Dec. 23, 1952 F. S. HAAS ET AL 2,622,375

GRINDING MACHINE

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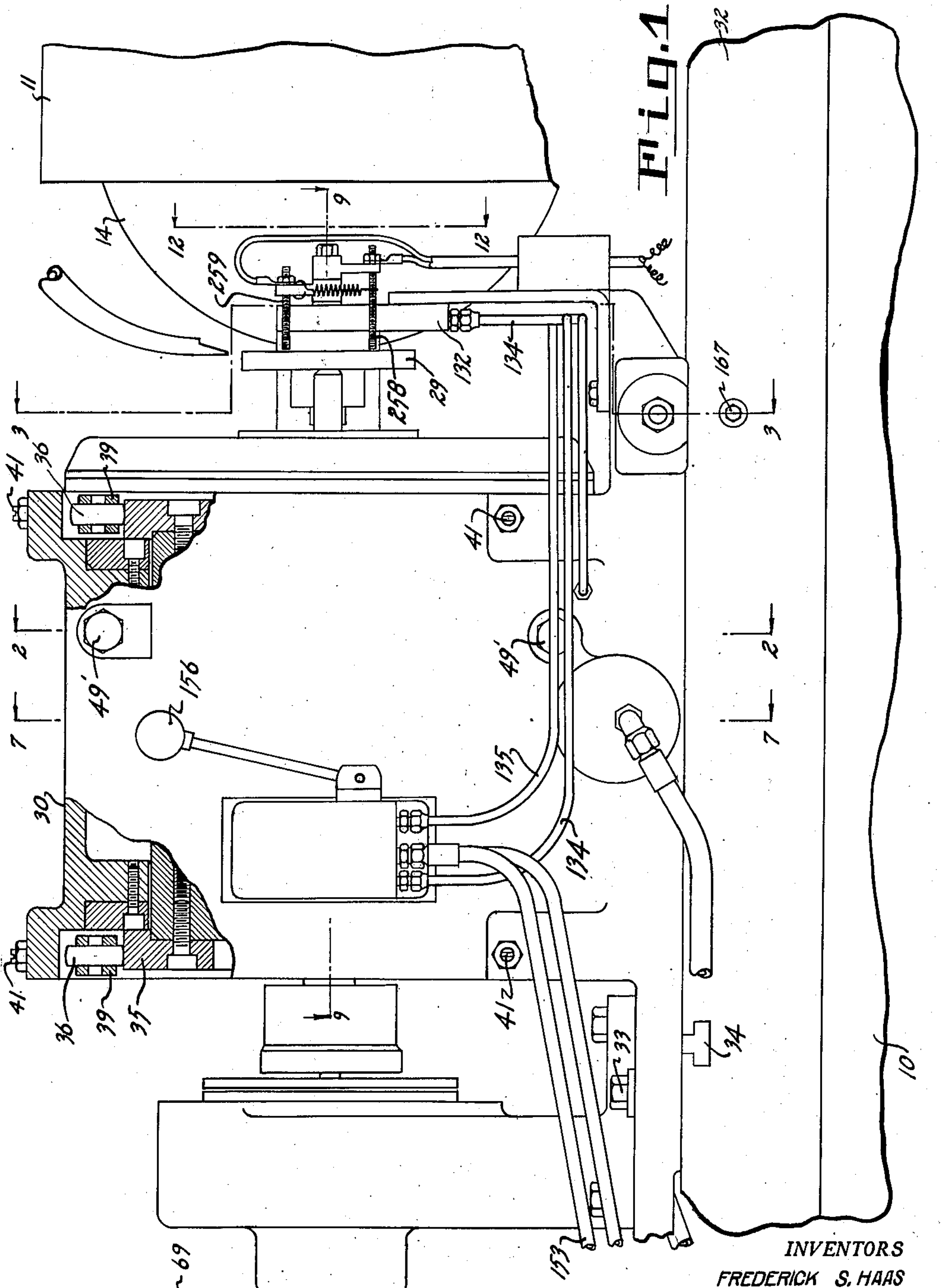

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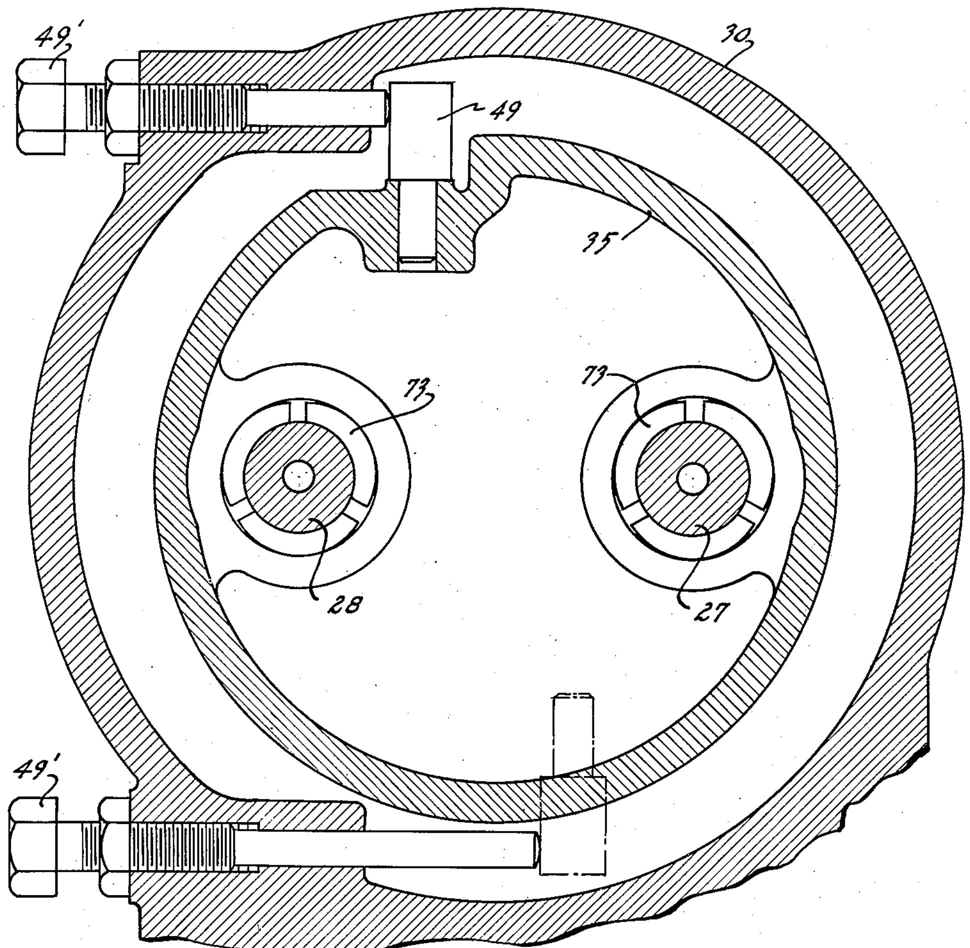
ATTORNEYS

Fig. 2



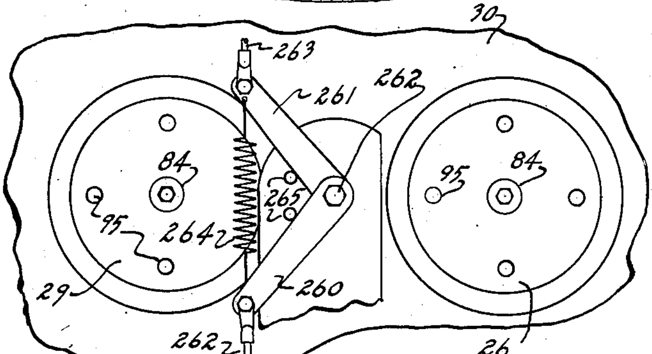


Fig. 12

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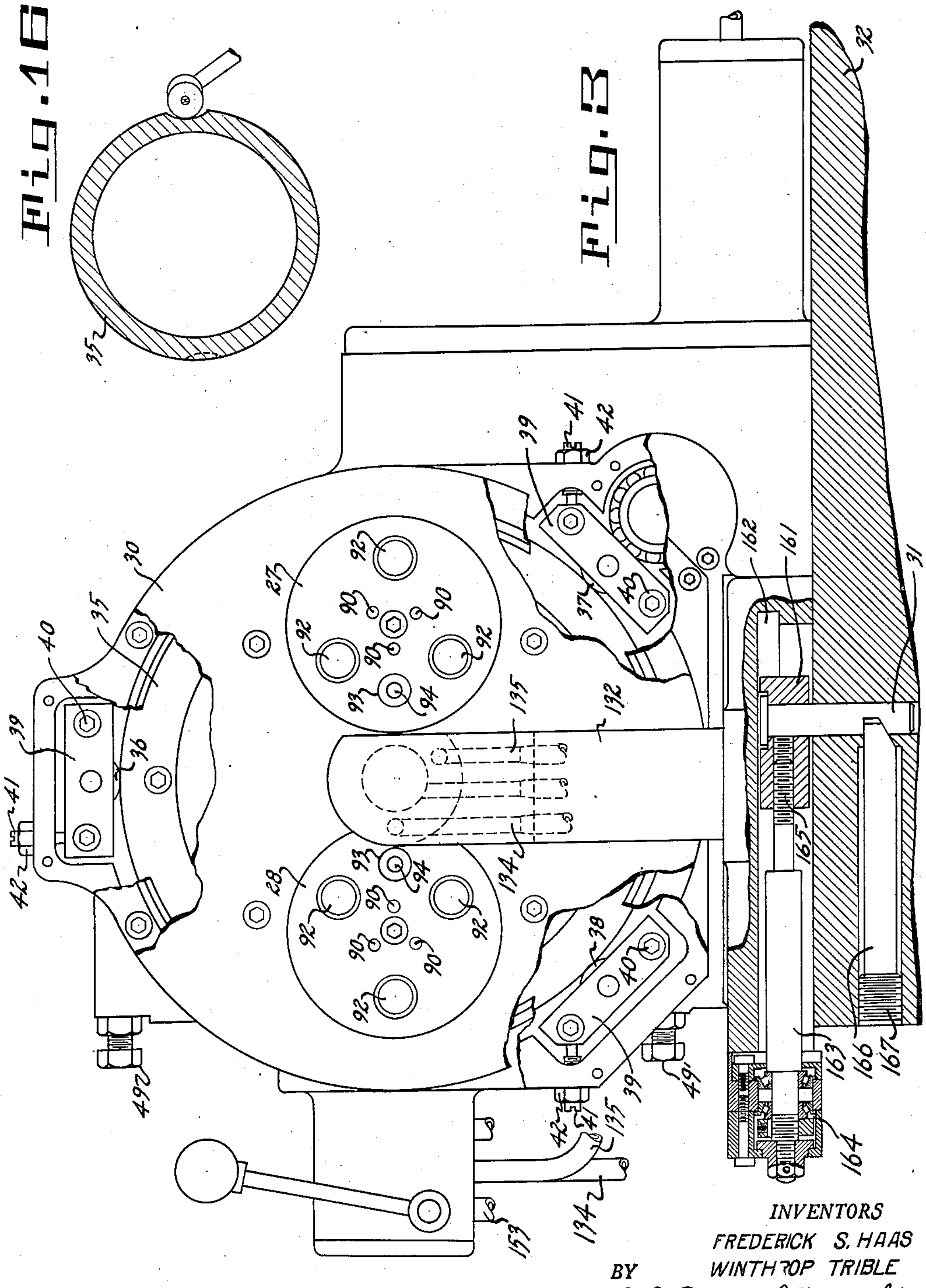

Fig. 16

Fig. 3

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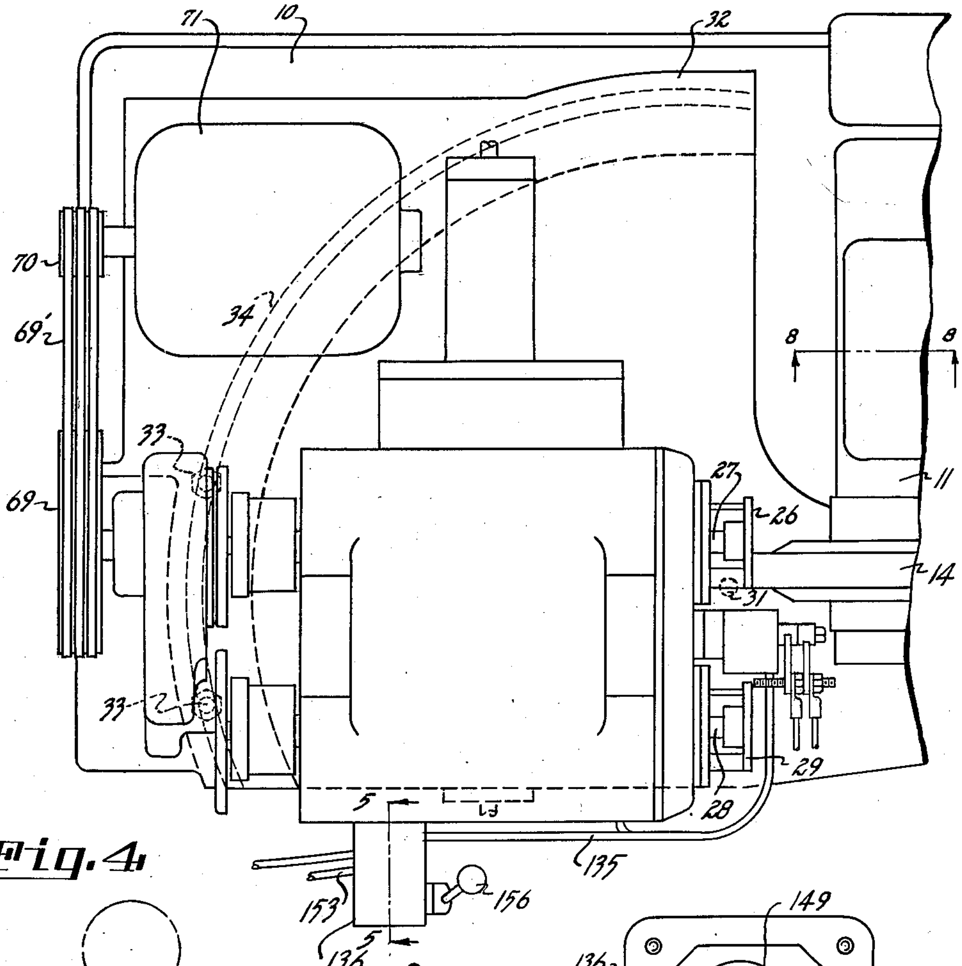

Fig. 4

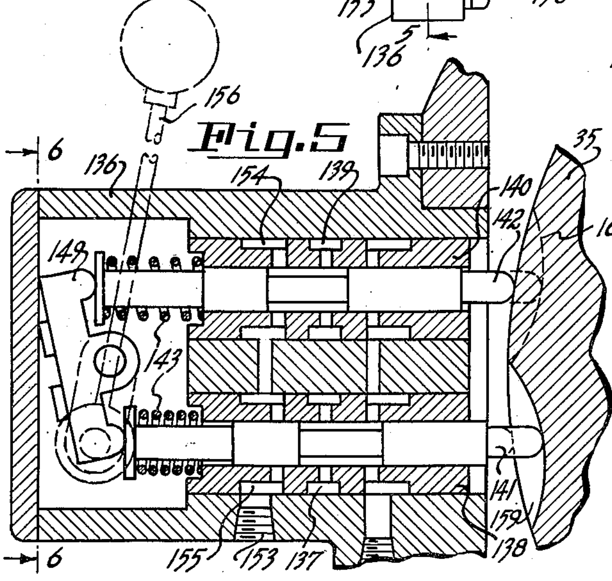

Fig. 5

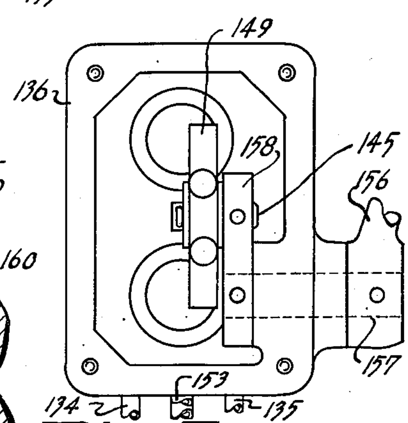

Fig. 6

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Fig. 15

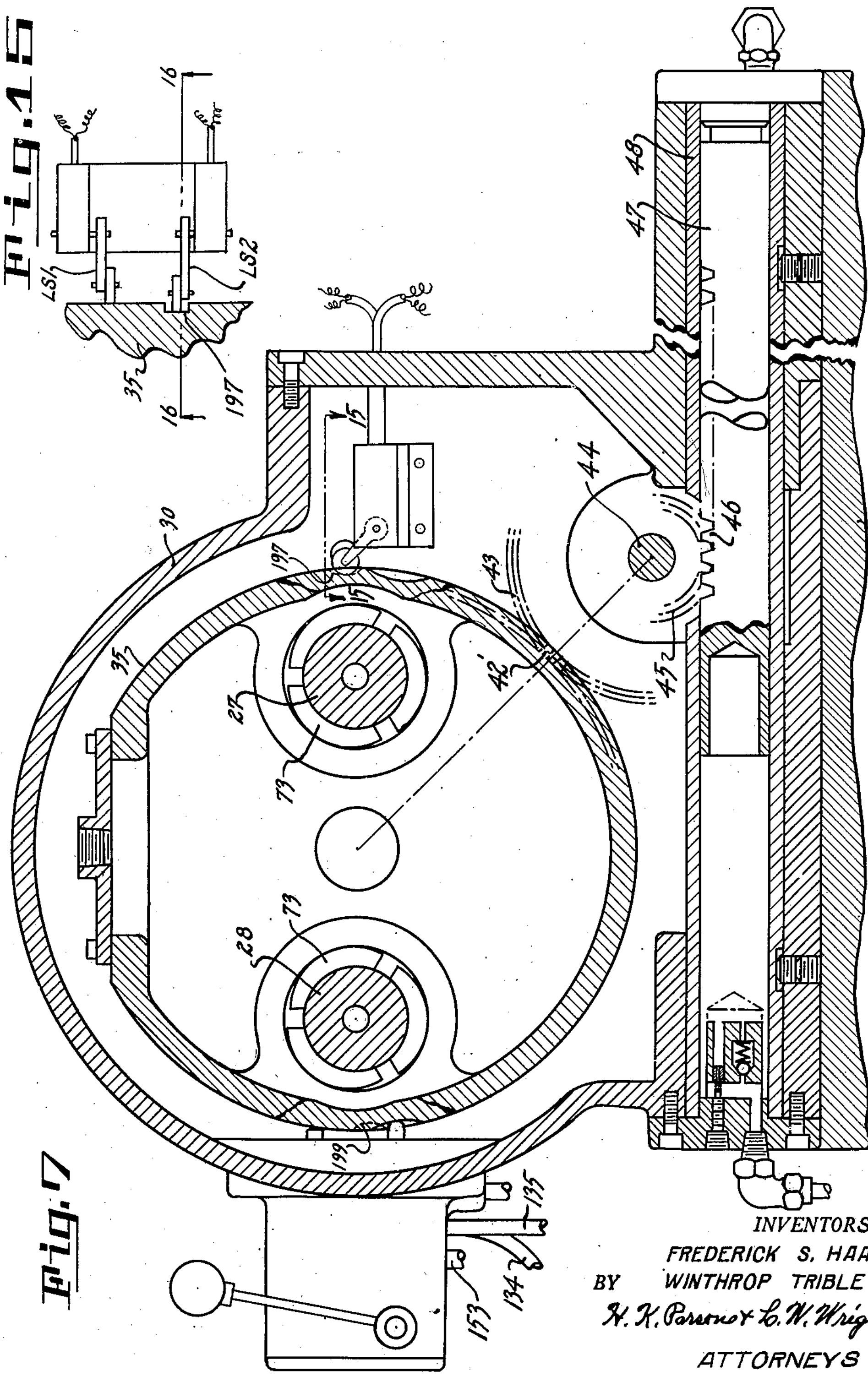

Fig. 7

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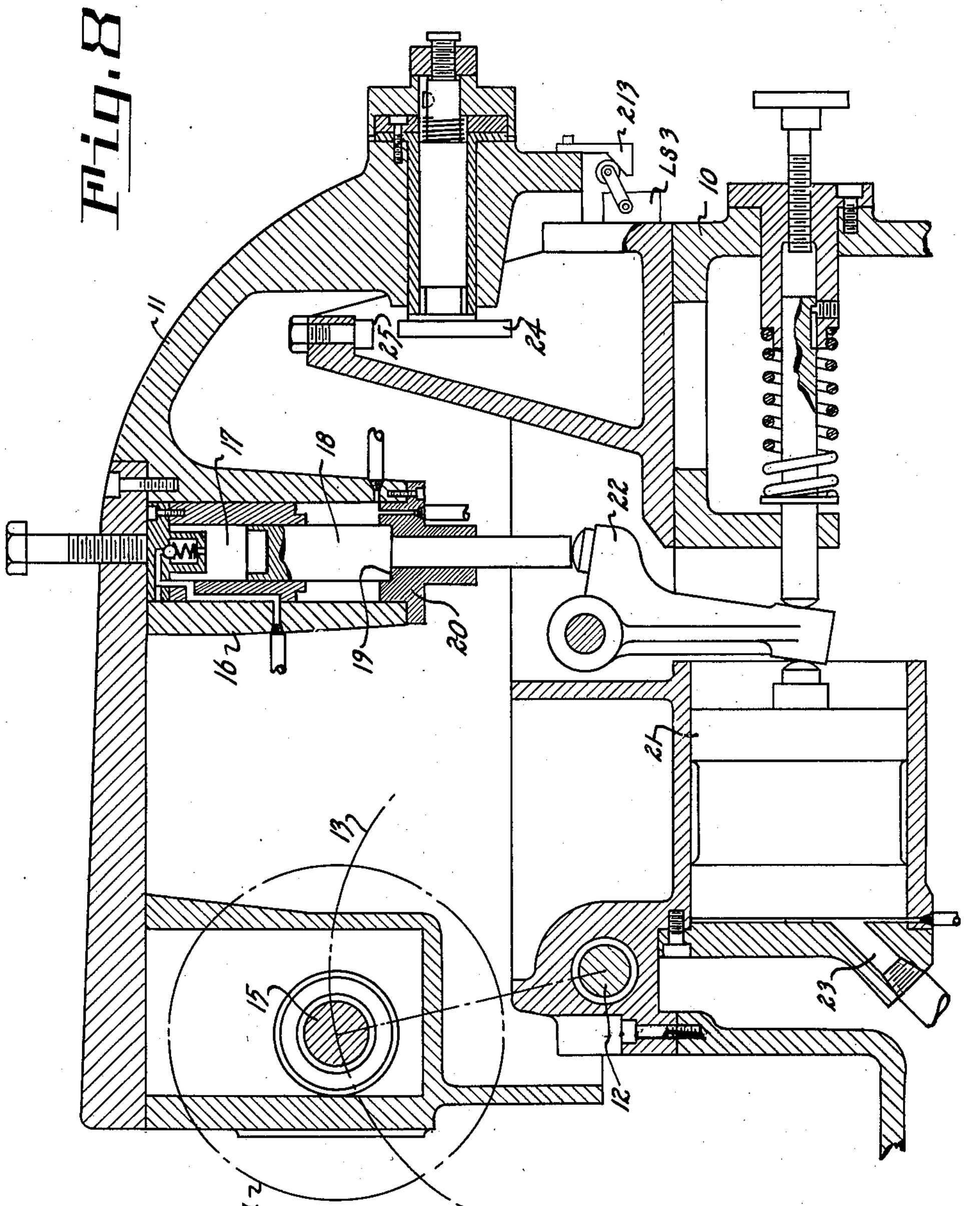
Fig. 8



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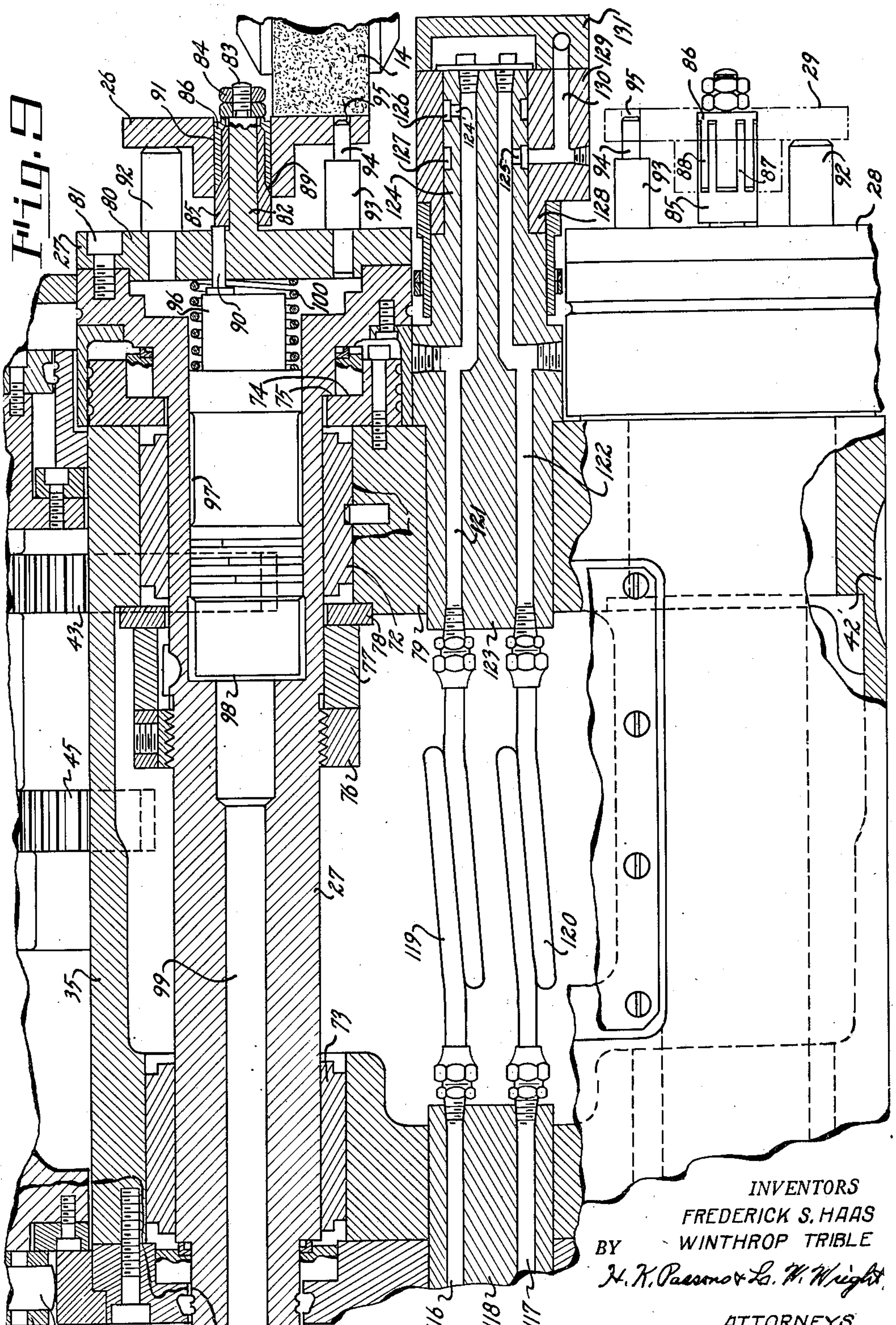

Fig. 9

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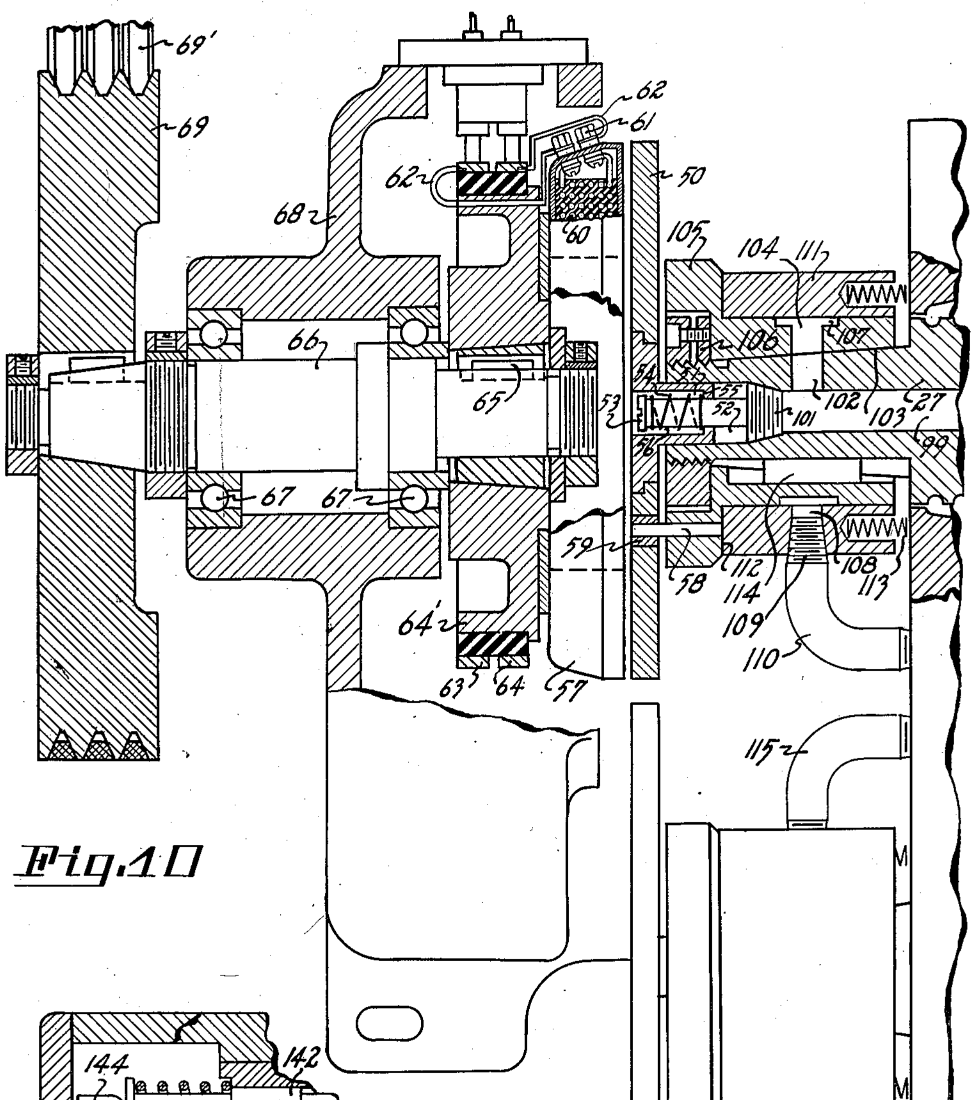

Fig. 10

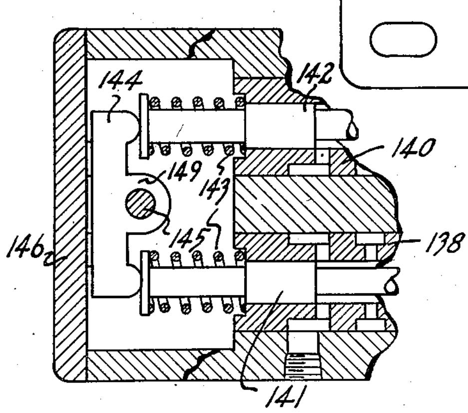

Fig. 11

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Fig. 13

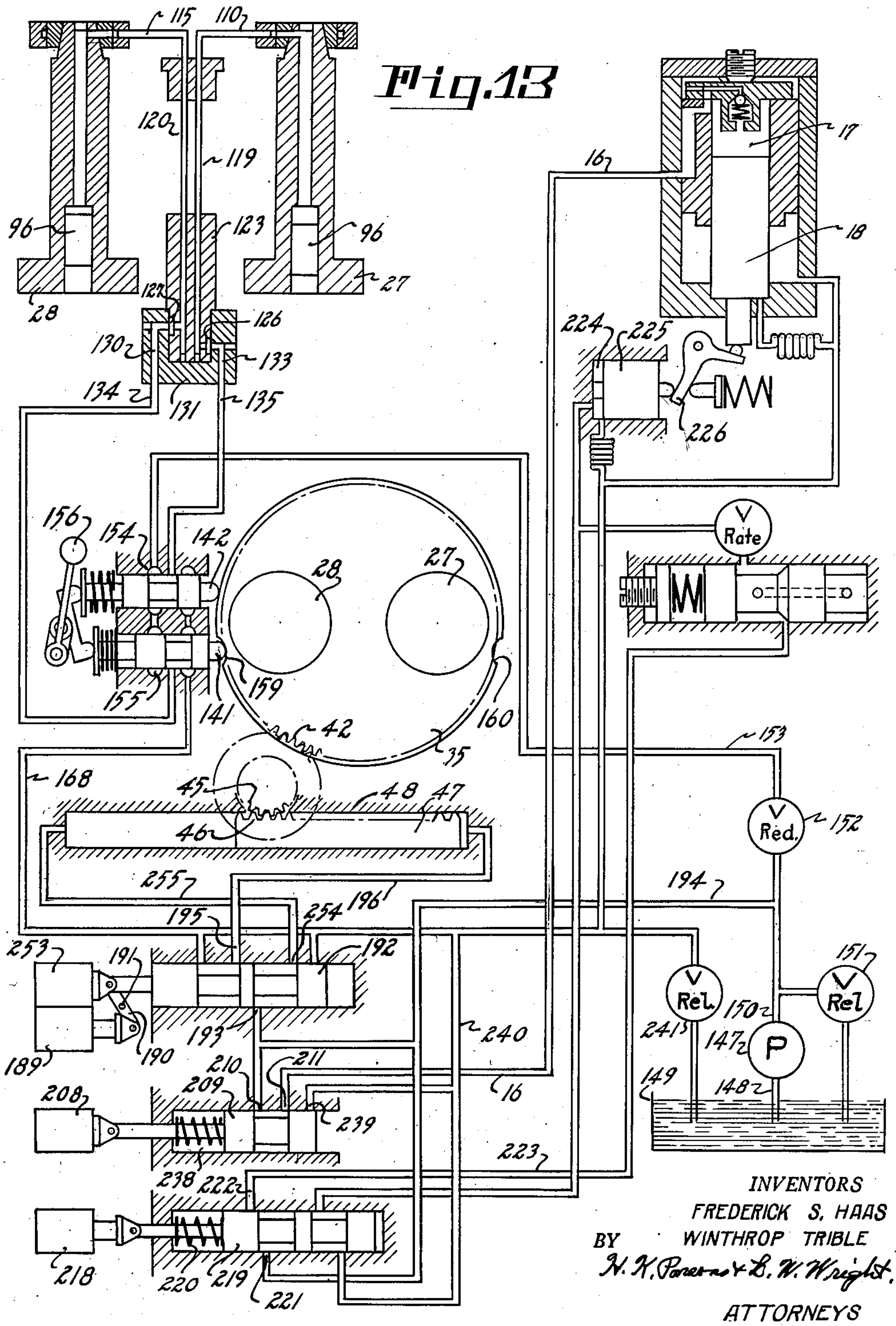

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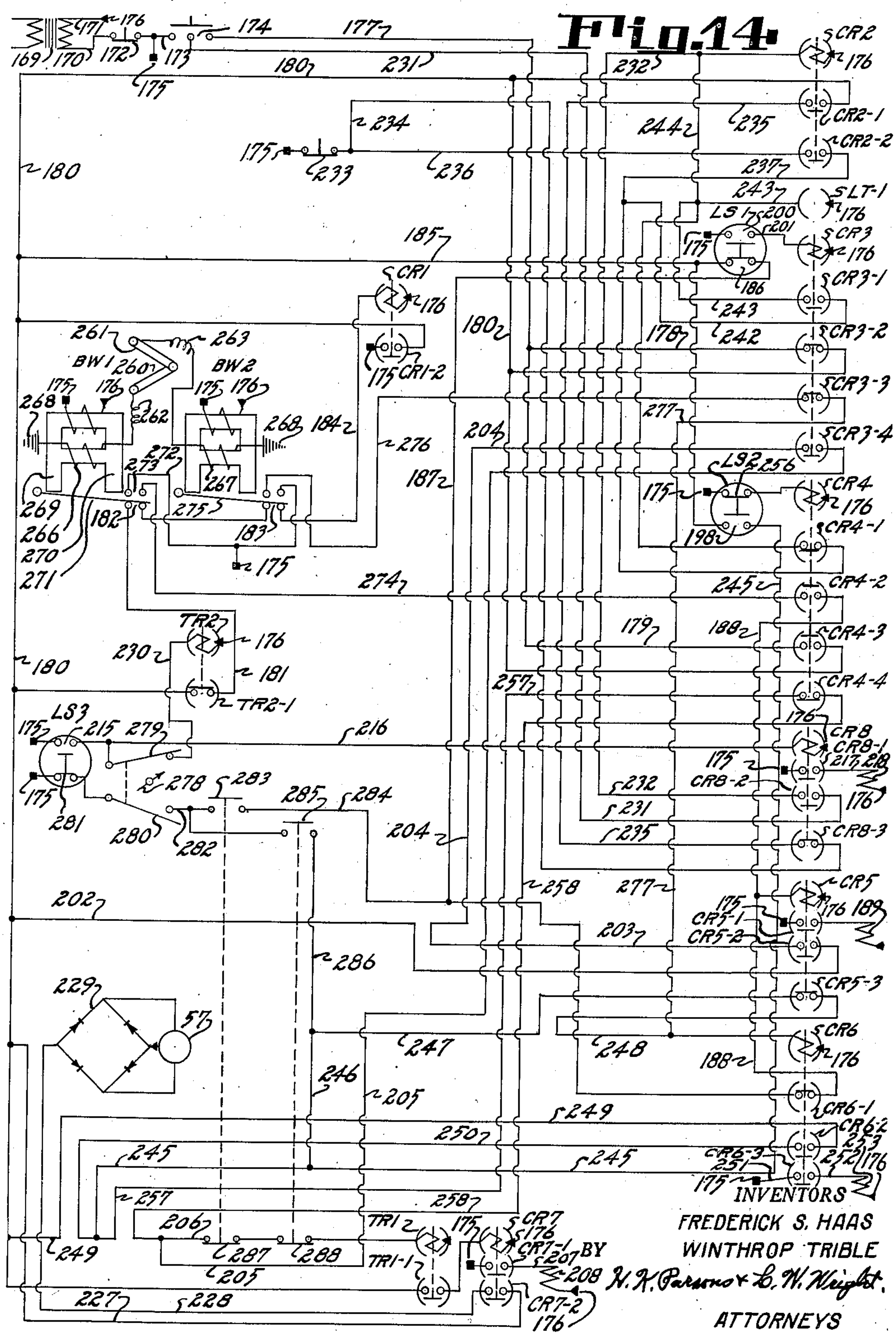
Fig. 14



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Patented Dec. 23, 1952

2,622,375

UNITED STATES PATENT OFFICE

2,622,375

GRINDING MACHINE

Frederick S. Haas, Orgonia, and Winthrop Trible, Cincinnati, Ohio, assignors to The Cincinnati Milling Machine Co., Cincinnati, Ohio, a corporation of Ohio

Application December 6, 1949, Serial No. 131,414

8 Claims. (Cl. 51—108)

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This invention relates to grinding machines and more particularly to an automatic machine, especially adaptable for grinding surfaces other than cylindrical surfaces such as flat or conical surfaces. Briefly summarized, this invention relates to the problem of grinding work surfaces which cannot be ground on the standard type of grinding machines, and are of such a nature that the work must be held by some form of chuck in order to properly present the surface to the grinding wheel. The present invention contemplates an improved automatic machine having two or more spindles, one of which may be at a grinding station while the other is at a loading station, the spindles being mounted in an indexible support movable from one station to the other, and a constantly rotating magnetic chuck located at the grinding station for driving whichever spindle is at that station. The grinding wheel moves through an automatic grinding cycle including rapid traverse advance, feed, and rapid return. The operator reloads the work on the spindle at the loading station during a grinding cycle, and by pressing a preset button after a work piece is loaded, the support will index automatically at the end of the current grinding cycle, and after indexing the next grinding cycle will automatically start, otherwise the machine will stop at the end of the particular cycle.

Thus, one of the objects of this invention is to provide an improved automatic grinding machine having dual stations whereby the operator may load at one station while a work piece is being ground at a second station.

Another object of this invention is to provide an improved automatic cycle operating and control mechanism for a machine of the character described.

A further object of this invention is to provide an improved automatic mechanism for supporting and indexing work between a grinding station and a loading station and continuously driven means for rotating either spindle at the grinding station without the use of mechanical clutches.

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

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Referring to the drawings in which like reference numerals indicate like or similar parts,

Figure 1 is a view in elevation of one embodiment of this invention.

Figure 2 is a section on the line 2—2 of Figure 1.

Figure 3 is a section on the line 3—3 of Figure 1.

Figure 4 is a plan view of the mechanism shown in Figure 1.

Figure 5 is a detail section on the line 5—5 of Figure 4.

Figure 6 is a section on the line 6—6 of Figure 5.

Figure 7 is a vertical cross section on the line 7—7 of Figure 1.

Figure 8 is a vertical section as viewed along the line 8—8 of Figure 4, showing the actuating mechanism for the grinding wheel.

Figure 9 is a plan view partly in section as viewed on the line 9—9 of Figure 1.

Figure 10 is a continuation of the plan view shown in Figure 9.

Figure 11 is a detail view showing the selector valve in its normal position.

Figure 12 is a detail view of a safety device as viewed on the line 12—12 of Figure 1.

Figure 13 is a diagram of the hydraulic circuit of the machine.

Figure 14 is an electrical diagram of the machine circuit.

Figure 15 is a detail view on the line 15—15 of Figure 7.

Figure 16 is a detail sectional view on the line 16—16 of Figure 15.

Referring to the drawings, and more particularly to Figures 1, 4, and 8, there is shown the general structure of the machine, the work holding mechanism being shown more particularly in Figures 1 and 4, and the grinding wheel supporting mechanism being shown in Figure 8. The grinding wheel head and actuating mechanism of Figure 8 is the same as that shown in co-pending application, Serial No. 734,080, filed March 12, 1947, and therefore the particular construction of this mechanism constitutes no part of the present invention. This mechanism, however, is adapted to move the grinding wheel through an automatic grinding cycle comprising a rapid traverse advance movement, a feeding or grinding movement and a rapid return movement.

The reference numeral 10 indicates a part of the bed or base structure of the machine, and the reference numeral 11 indicates, in general, the wheel head structure which is pivoted at 12, Figure 8, for swinging movement of the grinding wheel through an arc indicated by the line 13. The grinding wheel indicated at 14 is suitably mounted for rotation on a shaft 15 which is journaled in the head 11. The head 11 is rotated counterclockwise at a rapid traverse rate by admitting oil through a pipe 16 to a chamber 17 which causes separation between the head 11 and a piston 18. A shoulder 19 on the piston 18 limits the extent of the rapid traverse movement by engagement with the cylinder head 20. It will thus be noted that the parts in Figure 8 are shown in the position they assume at the end of the rapid traverse movement, or in other words at the beginning of the feed movement.

The feeding movement is effected by a piston 21 which rotates a bell crank 22 acting on the end of the piston 18, thereby continuing the counterclockwise movement of the head 11. The piston 21 is moved by admitting fluid pressure through the channel 23. This movement will continue until an adjustable stop 24 on the moving head 11 engages a fixed stop 25 carried by the bed 10.

As the grinding wheel advances through its feeding stroke, it grinds the work piece, indicated generally by the reference numeral 26 in Figure 4, which is mounted on the end of a work receiving spindle 27 located at a grinding station, while a second work receiving spindle 28 is located at a loading station for receiving an unground work piece indicated by the reference numeral 29.

The spindles 27 and 28 are journaled in a rotatable drum 35 shown in Figures 7 and 9, which is enclosed in a housing 30. The housing is mounted for angular adjustment and as shown in Figures 1 and 4, the base of the housing 30 is supported on and pivotally connected by a pivot pin 31, Figures 3 and 4, to a slide 32 which is guided on the bed 10 for movement toward and from the grinding wheel. T bolts 33 movable in a T slot 34 formed in the slide 32 and passing through the base of the housing 30 serves to clamp the housing and contained spindles in proper angular relation to the axis of the grinding wheel. As shown, the axes of the spindles are perpendicular to the axis of the grinding wheel, and this makes it possible to grind flat surfaces on the end of the work pieces, such as 26, but the housing may be angularly adjusted about the pivot 31 for grinding conical surfaces on the work.

The drum 35, in which the spindles are mounted, is rotatably supported at opposite ends in the housing 30 by two sets of rollers, one set of which is shown in Figure 3. There are three equally spaced rollers 36, 37, and 38 which are journaled in roller blocks 39 that are attached to the housing in such a manner that one end of the block is pivoted as at 40, and the other end of the block is acted on by an adjusting screw 41 threaded in the housing 30 and secured by a clamping nut 42 so that the block may be pivoted toward the center of the drum to preload the rollers and properly position the axis of the drum.

The drum 35 is adapted to be rotated 180 degrees back and forth to interchange the position of the spindles and to this end the periphery of the drum has a series of gear teeth 42′, as shown in Figures 7 and 9, cut in its periphery to an angular extent slightly greater than 180 degrees, and these gear teeth mesh with a gear 43 which is fixed to a shaft 44 rotatably mounted in the base of the housing 30. This shaft also has fixed to it a pinion 45 which meshes with

rack teeth 46 formed on the exterior of a piston 47 which is slidably mounted in a cylinder 48 formed in the base of the housing 30. The piston 47 has sufficient stroke that upon movement, as to the left in Figure 7, it will impart substantially 180 degrees of rotation to the drum.

In order to insure that the drum accurately positions the respective spindles at the grinding station, a stop mechanism has been provided. As shown in Figure 2, the drum 35 is provided in its periphery with a stop pin 49 which is alternately engageable with the ends of stop bolts 49′ which are threaded in the housing and are adjustable from the exterior thereof.

As a work spindle is indexed into the grinding station, the end of the spindle opposite to the work receiving end is automatically positioned in line with a magnetic clutch mechanism for rotating the spindle and work for the grinding operation. This mechanism is shown more particularly in Figure 10, from which it will be noted that an armature plate 50 has a central stud 51 formed on one side which is slidably mounted in a bore 52 formed in the end of a work spindle, such as the spindle 27. A bolt 53 is threaded in the end of the spindle, and a spring 54 is interposed between the head of the bolt and a shoulder 55 formed at the end of a central bore 56 drilled in the stud portion 51. The spring tends to hold the armature plate 50 retracted from a magnetic clutch 57. This insures that the armature plates will not interfere with the magnetic chuck plate during indexing of the drum.

The armature plate engages driving pins 58 which project from the end of the spindle and are slidably mounted in bushings 59 carried by the armature plate. This allows the plate 50 to slide relative to the pins while still maintaining a driving connection with the spindle.

The magnetic clutch 57 has a series of magnetizing coils 60 mounted therein which terminate in two binding posts 61 mounted on the periphery of the member 57, and these are electrically connected by wires 62 to armature rings 63 and 64 which are mounted in insulated relation on the periphery of a disc 64′. This disc is keyed at 65 to the end of a shaft 66 which is mounted on anti-friction bearings 67 in an uprising support 68. The end of the shaft 66 is provided with a drive pulley 69 which is suitably connected by V-belts 69′ to the drive pulley 70, Figure 4, of an electrical motor 71 mounted on the plate 32. The motor 71 is continuously driven which means that the magnetic clutch member 57 is continuously rotating, and at suitable times, to be explained hereafter, the clutch is magnetized to effect rotation of the particular spindle which has been moved into alignment therewith at the grinding station.

The specific construction of the spindles is shown in Figure 9, from which it will be noted that the spindle 27, for example, is rotatably journaled in the drum by means of spaced bearings 72 and 73. These bearings are of the rocker shoe type as shown in Figure 7. The spindle is held against axial movement in the drum by means of a collar 74 which engages a shoulder 75 formed on the spindle. A nut 76 which is threaded on the spindle and acts through the sleeve 77, abutting the plate 78 mounted against the fixed part 79 of the drum, to pull the shoulder 75 axially against the member 74 and thereby axially position the spindle as well as holding it against axial movement.

The work end of the spindle has a face plate

80 secured to the spindle as by bolts 81, and this plate has a central axially projecting stud 82. This stud is threaded at 83 to receive a pair of lock nuts 84. A pair of telescoping chuck members 85 and 86 are slidably mounted on the stud and from the view of these parts shown in the lower part of Figure 9 in connection with spindle 28, it will be noted that the members 85 and 86 are split to form interlocking fingers 87 which are integral with the member 85, and fingers 88 which are integral with the member 86. The member 85 is provided with a tapered seat 89, while the member 86 is in abutting relation with the lock nuts 84 whereby when the member 85 is pushed by a series of pins 90 toward the member 86, the fingers are expanded outwardly into engagement with a bore 91 of the work piece 26.

There are three equally spaced pins 90 around the stud 82 as shown in Figure 3. When the pressure is taken off of the pins, the fingers collapse sufficiently to permit removal of the work piece, and when a new work piece is placed in position it is accurately positioned axially by means of another series of pins 92 projecting from the face plate 80. In addition, a driving pin 93 mounted in the plate 80 has a reduced end 94 which engages a hole 95 in the work piece to effect rotation thereof upon rotation of the spindle. Both spindles are of the same construction.

The chuck actuating pins 90 abut the end of a piston 96 which is slidably mounted in a cylinder 97 formed in the interior of the spindle. The rear end 98 of the piston communicates with an axial bore 99 formed in the spindle through which hydraulic pressure is admitted to force the piston 96 axially to the right as viewed in Figure 9 to effect expansion of the chuck. Upon withdrawal of the hydraulic pressure, a spring 100 encircling the reduced end of the piston effects retraction of the piston to permit contraction of the chuck.

The bore 99 extends to the rear end of the spindle 27 as shown in Figure 10 and is closed by a plug 101. However, a cross bore 102 is drilled in the tapered end 103 of the spindle and in communication with a radial bore 104 formed in a sleeve 105 which is held in position on the taper by a lock nut 106 threaded on the end of the spindle. The bore 104 terminates in an annular groove 107 which is in constant communication with a bore 108 which terminates in a threaded portion 109 to which the pressure supply pipe 110 is connected. The bore 108 is formed in a sleeve 111 which is held against a shoulder 112 of the member 105 by suitable springs 113 to maintain the parts in position and to prevent leakage. In this connection, attention is invited to the fact that the spindle and sleeve 105 rotates together by means of the key connection 114 and that the member 111 is held against rotation by the pipe connection 110.

The pipe 110, as well as a pipe 115 which supplies fluid pressure to the chuck on spindle 28, which is of the same construction as spindle 27, are connected to the center of the drum by being threaded in the ends of bores 116 and 117, Figure 9, formed in a plug 118 which is integral with the drum. It is to be remembered that the drum rotates through an angle of 180 degrees to alternately position the spindles in loading position and grinding position, and therefore these hydraulic connections must be maintained for either position of the drum, but the spindles also rotate independently of the drum.

The bores 116 and 117, as shown in Figure 9, are connected by pipes 119 and 120 to bores 121 and 122 formed in a centrally located member 123 with respect to the drum and rotatable therewith, and this member has a portion 124 which projects beyond the end face of the drum. The passages 121 and 122 are connected by cross bores 124' and 125 respectively to annular grooves 126 and 127 formed in the periphery of the portion 124. The portion 124 has a shoulder 128 formed thereon against which abuts a fixed member 129 in which is formed interdrilled passages, one of which is shown at 130 which is in constant communication with the annular groove 127. These interdrilled passages terminate in a cap member 131 secured to the end of the member 129 and also to an upstanding fixed bracket 132 shown in Figure 1, which bracket is fixed to the base of the housing 30. Since the bracket is fixed, the cap 131 and the member 129 are held against rotation during rotation of the drum, but it will be noted that the construction is such as to maintain the hydraulic connections regardless of rotation of the drum. The interdrilled passage 130 and the interdrilled passage 133 communicating with the annular groove 126, shown in Figure 13, terminate in pipes 134 and 135 respectively which terminate in the chuck selector valve, indicated generally by the reference numeral 136 in Figures 4, 5, and 6. The pipe 134 terminates in the annular groove 137 in valve sleeve 138 and the pipe 135 terminates in the annular groove 139 in valve sleeve 140 as shown in Figures 5 and 13.

The valve sleeve 138 has a valve plunger 141, and the sleeve 140 has a valve plunger 142, which plungers are slidably mounted in their respective sleeves, and as shown in Figure 11, held in normally retracted positions by springs 143. A rock lever 144 centrally pivoted at 145 abuts the ends of the respective plungers and is held in balance against the wall 146 by the springs 143. In this position the valves connect a source of pressure to the respective work chucks, thereby holding the chucks in work engaging position.

Referring to Figure 13, fluid pressure is supplied to the valves by pump 147 which has an intake 148 for withdrawing fluid from a suitably located reservoir 149 in the machine, and a delivery line 150. This line has a branch connection to a relief valve 151 for returning excess fluid to reservoir. The line 150 is connected through a pressure reducing valve 152 to a supply line 153 leading to the valves 141 and 142 and terminating in the pressure grooves 154 and 155. Thus, when both valve plungers are in the retracted position fluid pressure is connected to both chucks.

A common actuating mechanism is provided for moving the valve plungers, but only one plunger is moved at a time by the mechanism, the plunger being moved depending upon the position of the drum. The common actuating mechanism includes a manually operated lever 156 attached to the end of a shaft 157, Figure 6, which is journaled in the valve housing 136 and the inner end of the shaft has a crank arm 158 which carries the pivot 145 upon which the rock lever 149 is mounted. Thus, when the lever 156 is moved to the right, the crank arm 158 moves clockwise as viewed in Figure 5 and thereby exerts pressure on the rock lever 149 to shift the plungers.

It will be noted that the drum 35 has a first depression 159 formed in the periphery thereof which is opposite the plunger 141 in one position of the drum and a second depression 160 on the opposite side of the drum which upon rotation of the drum through an angle of 180 degrees is positioned opposite the plunger 142 as shown in dotted lines in Figure 5. Thus, upon movement of the common actuator 156 one plunger is held or blocked against movement by the periphery of the drum and the other plunger is free to move into the depression opposite the respective plunger whereby the rock lever is pivoted about the end of one plunger and caused to move by the crank lever to shift the other plunger. It will thus be seen that a common actuator is provided for shifting either plunger and that the plunger to be shifted is automatically determined by the position of the drum, and furthermore the position of the drum determines which work chuck is at the work loading station so that only the chuck at the work loading station is released, and this automatically insures that the chuck at the grinding station cannot be accidentally released.

Provision is made for slight lateral adjustment of the drum to slightly change the pivot point of the pivot pin 31, shown in Figure 3, to assist in locating the work with respect to the grinding wheel and to insure that the flat face being ground on the end of the work is normally to the axis of the work and thereby to the axis of the work supporting chuck. This is accomplished by mounting a pivot block 161 in a T slot 162 formed in the base of the housing 30 and mounting the pivot block on the end of the pivot pin 31. An adjusting screw 163 is anchored at 164 to the housing 30 and threaded at 165 in the block. Thus, upon rotation of the screw the block 160 does not move but the entire housing will be moved laterally. This slightly changes the pivot point about which the housing will be swiveled upon adjustment thereof. After adjustment the pivot pin is clamped by a tapered ended clamp member 166, which is secured in position by a set screw 167.

The machine is operated and controlled in the following manner, reference being had to the hydraulic diagram of Figure 13 and the electrical diagram of Figure 14. For purposes of continuity of this explanation, an unground work piece 29 is placed on the spindle 28 and in order to make this possible the lever 156, as shown in Figure 13, is moved to the right which permits the fluid pressure in the spindle 28 to be exhausted to reservoir through the line 134 and line 168, thus permitting retraction of the piston 96 so as to release the chuck and permit the work piece to be mounted on the end thereof and against the locating pins 92. Upon release of the lever 156, the valve plunger 141 is retracted by its spring, thereby connecting the pressure supply line 153 to line 134 whereby the work becomes clamped on the chuck. The next step is to index the drum to move the unground work piece to grinding position which is effected by means of the electrical control circuit shown in Figure 14.

In the electrical control circuit there is shown a transformer 169 which is adapted to be connected through suitable switch means to a source of electrical power. The secondary of this transformer has two lines which may be differentiated by designating the line 170 as the power supply line and the line 171 as the power return line. The power supply line 170 has a cycle stop switch 172 therein for stopping the entire machine cycle

at will. This switch is connected by a line 173 to a cycle start button 174. It will be noted that the line 173 has a branch connection to an indicium 175 in the form of a black square. This square is repeated at various points in the electrical diagram to indicate the power supply line and thus eliminate the necessity of running connecting lines across the drawing, thereby making the diagram clearer. Therefore, wherever a black square appears on the diagram, it indicates the power supply line. Similarly, an indicium in the form of a black triangle 176 is attached to the end of the power return line 171 and wherever the triangle 176 reappears in the electrical diagram it is synonymous with and indicates the power return line and thus avoids the necessity of extra lines on the electrical diagram.

The operator starts the automatic cycle of the machine beginning with the indexing of the drum by pressing the start button 174 which connects the power supply line to line 177, which is connected in parallel through lines 178 and 179 to switches CR3–2 and CR4–3 of index control relays CR3 and CR4 respectively, which relays are respectively energized in accordance with the position of limit switches LS1 and LS2 which, in turn, is determined by the position of the drum.

Thus, the relay CR4 is shown energized by limit switch LS2 and relay CR3 is deenergized by limit switch LS1. Accordingly, the switch CR3–2 is closed at this time while the switch CR4–3 is open. A circuit is thus established through switch CR3–2 from line 178 to line 180, which line continues to the normally closed switch TR2–1 of timer relay TR2. The circuit continues through line 181, closed switch 182 of relay BW–1 which is serially connected with closed switch 183 of a second relay BW–2, and line 184 to cycle control relay CR1. This relay becomes energized, thereby closing its switch CR1–2 to set up a latching circuit from the power line 175 to line 180 so that the relay CR1 is now latched in independent of switches CR3–2, CR4–3, and the start button, which is released. Power is thus connected to the circuit. The line 180 has a branch line 185 to closed contacts 186 of limit switch LS–1 which is electrically connected through line 187, closed switch CR6–1, line 188 to control relay CR5, causing energization thereof. This relay closes its switch CR5–1, completing a circuit from the power supply line 175 to indexing solenoid 189. Thus, the cycle control relay CR1 starts the cycle by shifting the indexing valve. Relay CR5 also closes its switch CR5–2 to set up a latch circuit from line 180 through line 202, closed switch CR5–2, line 203, line 187, closed switch CR6–1 and line 188.

Referring to the hydraulic diagram of Figure 13, it will be noted that the solenoid 189 is connected by a rock lever 190, centrally pivoted at 191 to the reversing valve plunger 192 which controls reciprocation of the rack piston 47. By energizing the solenoid 189, the valve plunger 192 is shifted to the right, thereby connecting the pressure port 193 which is directly supplied by the pump 147 through line 194 to port 195 whereby fluid pressure will flow through line 196 to the right hand end of cylinder 48, thereby shifting the piston 47 to the left and, through the interconnected gearing, causing counterclockwise indexing of the drum. As soon as the drum starts rotation, the limit switch LS2, as shown in Figures 7 and 15, will be actuated by riding out of the depression 197 formed in the periphery of the drum and thereby open the circuit to the relay

CR4 as seen in Figure 14 and simultaneously close its switch contacts 198.

The drum continues to rotate for substantially 180 degrees during which time both relays CR3 and CR4 are released. A second depression 199 formed in the periphery of the drum and spaced 180 degrees from the first depression 197 permits limit switch LS1 to operate, opening its contacts 186 and closing its switch contact 200, completing a circuit from the power supply line 175 to index control relay CR3 through line 201. Relay CR3, in turn, closes its switch CR3-4 and establishes a circuit beginning from the line 180 through line 202, closed switch CR5-2 of relay CR5, line 203, line 204, closed switch CR3-4 of relay CR3, line 205 to line 206 which is connected to the timer relay TR1. This timer relay is set for time closing, thereby providing a slight delay to insure that the hydraulic piston 47 has moved the drum against a positive stop as shown in Figure 2, and then the relay closes its switch TR1-1 and completes a circuit from line 180 to operate rapid traverse control relay CR7. Operation of this relay closes its switch CR7-1 and completes a circuit from the power supply line 175 through line 207 to rapid traverse solenoid 208.

This solenoid, as shown in Figure 13, is connected to the rapid traverse control valve plunger 209, thereby shifting the plunger to the left. This valve is already shown in its shifted position due to the fact that the wheel head is shown in the position it assumes at the end of the rapid traverse movement or, in other words, at the beginning of the feed movement. Thus, when the valve 209 is shifted to this position, it connects the pressure port 210, which is also supplied from the pump line 194 to port 211 whereby fluid pressure flows through line 16 to chamber 17 as previously described, moving the wheel head at a rapid traverse rate to the position shown in Figure 8.

When the wheel head reaches the position shown in Figure 8, a dog 213 attached to the wheel head operates the limit switch LS3 and thereby moves its contactor 214 to close switch contacts 215 and complete a circuit from the power supply line 175 through line 216 to operate feed control relay CR8. This relay closes its switch CR8-1 and completes a circuit from the power supply line 175 through line 217 to the feed solenoid 218. The solenoid 218, as shown in Figure 13, is connected to the feed valve plunger 219 which is normally held by a spring 220 in the position shown. This valve has a pressure port 221, which is also connected to the pump line 194, and when the plunger is shifted to the left, this port is connected to port 222 whereby fluid flows through line 223 to the feed cylinder 224. The piston 225 moves to the right, as viewed in Figure 13, and through the bell crank 226 moves the entire wheel head assembly, shown in Figure 8, in a counterclockwise direction to feed the grinding wheel into the work to effect the grinding operation.

The work spindle and the work have been set in rotation before this by the rapid traverse control relay CR7 which closed its other switch CR7-2 and, completing a circuit from line 180 through line 277, closed switch CR7-2 and line 228 to the rectifier 229 which supplies direct current to the magnetic clutch 57. As shown in Figure 10, this connects the drive pulley 69 to the drive plate 50 on the end of the chuck spindle.

The grinding operation continues according to the time setting of the timer relay TR2. This relay was energized simultaneously with feed relay CR8 by the closing of limit switch LS3, the relay being connected by a branch line 230 to line 216. This relay is set for a timed opening which is of just sufficient time to permit the stop 24 on the wheel head to engage the positive stop 25 and still allow a slight tarry before the wheel head is withdrawn to allow the grinding wheel to spark out. The timer relay then opens its switch TR2-1, thereby breaking the holding circuit to cycle control relay CR1.

During the grinding operation just described the operator is loading another workpiece in the chuck located at the loading station. Two alternatives now happen. One is that when the timer relay TR2 operates, it can cause retraction of the grinding wheel and the machine will stop. The other is that, if the operator completes the loading operation before the work piece at the grinding station is completed, he may press the starting button 174 and set up a condition in the circuit whereby the machine will continue into the next cycle without stopping.

In the first alternative the timer relay will break the holding circuit to control relay CR1, and its switch CR1-2 will disconnect the source of power from line 180, deenergizing the solenoid relays CR5, CR7, CR8, so that the control valves will spring return and cause the grinding wheel head to retract to a stop position; and rotation of the work will stop because of deenergization of the magnetic clutch 57 by opening of switch CR7-2.

In the other alternative, the operator will press the button 174 after loading the work piece and before the grinding cycle is completed. By so doing he completes a circuit through the button to line 231, closed switch CR8-2 of feed relay CR8, and line 232 to cycle preset control relay CR2. This relay will close its switches CR2-1 and CR2-2. The closing of switch CR2-2 will set up a latching circuit from the supply line 175 through line 236, switch CR2-2, line 237, branch line 242, closed switch CR3-1, lines 243, 244, and 232 to relay CR2. Line 243 extends to the signal light LT-1. The switch CR2-1 will set up a potential circuit from the supply line 175 through cycle control stop switch 233 and line 234 to switch CR8-3 which is held open at this time by the feed control relay CR8, but when the feed control relay CR8 is released at the end of the cycle, power will automatically be reconnected to line 180 through line 235 and switch CR2-1.

The return movement of the wheelhead starts with the release of solenoid 208, causing the rapid traverse 209 to shift to the right by spring 238, thereby connecting line 16 from the rapid traverse cylinder 17 through port 211 to an exhaust port 239 whereby the fluid in cylinder 17 is free to return to reservoir through line 240 and low pressure relief valve 241. As the wheel head returns, it operates limit switch LS3 which thereby opens the circuit to line 216 to release and simultaneously open the circuit to relay TR2 which closes TR2-1. This deenergizes the solenoid 218 whereby the feed valve plunger 219 is returned to the position shown in Figure 13 to connect the feed cylinder 224 to reservoir.

Summarizing the cycle so far, the timer relay TR2 which determines the length of time of the grinding operation opens the holding circuit to relay CR1 which, in turn, disconnects power from line 180, thereby causing deenergization of the rapid traverse solenoid and start of the rapid traverse return of the wheel head.

During the grinding operation, the operator latched in the cycle preset relay CR2 by pressing the starting button, thereby setting up a potential circuit through an open switch of the feed control relay CR8 for reconnecting power to the line 180.

During the rapid traverse return, the wheel head operates the limit switch LS3 to release the feed control relay CR8 so that its open switch now closes to complete the potential circuit to line 180. At the same time the limit switch LS3 opens the circuit to the timer relay TR2 whereby its switch TR2–1 returns to its normally closed position connecting power from line 180 to operate relay CR1 which again establishes a latching circuit through closure of its switch CR1–2 to maintain a power connection to line 180.

Due to the fact that relay CR5 was released when power was disconnected from line 180 it closed its switch CR5–3 whereby upon reconnection of power to line 180 a circuit is set up from line 180 through line 185, closed contacts 198 of limit switch LS2, line 245, line 246, line 247, closed switch CR5–3, line 248 to control relay CR6. A relay CR6 controls indexing of the drum in a direction opposite to the direction controlled by relay CR5.

The relay CR6 opens its switch CR6–1, opening the circuit between line 187 and line 188 which leads to relay CR5; and closes its switches CR6–2 and CR6–3. The switch CR6–2 latches in the relay CR6 by completing a circuit from line 180 through line 249, closed switch CR6–2, line 250, line 245, line 246, line 247, and closed switch CR5–3 and line 248. This short circuits out the limit switch LS2.

The switch CR6–3 completes a circuit from the power line 175 through line 251, flow switch CR6–3, and line 252 to solenoid 253.

Referring to Figure 13, the solenoid 253 shifts the indexing valve plunger 192 into the position in which it is shown in the drawing, thereby connecting the pressure port 193 to port 254 and line 255 to the left end of the piston 47 which thereby moves to the right, causing clockwise rotation of the drum 35. The initial rotation of the drum operative limit switch LS–1, thereby opening its contacts 200 and breaking the circuit to relay CR3, and final rotation of the drum operates limit switch LS–2, opening its contacts 198 and closing its contacts 256 to complete a circuit from line 175 to relay CR4. Operation of relay CR4 closes its switch CR4–4, which completes the circuit from the line 180 through line 249, closed switch CR2–2, line 250, line 257, closed switch CR4–4, line 258, and line 206 to timer relay TR1. This relay closes its switch TR1–1 and completes a circuit to rapid traverse control relay CR7 which closes its switch CR7–1 and effects operation of solenoid 208 to start the rapid traverse movement of the next cycle.

The grinding cycle continues in the same manner and at the end of the grinding cycle the line 180 will again become deenergized, dropping out the relay CR6 and closing switch CR6–1. On the next indexing movement, switch CR3–4 of index controlled relay CR3 will be closed and the switch CR4–4 of index control relay CR4 will be open, whereby the relay CR5 will operate to effect the next indexing movement.

For protection during the indexing operation a safety device is provided to protect the machine against oversize work pieces as well as detecting whether the work piece is properly seated in the chuck. This device comprises a pair of rods 258 and 259 shown in Figure 1 opposite the work loading station, these rods being supported in the ends of lever arms 260 and 261 respectively as shown in Figure 12, the arms being supported for rotation about a common center 262. The rods are insulated from their respective lever arms, and the rod 258 has a wire 262 connected thereto, and the rod 259 has a wire 263 connected thereto. A spring 264 urges the lever arms toward one another and against stop pins 265 which positions the lever arms at a predetermined angle. The levers are free to swing away from the stop pins in case of engagement of the work piece with either rod. The rods are so positioned as to provide the necessary clearance desired, but should the work piece project from the chuck beyond the predetermined amount when the drum is rotated, the work piece will engage either one rod or the other, depending upon the direction of rotation of the drum.

In the electrical diagram in Figure 14, the rod in lever arm 260 is electrically connected by the wire 262 to the secondary 266 of transformer BW–1, while the rod in the end of arm 261 is connected by the wire 263 to the secondary 267 of the transformer BW–2. It will be noted that both of these secondaries are connected to ground indicated by the reference numeral 268 whereby should the rod in either lever arm engage the work piece the other end of the secondary will be grounded through the machine, thereby completing a closed circuit through the secondary. It will be noted that each of these transformers has a primary coil, the ends of which are connected to the power supply line 175 and the power return line 176. This causes a flow of flux through the armature leg upon which the secondary coil is wound.

So long as the secondary coil circuit is open there will be a free flow of flux through its armature, but when both ends of the secondary coil are grounded, an inductive current is created in the secondary coil which opposes flow of flux through the secondary armature, thereby increasing the flow of flux through the two legs 269 and 270 which thereby creates a magnetic circuit through the switch arm 271 to attract and operate the switch. The operation of either switch arm will break the circuit to the control relay CR–1 and in the case of switch arm 271 will complete a circuit from the power supply line 175 through line 272, closed contacts 273 and line 274 to switch CR4–2.

If this switch is closed, a circuit will be completed to line 188 and index control relay CR5, causing operation of this relay. If the other switch arm 275 is operated, it will complete a circuit from the power source in like manner through line 276 to switch CR3–3, and if this switch is closed the circuit will be completed through line 277 to index control relay CR6. It will be obvious that at the time of indexing either relay CR5 or CR6 will be energized to cause the indexing movement. Therefore, the connections are such that if an interference rod is grounded, it will break the circuit to the energized index relay, thereby stopping the indexing movement in that direction and energizing the other index control relay to reverse the direction of indexing and cause the work to return to the loading station so that the operator can examine the work and make the necessary adjustments.

For manual control of the indexing operations a cycle delay switch 278 is provided which when operated causes its lever arm 279 to break the circuit to line 230 and cause lever arm 280 to close a circuit from the power supply line 175 through closed contacts 281 of limit switch LS3 to line 282. This line is connectible by the manual push button switch 283 to line 284 which leads to relay CR5 through switch CR6-1, while a second manually operated push button switch 285 serves to connect the line 282 to line 286 and thereby to index relay CR6 through switch CR5-3. Thus, either one of these relays may be manually controlled to effect an indexing of the work drum. To be sure that the grinding wheel is retracted, in either case, the switch 283 has a second contactor 287 in series with another contactor 288 of push button 285 whereby operation of either of these push buttons will break the circuit of line 206 to the timer relay TR1, which through its switch TR1-1 will break the circuit to the rapid traverse control relay CR7.

It should now be clear that an improved machine has been provided for automatically grinding flat faces on the ends of work pieces and that the manner of operation of the machine is fully automatic, the operator loading the work in the chuck that is located at the loading station by operating the lever 156 to release the chuck while the work is being changed. The operator then presses the start button and when the grinding operation on the other work piece is finished, the work drum will be automatically indexed to reverse the position of the two work pieces. The electrical circuit serves to coordinate the automatic cycle of the grinding machine with the automatic cycle of the indexing mechanism.

What is claimed is:

1. In a grinding machine having a support, an indexible spindle carrier mounted on the support, a pair of work spindles journaled in the carrier parallel to the axis of carrier rotation, means to reversibly index the carrier 180 degrees to position the spindles alternately at a grinding station and a work loading station, a grinding wheel mounted on the support at the grinding station for grinding work supported in the end of that spindle located at said station, a continuously driven rotator mounted on the support adjacent the other end of said last-named spindle, a magnetic clutch carried by the rotator for automatic coupling with the respective spindles at the grinding station, power operable means for feeding the grinding wheel, additional power means for energizing said clutch, a control circuit operatively connected to said clutch and power operable means, and means operable by the carrier upon completion of an indexing movement to energize said circuit to effect a grinding operation.

2. In a grinding machine having a support, an indexible spindle carrier mounted on the support, a pair of work spindles journaled in the carrier parallel to the axis of carrier rotation, means to reversibly index the carrier 180 degrees to position the spindles alternately at a grinding station and a work loading station, a grinding wheel mounted on the support at the grinding station for grinding work supported in the end of that spindle located at said station, a continuously driven rotator mounted on the support adjacent the other end of said last-named spindle, a magnetic clutch carried by the rotator for automatic coupling with the respective spindles at the grinding station, power operable means for feeding the grinding wheel, additional power means for energizing said clutch, a control circuit operatively connected to said clutch and power operable means, means operable by the

carrier upon completion of an indexing movement to energize said circuit to effect a grinding operation, and means in said circuit responsive to predetermined movement of the grinding wheel to deenergize said circuit and stop the grinding operation.

3. In a grinding machine having a support, an indexible work spindle carrier reversibly, oscillatably mounted on the support for movement through half a revolution to alternately position work spindles carried thereby at a loading station or a grinding station, each of said spindles having a work holding chuck, fluid operable means for releasing said chucks including individual control valves, a common actuator for moving said valves mounted on said support adjacent the carrier, and locking means selectively positioned by the carrier in accordance with the rotatable position thereof to alternately render said valves non-responsive to movement of said actuator.

4. In a grinding machine having a support, a housing mounted on the support, an indexable spindle carrier, means for supporting the carrier within the housing for rotation, work spindles journaled in the carrier, a hydraulic piston mounted in the support and operatively connected to the carrier for effecting rotation thereof through one-half a revolution to alternately position the work spindles at a loading station and a grinding station respectively, stops carried by the housing for locating the carrier in either position, and means to maintain pressure in said cylinder to hold the carrier against the respective stops during a grinding operation.

5. In a grinding machine having a support, an indexible carrier, means rotatably supporting the carrier on said support, a plurality of work spindles journaled in the carrier, one end of said spindles having means for receiving and securing a work piece, the other end of said spindles having an armature plate secured thereto, means on said support rotatably mounting a magnetic clutch plate, power operable means on the support for continuously rotating said clutch plate, power operable means for indexing the carrier to position a spindle in axial alignment with said rotating clutch plate, and means to successively energize said clutch after each indexing of the carrier to effect magnetic coupling thereof with the armature plate on the spindle positioned in alignment therewith.

6. A grinding machine having a support, an indexible spindle carrier, a carrier housing mounted on the support having means for rotatably supporting the carrier, work spindles journaled in the carrier, each spindle having fluid operable means for operating a work receiving chuck mounted in one end of the spindle including a fluid operable piston axially slidable within the spindle, a hydraulic collector sleeve connection to the other end of the spindle including a non-rotatable sleeve fixed to the carrier, hydraulic channels extending through the center of the carrier with one end connected to the respective sleeves, a hydraulic collector sleeve mounted on the carrier having hydraulic connections to said channel, a control valve means mounted on the housing and hydraulic connections from the valve means to said last-named collector sleeve whereby the chucks may be remotely controlled from said valve.

7. A grinding machine having a support, an indexible spindle carrier, a carrier housing mounted on the support having means for ro-

tatably supporting the carrier, work spindles journaled in the carrier, each spindle having fluid operable means for operating a work receiving chuck mounted in one end of the spindle including a fluid operable piston axially slidable within the spindle, a hydraulic collector sleeve connection to the other end of the spindle including a non-rotatable sleeve fixed to the carrier, hydraulic channels extending through the center of the carrier with one end connected to the respective sleeves, a hydraulic collector sleeve mounted on the carrier having hydraulic connections to said channel, a pair of control valves mounted on the housing having a source of hydraulic pressure connected thereto, a control lever for simultaneously operating said valves to release the pressure in said channels, and blocking means selectively positioned by the carrier in accordance with the rotatable position thereof for inhibiting movement of one or the other of said valves upon operation of said lever.

8. A grinding machine having a spindle carrier with work spindles journaled therein, means to index the carrier to successively position the spindles at a grinding station, a grinding wheel movably mounted on the support opposite one end of the work spindle at the grinding station, a spindle rotator mounted on the support opposite the other end of the spindle located at the grinding station, means to continuously actuate said rotator, power operable means for feeding said grinding wheel, a magnetic clutch carried by the rotator for coupling the rotator to the spindle, and means to simultaneously energize said clutch and said power operable means.

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