordingly retained by said latch in its original position during the remainder of the grinding operation.

After grinding is resumed, following the dressing operation, the cam 150 continues to move clockwise as a result of the cross feed movement until said cam engages and elevates the screw 152, thereby procuring a further movement of the bar 165 to the left into engagement with an arm 227 of a lever 228 pivotally mounted on the same stud 170 on which the lever 168 is mounted. (The lever 228 in Fig. 2 is directly behind the lever 168 and only the arm 227 of said lever appears; the remainder of the lever is shown more fully in Figs. 3 and 4.) Clockwise turning movement of the lever 228 in response to engagement of the bar 165 therewith elevates an arm 230, Figs. 3 and 4, of said lever to raise the end thereof out of engagement with a notch 231 in a lug 232 on a depending arm 233, Figs. 3, 4 and 5, journaled on the shaft 175 in back of the arm 174. Said arm 233 is provided with a projecting pin 234, Fig. 5, which is engaged by one end of a spring, not shown, positioned directly in back of a spring 176 and received in a recess in the bracket 178 parallel to the recess 177. The spring urges the arm 233 to the right and when the arm 230 is lifted out of the notch 231, the depending arm 233 is shifted into the position indicated in Fig. 4. Movement of the arm 233 to the right procures an extended movement of the table to the left into rest position and also shifts the valve member 225 to change the rate of travel of the table.

For procuring the extended movement of the table into rest position, the depending arm 233 carries a pin 235 projecting from the rearward side thereof in a position to engage with the lower end of an arm 236, Fig. 5, journaled on the shaft 175. Said arm is connected to the upwardly extending arm 185 of the bell crank lever 182 by an integral connecting portion 237 which extends, as indicated in Figs. 2 and 5, forwardly from the arm 236 into engagement with the arm 185. The counterclockwise swinging movement of the depending arm 233 procures an elevation of the arm 185 into alinement with the reversing dogs 22 and 192 to elevate said dogs and prevent their engagement with the lug 25 of the reversing member. The elevation of the arm 185 in response to the swinging movement of the depending arm 233 is higher than the elevation of said arm in response to the swinging movement of the depending arm 174 and the dog 192 is accordingly elevated high enough to avoid engagement of said dog with the reversing member. The table accordingly moves to the left to the rest position shown in Fig. 1 where it is brought to rest by the fluid pressure mechanism above described.

The fluid pressure mechanism is shown in detail in Figs. 13 to 20 inclusive and diagrammatically in Fig. 21. Referring first to Fig. 13, fluid under pressure from the pump 27 enters the casing 238 through a conduit 239 which is connected by a short channel 240 to a longitudinal bore 241 in said casing. The valve member 225 above referred to is slidable in the bore 241 and the valve member 191 is slidable in a parallel bore 242 also provided by the casing 238. Although in the diagrammatic showing of Fig. 21, the bores 241 and 242 are shown in separate casings 238*a* and 238*b*, this is done merely to clarify the drawings and the separate casings are actually a single casing as indicated in Fig. 13. The bores 241 and 242 are connected by a channel 243 (a pipe 243*a*, Fig. 21) which is substantially in alinement with a channel 240. The channel 243 extends beyond the longitudinal bore 242 and receives a throttle valve 244 held in position by a packing nut 245 and having a projecting stem 246. The latter extends through the cover plate 247, Fig. 1, and has a knob 248 on the forward end thereof for manual adjustment of said valve.

As indicated in Figs. 13, 14 and 20, the inner end of the throttle valve 244 has a recess 250 and the side of said valve is provided with a slot 251 which is connected to said recess by a short port 251'. A horizontal channel 252, Figs. 13 and 20, positioned above the channel 243 intersects the latter at a point in alinement with the slot and turning movement of the throttle valve permits a variation in the size of the opening from the slot 251 into the channel 252 for controlling the amount of fluid under pressure entering said channel. The latter intersects a horizontal channel 253 which intersects the longitudinal bore 242 at a point spaced from the channel 243. A vertical channel 254 intersects the longitudinal bore 242 adjacent the channel 253 and projects upwardly therefrom to intersect a longitudinal bore 255, Fig. 17, in which the main throttle valve 256 is positioned. This valve 256 is provided with a longitudinal recess 257 which is intersected by a V-shaped notch 258 adjacent the channel 254. The valve 256 also has a forwardly projecting valve stem 260 which extends forwardly through the cover plate 247 and has an arm 261 on the forward end thereof for manual adjustment of said valve. Turning movement of this valve 256 varies the size of the opening between the channel 254 and the longitudinal recess 257, thereby varying the amount of fluid under pressure entering said recess from the channel 254. The recess communicates with the end of the bore 255 and the latter is connected by a pipe 262 to the inlet port 28 of the reversing valve.

The throttle valve 256 in Fig. 17 is shown in the diagrammatic showing of Fig. 21 in a casing 238c separate from the casing in which the valves 191 and 225 are positioned, although, in the construction of Figs. 17 and 18, this is an integral part of the casing 238. Further, the auxiliary throttle valve 244 is indicated conventionally in Fig. 21 so that the operation may be more readily understood. The channels 252 and 253 are similarly identified in Fig. 21 although not in the proper plane and the channel 254 is represented by a pipe 254*a*.

The valve member 225 has a reduced portion 263 which is normally in alinement with the channels 240 and 243. The valve 191 also has a reduced portion 264 at the left of a full-size portion 264', and this reduced portion, in the position of the valve indicated in Fig. 13, connects the channel 243 to the vertical channel 254. Fluid under pressure is thus admitted directly from the pump 27 through the channels 240 and 243 into the channel 254 and thence through the main throttle valve 256 to the reversing valve 36. The normal rate of movement of the table is accordingly determined by the setting of said main throttle valve 256.

The longitudinal bore 241 is provided with an annular groove 265 spaced from the intersection of the channel 240 with said bore, and said annular groove is connected by a vertical channel 266 (a pipe 266*a*, Fig. 21) to the horizontal bore 255 in which the main throttle valve is mounted. Adjacent the intersection of the channel 266 with the bore 255, the main throttle valve 256 is provided with a rectangular notch 267 which intersects the longitudinal recess 257 in said valve so that the size of the opening from the channel 266 into the recess in the valve is unrestricted regardless of the position of said valve.

When the table is started from the rest position shown in Fig. 1 to bring the workpiece in the workhead into operative engagement with a grinding wheel, the valve members 225 and 191 are in the position indicated in Fig. 16 into which position they are moved during the left hand movement of the table into rest position at the end of the preceding grinding operation. In this position of the valves, fluid connection is provided from the channel 240 directly to the annular groove 265 and thence through the main throttle valve to the reversing valve. Movement of the table to the right into operative position is procured by manual turning movement of the lever 62 for shifting the reversing valve 36 from the position shown into its opposite position, thereby providing fluid connection between the inlet port 28 and the left hand end of the cylinder. At this time, the full volume of the pump 27 is directed to the left hand end of the cylinder 33 through the channel 240, the vertical channel 266 and the rectangular notch 267, thereby procuring movement of the table to the right into operative position at the maximum rate of speed.

During the movement of the table to the right, the depending dog 196, above referred to, engages the upper end of the arm 185 which, during the preceding grinding operation, was shifted into the raised position of Fig. 4. Engagement between the dog 196 and the arm 185 depresses said arm and procures a swinging movement of the arm 233 to the left, thereby returning the valve 225 to the position of Fig. 13. This shifting movement of the valve occurs just before the grinding wheel enters the bore of the workpiece and reduces the rate of travel of the workpiece to the proper rough grinding speed. As indicated, fluid connection between the channel 240 and the annular groove 265 is cut off, when the valve 225 is shifted into the position of Fig. 13, by the full sized portion 263' at the end of the reduced portion 263 and fluid under pressure from the pump is then directed through the channel 243 and around the reduced portion 264 of the valve 191 into the vertical channel 254 to the throttling notch 258 of the main throttle valve by which the flow of fluid to the reversing valve is controlled. The grinding operation continues with the workpiece reciprocated axially relative to the grinding wheel until the dressing operation, above referred to, takes place. At this time, the depending arm 174, by its swinging movement to the right, procures the extended movement of the table to the left, above referred to, and at the same time shifts the valve 191 into the position indicated in Fig. 14. In this position, direct fluid connection between the channel 243 and the vertical channel 254 is cut off by the full-sized portion 268 of the valve 191, and fluid under pressure then passes from the channel 243 around a reduced portion 269 of the valve 191 to the auxiliary throttle valve 244. The reduced portion 269 is spaced from the reduced portion 264 of the valve 191 by the full-sized portion 268 and is positioned between said portion 268 and another full-sized portion 270. The auxiliary throttle valve 244 reduces the volume of fluid entering the main cylinder 33 to a greater extent than the fluid is throttled by the main throttle valve 256 so that the table, during the movement of the dressing tool past the grinding wheel, is actuated at a relatively slow rate.

When the valve member 191 is shifted, at the beginning of the dressing operation, into the position shown in Fig. 14, the reduced portion 269 of said valve provides fluid connection between the channel 243 and an annular groove 271 spaced from the intersection of the channel 243 with the bore 242. The annular groove 271 is connected by a channel 272 and an intersecting channel 273 (both said channels being indicated by a pipe 272a, Fig. 21) to an annular groove 274 surrounding the longitudinal bore 241 in spaced relation to the intersection of said bore with the channel 240.

Said groove is connected by a short channel 275 to a pipe 276 leading from said channel to a cylinder 277 which is positioned on the back of the table and in which a piston 278 is slidable. Said piston is suitably connected to the support for the dressing tool and entry of fluid under pressure into the cylinder procures movement of the dressing tool into operative position.

A full-sized portion 280 of the valve 225 at the end of the reduced portion 263 prevents fluid connection between the channel 240 and the annular groove 274. An enlarged portion 281 of the valve 225 at the left of the portion 280 is positioned in an enlarged portion 282 of the longitudinal bore 241, said enlarged portion 282 extending from the end of said bore and intersecting the annular groove 274. When the valve 191 is shifted into the position of Fig. 14, fluid under pressure from the channel 240 passes around the reduced portion 263 of the valve 225, around the reduction portion 269 of the valve 191 through the channels 272 and 273 into the annular groove 274 and thence to the actuating mechanism for the dressing tool. At the same time, the fluid under pressure in the annular groove 274 exerts a pressure on the shoulder 282' at the right hand end of the enlarged portion 281, said pressure urging the valve 225 to the left. Said valve is, however, temporarily retained in the position of Figs. 13 and 14 by engagement between the end of said valve and the notch 224 in the lever 211.

A vertical channel 281' intersects the bore 242 at a point spaced from the annular groove 271 and fluid connection is normally provided between said groove and channel by the reduced portion 269 of the valve 191 when the latter is in the normal position. During the extended movement of the table for the dressing operation, and just prior to reversal of said extended movement, the right hand end of the lever 211 is rocked upwardly by the mechanism above described to permit movement of the valve 225 to the left under the influence of the fluid under pressure acting against the shoulder 282' to move said valve into the position indicated in Fig. 15.

The extent of movement of the valve 225 to the left under the influence of the fluid pressure acting on the shoulder 282' is limited by a stud 283 eccentrically mounted on the end of a shaft 284 journaled in the casing 238. The valve 225 has a reduced portion 285 between the full-sized portion 263' and a full-sized portion 286 at the extreme right hand end thereof. As the valve 225 moves to the left, the full-sized portion 286 engages the stud 283, and the latter prevents movement of said valve beyond the position of Fig. 15. In this position, the full-sized portion 263' of the valve 225 partially closes the opening from the bore 241 into the channel 243 as indicated in Fig. 15, thereby reducing the flow of fluid into the channel to an amount less than the throttled flow through the main throttle valve 256 and the reciprocations of the table, following the shifting of the valve 225 to the left, occur at a relatively slow speed during the remainder of the grinding operation. The shaft 284 also has a reduced portion 287 with which the right hand end of the valve 191 engages when the latter is shifted to the right into the position of Fig. 14.

The position of the stud 283, which determines the extent of the throttling of the fluid during the finish grinding operation is adjustable. As best indicated in Fig. 19, the shaft 284 has a ratchet wheel 288 which is engaged by a spring pressed pawl 290 slidable in a bore 291 in the casing. The end of the shaft 284 projects forwardly beyond the casing and through the cover plate, and the forward end of said shaft carries a knob 284' by which the shaft 284 may be turned, thereby shifting the position of the stud. The spring pressed pawl supports the shaft 284 against turning movement from the adjusted position. The shaft 284 is held against axial movement by a projection 285' on a plug 286' in the casing, said projection engaging with one surface of the ratchet wheel 288.

When the workpiece is reduced to the desired size and the arm 233 swings to the right, as above stated, the valve 225 is shifted to the position indicated in Fig. 16 to establish a flow of fluid from the channel 240 directly to the annular groove 265 and thence without throttling to the reversing valve so that the table is moved to the left into the rest position shown at the maximum rate of speed.

A subsequent grinding operation, after an unground workpiece has been positioned within the work-supprting member and after the workpiece movement has been retracted by a counterclockwise turning of the hand wheel 112 is procured by turning of the lever 62, thereby causing movement of the table to the right. During this movement, the valve 225 is reset to the position of Fig. 13 and the grinding operation is repeated.

In the operation of the machine, as above described, the workhead is normally in the rest position shown in Fig. 1 at which time the valves 191 and 225 are in the position shown in Fig. 16. Movement of the workhead to the right to bring an unground workpiece into operative relation to the grinding wheel is procured by swinging movement of the lever 62 which shifts the reversing valve 36 through the medium of the plate 60. Fluid under pressure is then admitted to the left hand end of the cylinder 33 and the workhead moves into operative position.

During the movement of the workhead into operative position, the depending dog 196 engages and depresses the upper end of the arm 185 to shift the arm 233 from the position of Fig. 4 to the original position of Fig. 2 in which position it is retained by engagement between the arm 230 and the notch 231 on the arm 233. The bar 165 has previously been returned to the original position of Fig. 2 by the retraction of the cross-feed movement, said retraction operating to withdraw the cam 159 from engagement with the screws 151 and 152 to permit the arm 153 to return to its original position. The downward movement of the arm 185 by the dog 196 also procures a slight clockwise turning movement of the arm 174 to release the latch 200 so that said arm is free to move during the subsequent grinding operation, said arm being held in the position of Fig. 2 by the arm or latching member 171. Release of the latch 200 permits the lever 211 to return to the position of Fig. 2, so that said lever may prevent movement of the valve 225 to the left.

The shifting of the arm 233 to the original position of Fig. 2 occurs just before the workhead reaches operative position, and the movement of said arm shifts the valve member 225 from the position of Fig. 16 into the position of Fig. 13. Prior to the shifting movement, the table has advanced to the right at the maximum rate of speed, the fluid under pressure passing directly from the pump 27 through the channel 249 and around the reduced portion 263 of the valve member 225 into the vertical channel 266 and through the rectangular notch 267 of the throttle valve 256 to the reversing valve so that the flow of fluid is unthrottled. When the valve member 225 is shifted into the position of Fig. 13, the direct flow of fluid is cut off and the fluid under pressure then passes through the channel 243 around the reduced portion 264 of the valve member 191 and through the vertical channel 254 to the throttling notch 258 of the main throttle valve 256. The position of this valve determines the amount of fluid entering the longitudinal bore of said valve and controls the rate of movement of the table during the remainder of the movement of said table into operative position and during the reciprocatory movements of the table or workhead in operative position.

When the workhead reaches operative position, the reversing dogs 22 and 23 are positioned between the lugs 25 and 26 of the reversing member 24 and alternately engage and rock said member to procure a short reciprocation of the workhead.

The grinding wheel is fed laterally against the surface of the workpiece by the crossfeed mechanism which is actuated in response to the reciprocations of the table by engagement between the cam 95 on the table and the roller 94. The crossfeed movement involves a rotation of the annular member 110 clockwise and procures a corresponding turning movement of the cam 150 into engagement with the adjustable screw 151, thereby procuring a clockwise turning movement of the lever 153 and a corresponding predetermined movement of the rod 165 to the left. This horizontal movement of the rod 165 oscillates the lever 168 and elevates the end of the arm 172 of said lever out of the notch 173 provided by the arm 174 to permit counterclockwise swinging movement of said arm.

Counterclockwise movement of the arm 174 rocks the lever 182 therewith and elevates the upwardly extending arm 185 of said lever into alinement with the reversing dog 22, so that the latter passes over the lug 25 of the reversing member without actuating said member, and the workhead is carried to the left beyond its operative position to permit a dressing operation to be performed on the grinding wheel.

The counterclockwise swinging movement of the arm 174 also shifts the valve member 191 to the right into the position of Fig. 14, the movement of said valve being limited by engagement with the reduced portion 287 of the shaft 284. With the valve in this position, fluid under pressure is admitted around the reduced portion 269 through the channels 272 and 273 to the cylinder and piston by which the dressing tool is actuated, thereby rocking said tool into operative position. At the same time, the enlarged portion 268 of the valve 191 cuts off the flow of fluid under pressure directly to the main throttle valve 256 and directs the fluid under pressure through the auxiliary throttle valve 244, thereby materially reducing the rate of movement of the table while the dressing tool is moved over the surface of the grinding wheel.

After the dressing tool is carried past the grinding wheel during the movement of the table to the left, the reversing dog 192 engages and shifts the reversing member 24 to reverse the direction of the table and return the workhead to operative position. During the return movement, the dog 196 engages the arm 185 and forces said arm downwardly, thereby returning the arm 174 substantially to the original position, as indicated in Fig. 4, in which position said arm is retained by the latch 200, the latter having been rendered operative by the downward movement of the left hand end of the lever 211 in response to and during the extended movement of the table to the left.

The downward movement of the left hand end of the lever 211 in response to the extended movement of the table lifts the notch 224 of said lever out of engagement with the end of the valve member 225 to allow said valve to move to the left into the position of Fig. 15. In this position, the full-sized portion 263′ of the valve member 225 partially closes the channel 243, thereby throttling the fluid under pressure passing through said channel and controlling the rate of movement of the table during the grinding operation. The valve member 191 having been shifted into the position of Fig. 15 during the return of the workhead to operative position and in response to the return of the arm 174 to original position, thereby rendering inoperative the auxiliary throttle valve 244, the grinding operation continues at a rate determined by the throttling action of the reduced portion 263′ of the valve 225.

The shifting movement of the valve 191 into the position of Fig. 15, following the dressing operation, also cuts off the flow of fluid under pressure to the mechanism for actuating the dressing tool and provides an exhaust for the fluid from said mechanism through the exhaust channel 281′, thereby permitting the dressing tool to be returned to inoperative position during the return movement of the workhead into grinding position.

Following the return of the workhead to operative position, after the grinding wheel has been dressed, the crossfeed movement continues until the cam 150 engages and elevates the adjustable screw 152, thereby procuring a further movement of the bar 165 to the left This movement of the bar 165 procures a clockwise turning movement of the lever 228 for elevating the arm 230 of said lever out of engagement with the notch 231 on the arm 233 to allow said arm to swing to the right into the position of Fig. 4.

Swinging movement of the arm 233 shifts the valve member 225 into the position of Fig. 16, thereby establishing fluid connection from the pump through the rectangular notch 267 of the main throttle valve 256 to the reversing valve so that movement of the table or workhead to rest position occurs at the maximum rate of speed. The swinging movement of the arm 233 also elevates the upper end of the arm 185 into alinement with the dogs 22 and 192 so that both of said dogs are inoperative and the table moves to the left beyond the grinding position and into the position of Fig. 1 where it is brought to rest.

Following the completion of the grinding operation, the crossfeed movement is retracted by a counterclockwise turning movement of the hand wheel 112, thereby positioning the grinding wheel for engagement within the bore of the succeeding workpiece and withdrawing the cam 150 out of engagement with the screws 151 and 152 to permit the bar 165 to be returned to the original position of Fig. 2 with the left hand end thereof out of engagement with the arms 167 and 227 of the levers 168 and 228 respectively. Said levers are accordingly free to return to the original position shown in Fig. 2 so that the arms 171 and 230 of said levers may engage the notches 172 and 231 on the depending arms 174 and 233 in readiness for a subsequent grinding operation.

During the clockwise advance of the annular member 110 for the crossfeed movement, the pin 124 on the pawl 120 engages the shield 125 and is accordingly withdrawn from the ratchet wheel 122 without, however, interfering with the crossfeed movement since the pawl 121 remains in engagement with the ratchet wheel. During the retraction of the crossfeed movement, however, the annular member 110, on which the cam 150 is mounted, is turned counterclockwise a short distance without a corresponding turning movement of the ratchet wheel 122 until the pin 124 is withdrawn from engagement with the shield 125. During the remainder of the retracting movement, the pawl 120 engages the ratchet wheel 122 and procures a corresponding retraction of the grinding wheel. The relative angular shifting movement between the annular member 110 and the ratchet wheel 122 which is connected directly to the crossfeed screw procures a retraction of the grinding wheel which is slightly less in extent than the advance of the grinding wheel during the crossfeed movement, thereby compensating for the reduction in size of the wheel. By this angular shifting or compensatory movement, the grinding wheel is advanced during each successive grinding operation a predetermined distance beyond the limit of its movement during the preceding grinding operation. This increased movement corresponding approximately to the reduction in size of the wheel so that each successive workpiece is automatically reduced to the same predetermined size.

The control mechanism, as above described, is actuated in response to the crossfeed movement through the medium of the cam 150 thereon and the bar 165 by which said control mechanism is connected to the crossfeed mechanism. The control mechanism may also be actuated directly from a gage mechanism of the general type disclosed in United States Letters Patent No. 1,731,719, issued to Kempton and Gallimore October 31, 1930, or in United States Letters Patent No. 1,534,302, issued to Conradson, et al. April 21, 1925. Either of these patents provides a plurality of gages which are in axial alinement with the bore in the workpiece and are adapted to enter the bore thereof successively during the grinding operation. Entry of the first or roughing gage occurs before the workpiece reaches the finished size and interrupts the grinding operation in order to procure a dressing operation on the grinding wheel; subsequent entry of the second gage after a further grinding on the workpiece procures a separation of the grinding wheel from the workpiece. Accordingly, in the present invention, the control mechanism above described is actuated directly from the gage mechanisms of this type through mechanical elements without the interposition of any electrical circuits.

Referring now to Fig. 11, the workhead 2 has a horizontally slidable rod 292 to one end of which a member 293 is secured. Said member has an upwardly extending arm 294 which is secured against axial movement to the end of a gage rod 295, Fig. 12, of any well known construction. As shown in Fig. 12, the gage rod 295 which projects axially through the spindle in the workhead, and is supported in axial alinement with the core of one or more workpieces *a*, has gages 296 and 297 thereon in a position for engagement with the end of one of said workpieces for entry within the bore thereof when the latter reach a predetermined size. The gages are urged to the right against the end of the workpiece by a coil spring 298 surrounding the rod 292. An outwardly extending arm 300 on the member 293 carries a horizontally extending adjustable screw 301 secured in adjusted position by a locking nut 302.

The opposite end of the rod 292 is in alinement with the head 303 of an adjustable screw 304 mounted in the bridge 4 as shown in dot-dash lines in Fig. 1. The head of the screw engages the rod 292 when the table is in the operative position shown and, during the movement of the table to the right in operative position, the rod 292 is shifted to the left relative to the workhead to procure separation of the gages from the end of the workpiece. As the table moves to the left, the rod 292 is moved to the right within the workhead by the spring 298 to bring the gages into contact with the end of the workpiece.

At the beginning of the grinding operation and during the rough grinding on the workpiece, the gages are prevented from entering the bore of said workpiece. As the grinding operation continues, however, the bore becomes larger and the roughing gage 296 enters within said bore so that the gage rod and the member 293 thereon move inwardly to the right beyond the position of Figs. 11 and 12 a distance corresponding to the thickness of the roughing gage. This movement of the member 293 to the right, relative to the workhead, brings the right hand end of the adjustable screw 301 into engagement with one end 305 of a bell crank lever 306 for rocking said lever.

The table 1, Fig. 11, carries a block 307 which supports a pin 308 on which the bell crank lever 306 is pivotally mounted. The latter is received within a slot in said block and is held frictionally against unintended movement therein. The end 305 of the lever extends upwardly into alinement with the adjustable screw 301 and the opposite end 310 of said lever extends substantially horizontally to the right from the block 307. During the preliminary or rough grinding operation, the right hand end of the adjustable screw 301 is adjacent to but does not engage the arm 305. Upon entry of the roughing gage within the workpiece, however, the resulting extended movement of the member 293 to the right brings the screw 301 into engagement with the lever 306 and procures a slight clockwise turning movement of said lever. The clockwise turning movement of said lever moves the arm 310 thereof downwardly into alinement with the upwardly projecting arm 311 of the lever 168 which, as above stated, is mounted within the control box 50 and forms a part of the control mechanism.

As the table 1 moves to the right following the entry of the roughing gage into the bore of the workpiece, the end of the arm 310 engages the upwardly projecting arm 311 and procures a clockwise turning movement of the lever 168 to elevate the arm 171 of said lever out of engagement with the notch 173 provided by the arm 174 for a dressing operation on the grinding wheel which is procured in the manner above pointed out.

Following the dressing operation, the workpiece and grinding wheel are automatically returned to operative position by the structure above disclosed and the grinding operation continues until the finish gage enters the bore of the workpiece. Entry of the finish gage procures a further movement of the member 293 to the right and a corresponding increased clockwise turning movement of the lever 306. The increased clockwise turning movement of the lever 306 moves the arm 310 thereof downwardly into alinement with the upwardly extending arm 312 of the lever 228. As the table moves to the right in operative position, the arm 310 engages and rocks the arm 312 to elevate the arm 230 of the lever 228 out of engagement with the notch 231 provided by the depending arm 233, thereby permitting said arm 233 to swing to the right for bringing the grinding operation to a close.

As the table is run out to rest position at the completion of the grinding operation, the arm 310 of the lever 306 engages a cam surface 313 provided by a bracket 314 secured to the control box. This cam surface elevates the arm 310 to return the lever 306 to the original position of Fig. 11 and at the same time to withdraw the gages from within the bore of the workpiece by movement of the member 293 to the left. As the arm 310 engages the cam surface 313, while the table is in rest position, the gages are withdrawn from the bore of the workpiece and maintained out of contact with the workpiece to permit the latter to be replaced by an unground workpiece.

During a grinding operation in which the machine is under the control of the gage mechanism, the connection between the crossfeed mechanism and the control mechanism is broken by removing the horizontal bar 165 or by shifting said bar to the right and positioning a notch 315 in said rod in engagement with the bolt 164. With the rod in this position, the control mechanism may be actuated directly from the gages without being interfered with by the crossfeed movement or by the structure connecting the crossfeed mechanism to the control mechanism.

The operation of the machine, when under the control of gages, is precisely the same as the operation above pointed out with the exception that the levers 168 and 228, forming part of the control mechanism, are actuated directly from the gage movement rather than directly in response to the crossfeed movement. It may be noted in this respect that the crossfeed mechanism described provides for a uniform compensatory movement when the machine is controlled by the crossfeed movement and provides a variable compensatory movement when the machine is under the control of gages. This variable compensatory movement, which corresponds precisely to the actual reduction in size of the grinding wheel, is determined by the position of the pin 124 on the pawl 120 relative to the shield 125 at the end of the grinding operation. Obviously, this position is variable, as determined by the extent of the crossfeed movement at the time that the finish gage enters the bore of the workpiece.

We claim,

1. In a grinding machine, a grinding member and a work-supporting member, a carriage on which one of said members is mounted and whose movement procures a relative axial movement between said members, means to procure a crossfeed movement between said members, automatic means for controlling the movements of the carriage, mechanical means for setting said controlling means in operation, and mechanical elements connecting said mechanical means directly to the cross-feed means and responsive to the crossfeed movement for actuating said mechanical means for procuring an axial separation between said members.

2. In a grinding machine, a grinding member and a work-supporting member, a carriage on which one of said members is mounted and whose movement procures a relative axial movement between said members, means to procure a crossfeed movement between said members, automatic means for controlling the movements of the carriage, mechanical means for setting said controlling means in operation, mechanical elements connecting said mechanical means directly to the cross-feed means and responsive to the crossfeed movement for actuating said mechanical means to procure, through said controlling means, an axial separation of the grinding member from a workpiece in the work-supporting member, said mechanical elements being again actuated after a return of the grinding member to operative position and in response to a further crossfeed movement for procuring another axial separation of said members.

3. In a grinding machine, a grinding member and a work-supporting member, a table on which one of said members is mounted, control means for procuring a change in the grinding operation, means to procure a crossfeed movement between said members, means responsive to the crossfeed movement for actuating said control means, size-determining mechanism for a workpiece in the work-supporting member, means responsive to the operation of the size-determining mechanism for actuating said control means, and mechanical elements providing a direct connection between either of said actuating means selectively and said control means.

4. In a grinding machine, a grinding member and a work-supporting member, a table on which one of said members is mounted, control means for procuring a change in the grinding operation, means to procure a crossfeed movement between said members, means responsive to the crossfeed movement for actuating said control means, gage means for determining the size of a workpiece in the work-supporting member, means responsive to movement of said gage when the workpiece reaches a predetermined size for actuating said control means, and means for rendering either of said actuating means selectively inoperative.

5. In a grinding machine, a grinding member and a work-supporting member, a carriage on which one of said members is mounted, means to procure a crossfeed movement between said members, means for controlling the progress of the grinding operation, a latch for retaining said controlling means in inoperative position, means responsive to the crossfeed movement for releasing said latch, size-determining mechanism, and means responsive to the operation of said size-determining mechanism for releasing said latch,

either of said releasing means being selectively inoperative.

6. In a grinding machine, a grinding member and a work-supporting member, a carriage on which one of said members is mounted, means to procure a crossfeed movement between said members, control means for procuring separation of the grinding member from a workpiece in the work-supporting member, a latch for retaining said control means in inoperative position, means responsive to the crossfeed movement for releasing said latch, size-determining mechanism, means responsive to the operation of said size-determining mechanism for releasing said latch, either of said releasing means being selectively inoperative, and means for returning said control means to original position in response to the return of the grinding member to operative position.

7. In grinding machines, in which the progress of the grinding operation is controlled selectively by gage members or in response to a relative crossfeed movement between the grinding member and the work-supporting member, the combination with a grinding member, a work-supporting member, a carriage for one of said members whose movement procures a relative axial movement between said members, and means for procuring a crossfeed movement between said members, of automatic means for controlling the movements of said carriage for procuring an axial separation between said members at a predetermined point in the grinding operation, and a latch for retaining said automatic means in inoperative position, said latch being actuated selectively by gage means or in response to the crossfeed movement.

8. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted and whose movement procures a relative axial movement between said members, means for procuring a crossfeed movement between said members, and control means for controlling the position of said carriage for an axial separation between said members at a predetermined point in the grinding operation, and mechanical means providing a direct connection selectively between said crossfeed means or a gage member and said control means for actuation of said control means in response to entry of a gage within the bore of a workpiece when the grinding operation is under the control of a gage or in response to the crossfeed movement when progress of the grinding operation is controlled by said crossfeed movement.

9. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted and whose movement procures a relative axial movement between said members, means for procuring a crossfeed movement between said members, automatic means for controlling the movements of said carriage for an axial separation between said members at a predetermined point in the grinding operation, a latch for setting said automatic means in operation, said latch being actuated selectively in response to entry of a gage within the bore of a workpiece when the grinding operation is under the control of a gage or in response to the crossfeed movement when progress of the grinding operation is controlled by said crossfeed movement.

10. In a grinding machine, a grinding member and a work-supporting member, a carriage on which one of said members is mounted, control means for controlling the movements of said carriage, means to procure a crossfeed movement between said members, means responsive to the crossfeed movement for actuating said control means, size-determining mechanism for a workpiece in the work-supporting member, means responsive to the operation of the size-determining mechanism for actuating said control means, and mechanical means providing a direction selectively between either of said actuating means and said control means.

11. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, and whose movement procures a relative axial movement between said members, automatic control means for controlling the movements of said carriage, a latch for retaining said means in inoperative position, means for procuring a crossfeed movement between said members, and mechanical elements providing a direct connection between said crossfeed means and said latch for positively actuating said latch to set said control means in operation.

12. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, and whose movement procures a relative axial movement between said members, automatic control means for controlling the movements of said carriage, a latch for retaining said means in inoperative position, means for procuring a crossfeed movement between said members, and mechanical elements providing a direct connection between said crossfeed means and said latch for positively actuating said latch to set said control means in operation for an axial separation between said members, said control means also controlling the rate of movement of the carriage.

13. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, and whose movement procures a relative axial movement between said members, automatic control means for controlling the movements of said carriage, a latch for retaining said means in inoperative position, a dressing tool, means for procuring a crossfeed movement between said members, and mechanical elements providing a direct connection between said crossfeed means and said latch for positively actuating said latch to set said control means in operation for an axial separation between said members, said control means also procuring movement of the dressing tool into operative position during said axial separation.

14. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, and whose movement procures a relative axial movement between said members, automatic control means for controlling the movements of said carriage, a pair of latches for retaining said control means in inoperative position, means for procuring a crossfeed movement between said members, means on said cross-feed means for actuating said latches at predetermined points in the grinding operation, and mechanical elements connecting said latches directly to the actuating means and providing for a direct actuation of said latches successively in response to the crossfeed movement.

15. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, and whose movement procures a relative axial movement between said members, automatic control means

for controlling the movements of said carriage, a latch for retaining said automatic means in inoperative position, a gage for determining the size of a workpiece in said member, and mechanical elements providing a direct connection between said gage and said latch for a positive actuation of said latch in response to entry of the gage within the bore of the workpiece for procuring, through said automatic means, an axial separation between said members.

16. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, and whose movement procures a relative axial movement between said members, automatic control means for controlling the movements of said carriage, a latch for retaining said automatic means in inoperative position, a gage for determining the size of a workpiece in said member, and mechanical elements providing a direct connection between said gage and said latch for a positive actuation of said latch in response to entry of the gage within the bore of the workpiece for procuring, through said automatic means, an axial separation between said members, said automatic means also controlling the rate of travel of said carriage.

17. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, fluid pressure means for actuating said carriage, dogs on said carriage for normally limiting the reciprocation of said carriage, means for rendering one of said dogs inoperative for an extended movement of the carriage, a latch for holding said last means in inoperative position, means governed by the progress of the grinding operation for releasing said latch, and means operative upon release of said latch for changing the rate of travel of the carriage.

18. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, fluid pressure means for actuating said carriage, dogs on said carriage for normally limiting the reciprocation of said carriage, means for rendering one of said dogs inoperative for an extended movement of the carriage, a latch for holding said last means in inoperative position, means governed by the progress of the grinding operation for releasing said latch, means operative upon release of said latch for changing the rate of travel of the carriage, and means operative upon a return of the carriage to its normal position of reciprocation and responsive to the return movement for resetting said last means.

19. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, fluid pressure means for actuating said carriage, dogs on said carriage for normally limiting the reciprocation of said carriage, means for rendering one of said dogs inoperative for an extended movement of the carriage, a latch normally retaining said last means in inoperative position, release of said latch providing for operation of said means, a pair of valves whose positions determine the rate of travel of the carriage, means connected to said dog-actuating means for shifting one of said valves, and means responsive to the extended movement of the carriage to provide for shifting of the other valve.

20. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, fluid pressure means for actuating said carriage, dogs on said carriage for normally limiting the reciprocation of said carriage, means for rendering one of said dogs inoperative for an extended movement of the carriage, a latch normally retaining said last means in inoperative position, release of said latch providing for operation of said means, a pair of valves whose positions determine the rate of travel of the carriage, means connected to said dog-actuating means for shifting one of said valves, means responsive to the extended movement of the carriage to provide for shifting of the other valve, and means operative during the return of the carriage to normal reciprocating position and in response to said return movement for resetting said first valve.

21. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, fluid pressure means for actuating said carriage, dogs on said carriage for normally limiting the reciprocation of said carriage, means for rendering one of said dogs inoperative for an extended movement of the carriage, a pair of members for actuating said last means, a pair of latches normally holding said members in inoperative position, said latches being successively released during the grinding operation for a plurality of extended movements of the carriage, and a valve controlled by each of said members and movable therewith for varying the rate of travel of the carriage in response to movement of either of said members.

22. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, fluid pressure means for actuating said carriage, dogs on said carriage for normally limiting the reciprocation of said carriage, means for rendering one of said dogs inoperative for an extended movement of the carriage, a pair of members for actuating said last means, a pair of latches normally holding said members in inoperative position, said latches being successively released during the grinding operation for a plurality of extended movements of the carriage, and a valve controlled by each of said members and movable therewith for varying the rate of travel of the carriage in response to movement of either of said members, and means operative during the return of the carriage to its normal reciprocatory position after the first extended movement for returning said dog actuating means to inoperative position.

23. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, fluid pressure means for actuating said carriage, dogs on said carriage for normally limiting the reciprocation of said carriage, means for rendering one of said dogs inoperative for an extended movement of the carriage, a pair of members for actuating said last means, a pair of latches normally holding said members in inoperative position, said latches being successively released during the grinding operation for a plurality of extended movements of the carriage, and a valve controlled by each of said members and movable therewith for varying the rate of travel of the carriage in response to movement of either of said members, a dressing tool under the control of one of said valves and movable into operative position during the first extended movement, means responsive to the return of the carriage to its normal reciprocatory position after the first extended movement for returning the dog-actuating means to inoperative position, said last means also resetting the valve

controlling the dressing tool for a return of the dressing tool to inoperative position.

24. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, dogs on said carriage for controlling the movements thereof, automatic control means for rendering one of said dogs inoperative for an extended movement of said carriage, a latch for normally retaining said control means in inoperative position, means for procuring a crossfeed movement between said members, means provided by said crossfeed means for actuating said latch, and mechanical elements providing a direct connection between said actuating means and said latch for positively actuating the latter for procuring the extended movement of the carriage.

25. In a grinding machine, a grinding member, a work-supporting member, a carriage on which one of said members is mounted, dogs on said carriage for controlling the movements thereof, automatic control means for rendering one of said dogs inoperative for an extended movement of said carriage, a latch for normally retaining said control means in inoperative position, a gage member arranged to enter the bore of a workpiece in the work-supporting member when the latter reaches the desired size, and mechanical elements providing a direct connection between said gage and said latch for positively actuating said latch for an extended movement of the carriage.

26. A control mechanism for the reciprocating carriage of internal grinding machines, the latter having either a crossfeed mechanism by which the grinding operation is controlled, or a gage member for controlling the grinding operation, said gage member being adapted to enter the bore of a workpiece in the grinding machine when said workpiece reaches a predetermined size, said control mechanism comprising a pair of members whose movement procures an extended movement of the carriage, a pair of latches for holding said members in inoperative position, and means connected to one of said members for carrying the rate of movement of the carriage in response to movement of said member.

27. A control mechanism for the reciprocating carriage of internal grinding machines, the latter having either a crossfeed mechanism by which the grinding operation is controlled, or a gage member for controlling the grinding operation, said gage member being adapted to enter the bore of a workpiece in the grinding machine when said workpiece reaches a predetermined size, said control mechanism comprising a pair of members whose movement procures an extended movement of the carriage, a pair of latches for holding said members in inoperative position, and means connected to one of said members for varying the rate of movement of the carriage in response to movement of said member, and a spring for actuating each of said members when the latch therefor is released.

28. A control mechanism for the reciprocating carriage of internal grinding machines, the latter having either a crossfeed mechanism by which the grinding operation is controlled, or a gage member for controlling the grinding operation, said gage member being adapted to enter the bore of a workpiece in the grinding machine when said workpiece reaches a predetermined size, said control mechanism comprising a pair of members whose movement procures an extended movement of the carriage, a pair of latches for holding said members in inoperative position, and means connected to one of said members for varying the rate of movement of the carriage in response to movement of said member, said latches being actuated selectively either by the crossfeed mechanism or in response to the gage movement.

29. A control mechanism for the reciprocating carriage of internal grinding machines, the latter having either a crossfeed mechanism by which the grinding operation is controlled, or a gage member for controlling the grinding operation, said gage member being adapted to enter the bore of a workpiece in the grinding machine when said workpiece reaches a predetermined size, said control mechanism comprising a pair of members whose movement procures an extended movement of the carriage, a pair of latches for holding said members in inoperative position, and means connected to one of said members for varying the rate of movement of the carriage in response to movement of said member, said latches being actuated selectively either by the crossfeed mechanism or in response to the gage movement, and a spring for each of said members for actuating said members when the latch therefor is released.

30. A control mechanism for the reciprocating carriage of internal grinding machines, the latter having either a crossfeed mechanism by which the grinding operation is controlled, or a gage member for controlling the grinding operation, said gage member being adapted to enter the bore of a workpiece in the grinding machine when said workpiece reaches a predetermined size, said control mechanism comprising a pair of members whose movement procures an extended movement of the carriage, a pair of latches for holding said members in inoperative position, and means connected to one of said members for varying the rate of movement of the carriage in response to movement of said member, each of said latches being arranged for actuation selectively in response to said crossfeed mechanism, or in response to entry of the gage member within the bore of the workpiece.

31. A control mechanism for the reciprocating carriage of internal grinding machines, the latter having either a crossfeed mechanism by which the grinding operation is controlled, or a gage member for controlling the grinding operation, said gage member being adapted to enter the bore of a workpiece in the grinding machine when said workpiece reaches a predetermined size, said control mechanism comprising a pair of members whose movement procures an extended movement of the carriage, a pair of latches for holding said members in inoperative position, and means connected to one of said members for varying the rate of movement of the carriage in response to movement of said member, and a spring for actuating each of said members when the latch therefor is released, each of said latches being arranged for actuation selectively in response to said crossfeed mechanism, or in response to entry of the gage member within the bore of the workpiece.

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CERTIFICATE OF CORRECTION.

Patent No. 2,011,705.

August 20, 1935.

HAROLD L. BLOOD, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 18, for the words "for a plurality of extended movements" read of the electrically actuated mechanism; and page 10, second column, line 12, for "core" read bore; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of November, A. D. 1935.

(Seal)

Leslie Frazer
Acting Commissioner of Patents.