Aug. 9, 1949. G. W. BINNS ET AL 2,478,562

GRINDING MACHINE

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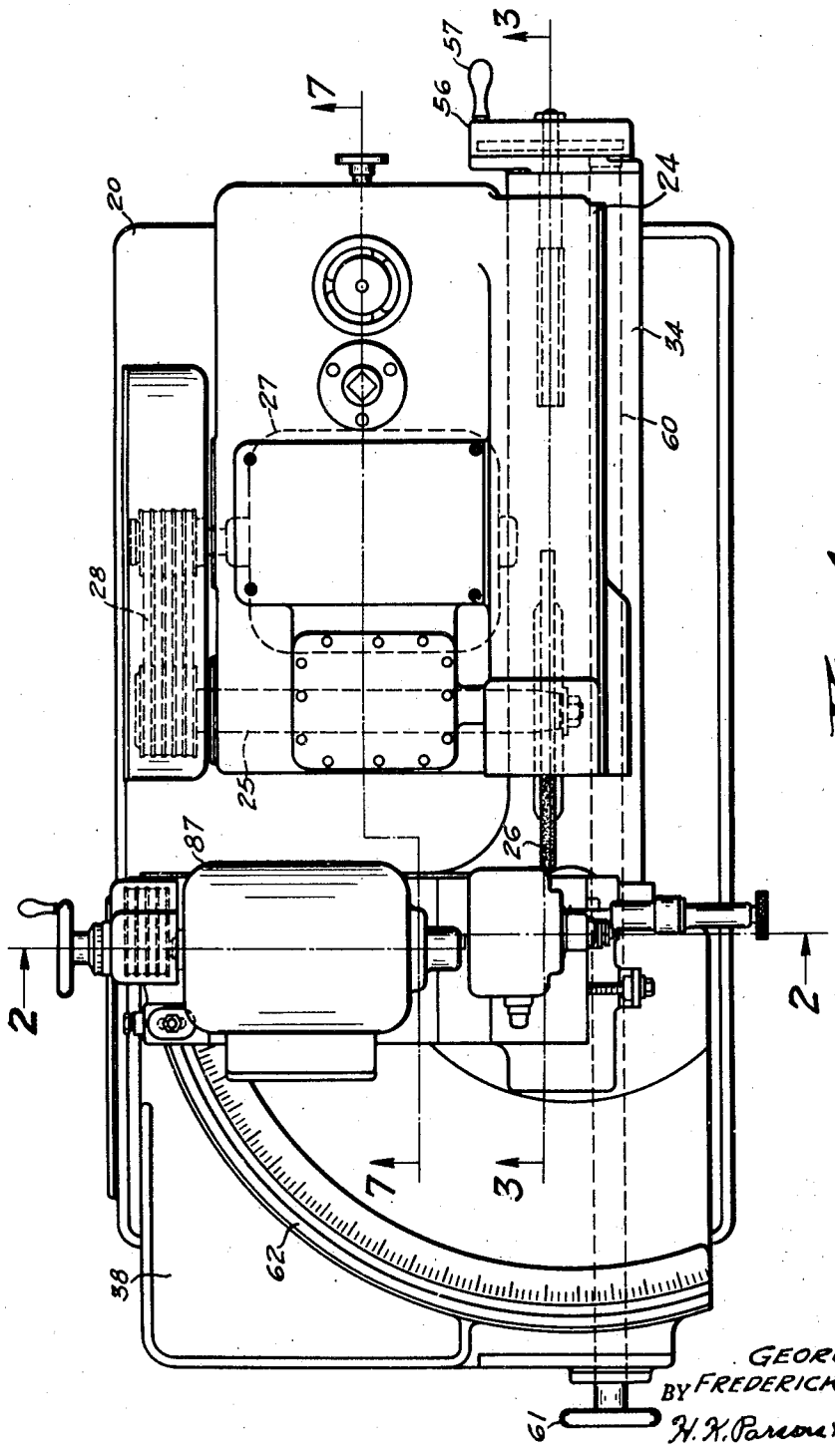


Fig. 1

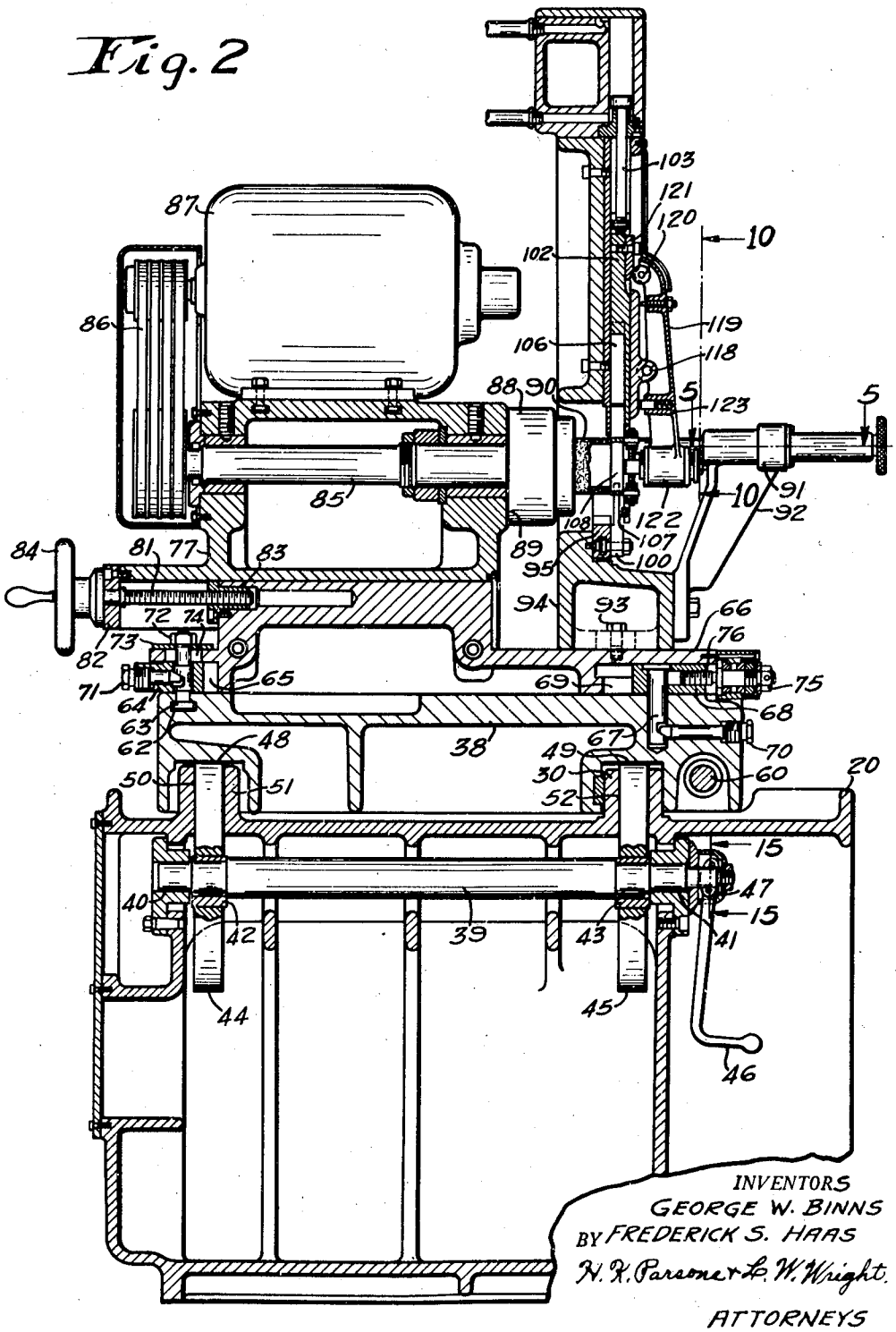
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Fig. 2

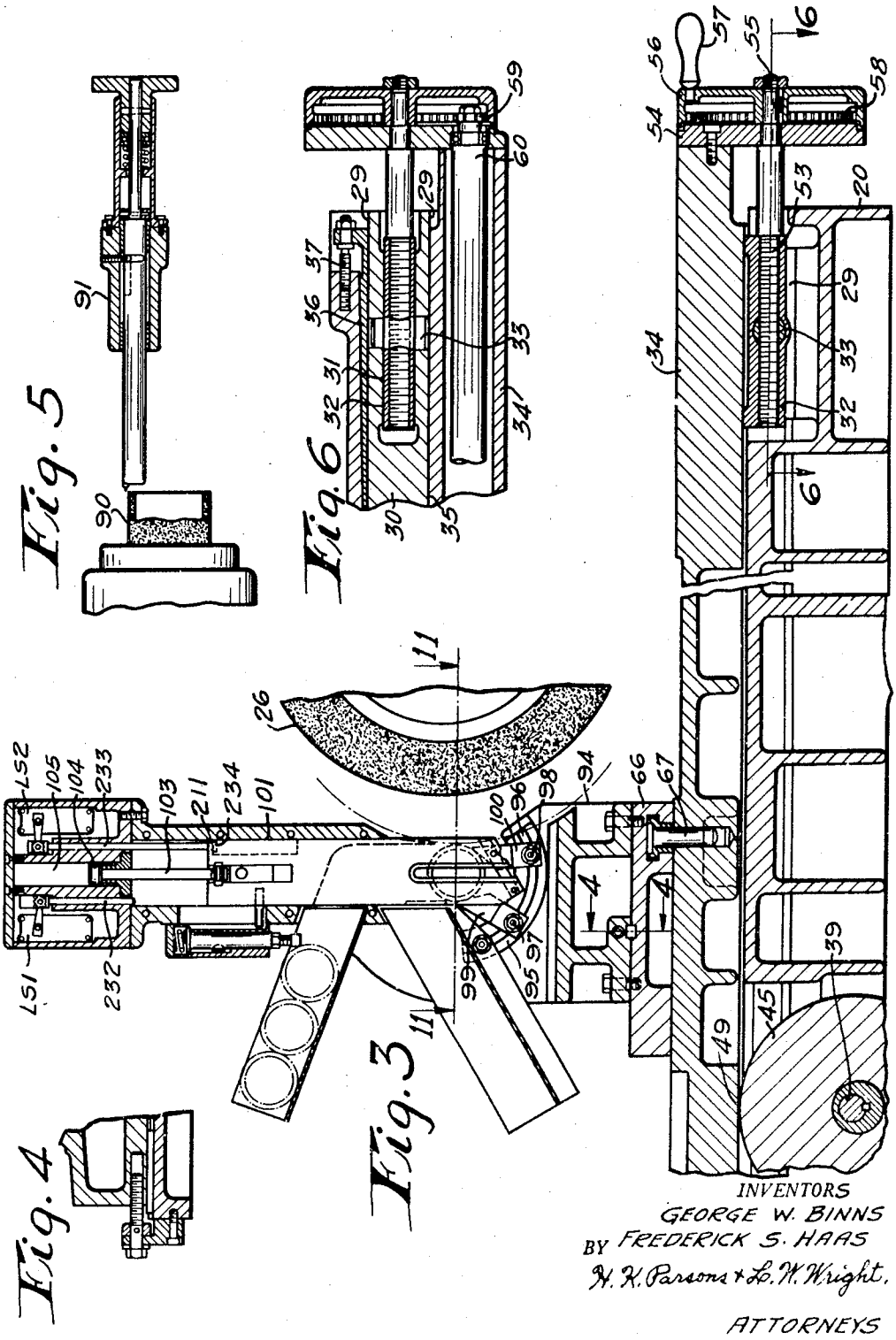


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GRINDING MACHINE

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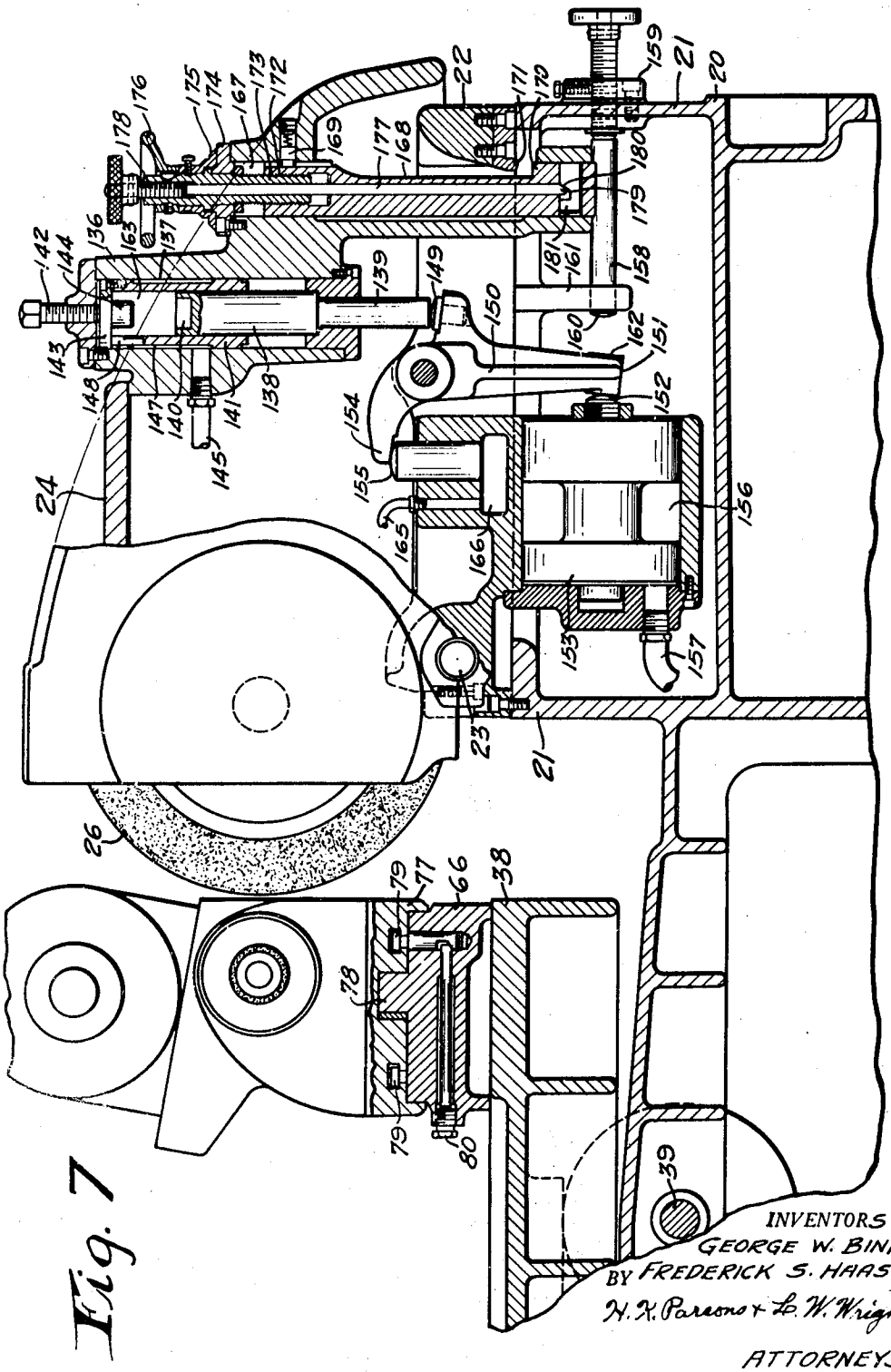


Fig. 7

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Fig. 8

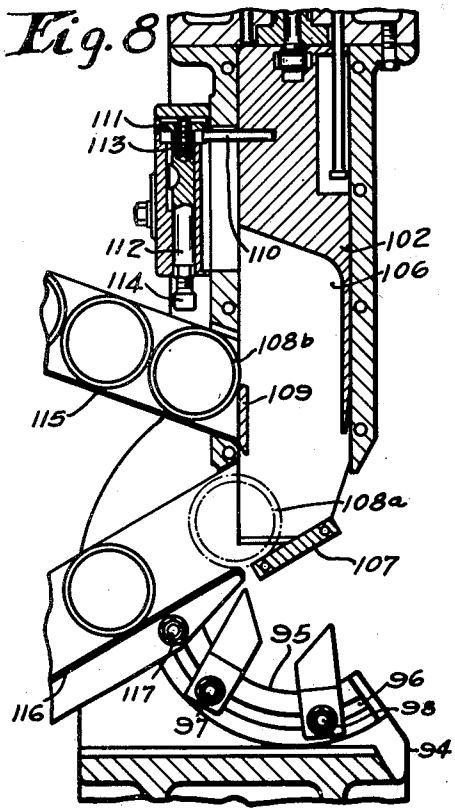


Fig. 9

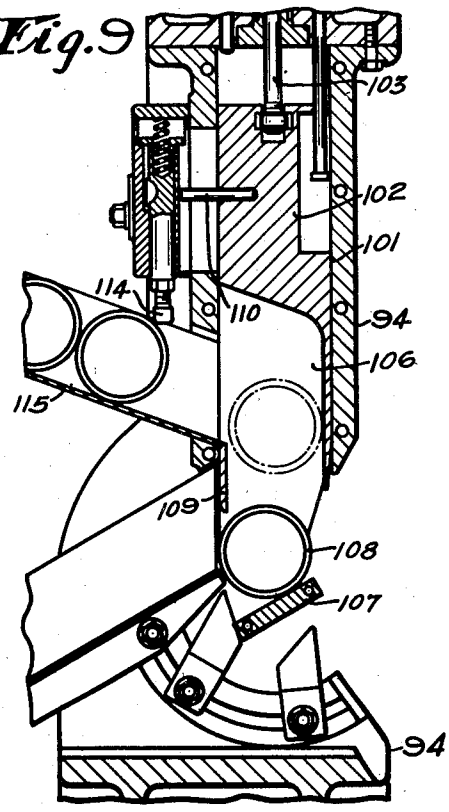


Fig. 10

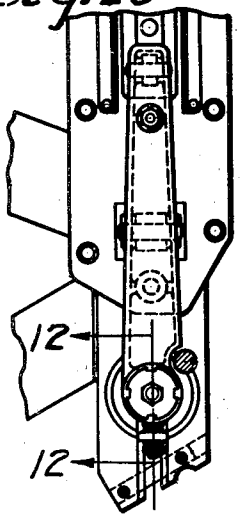


Fig. 11

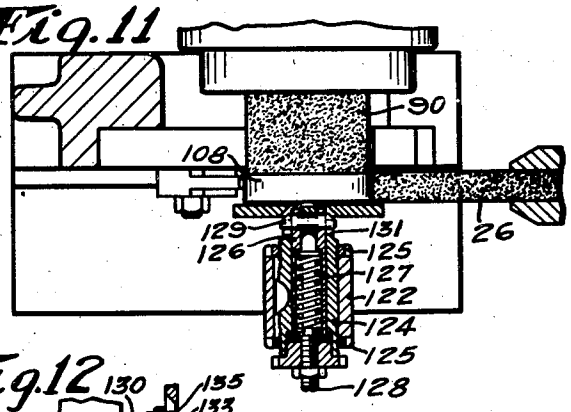
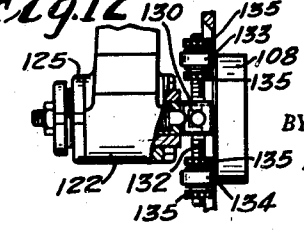


Fig. 12



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GRINDING MACHINE

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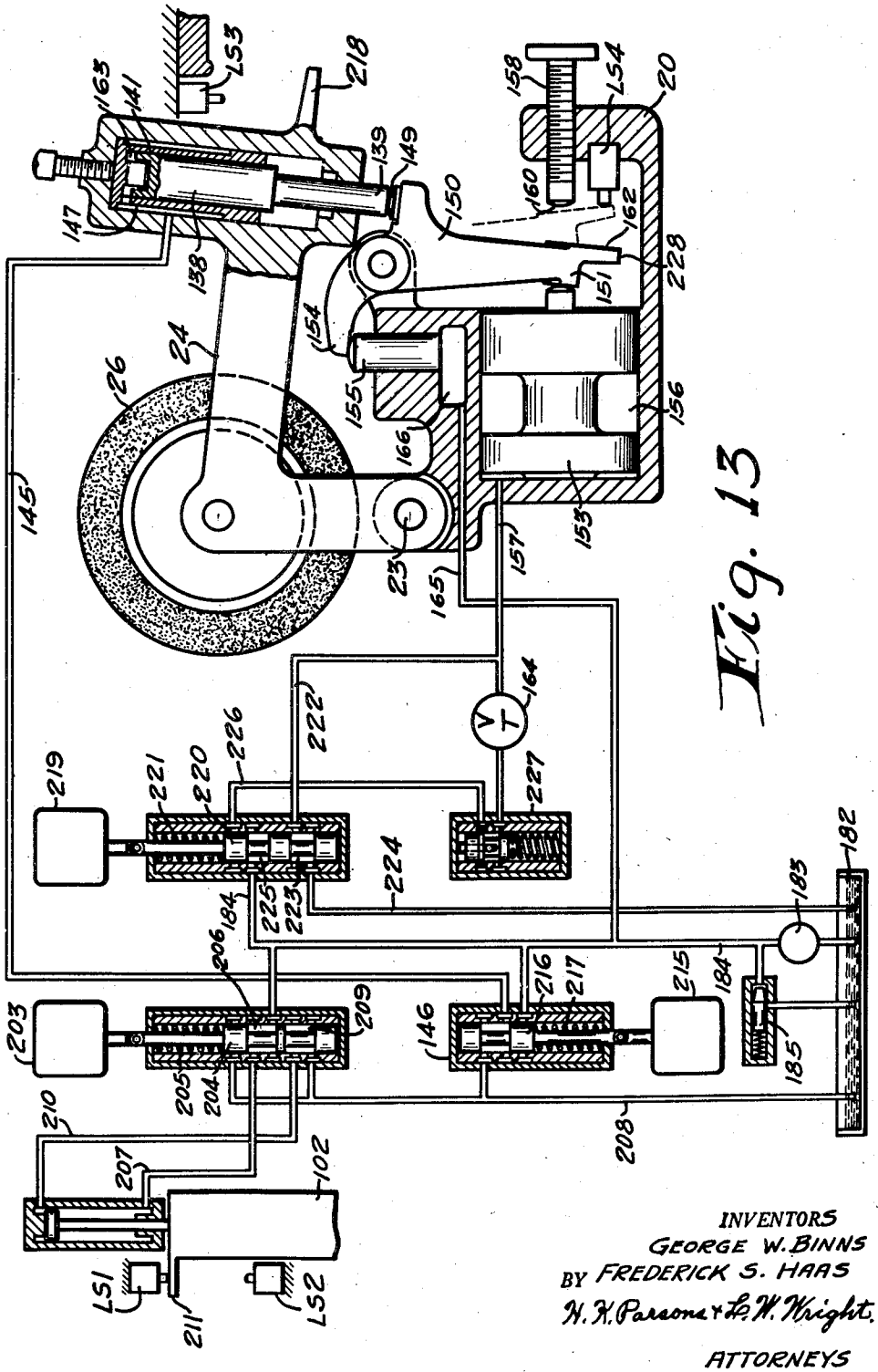


Fig. 13

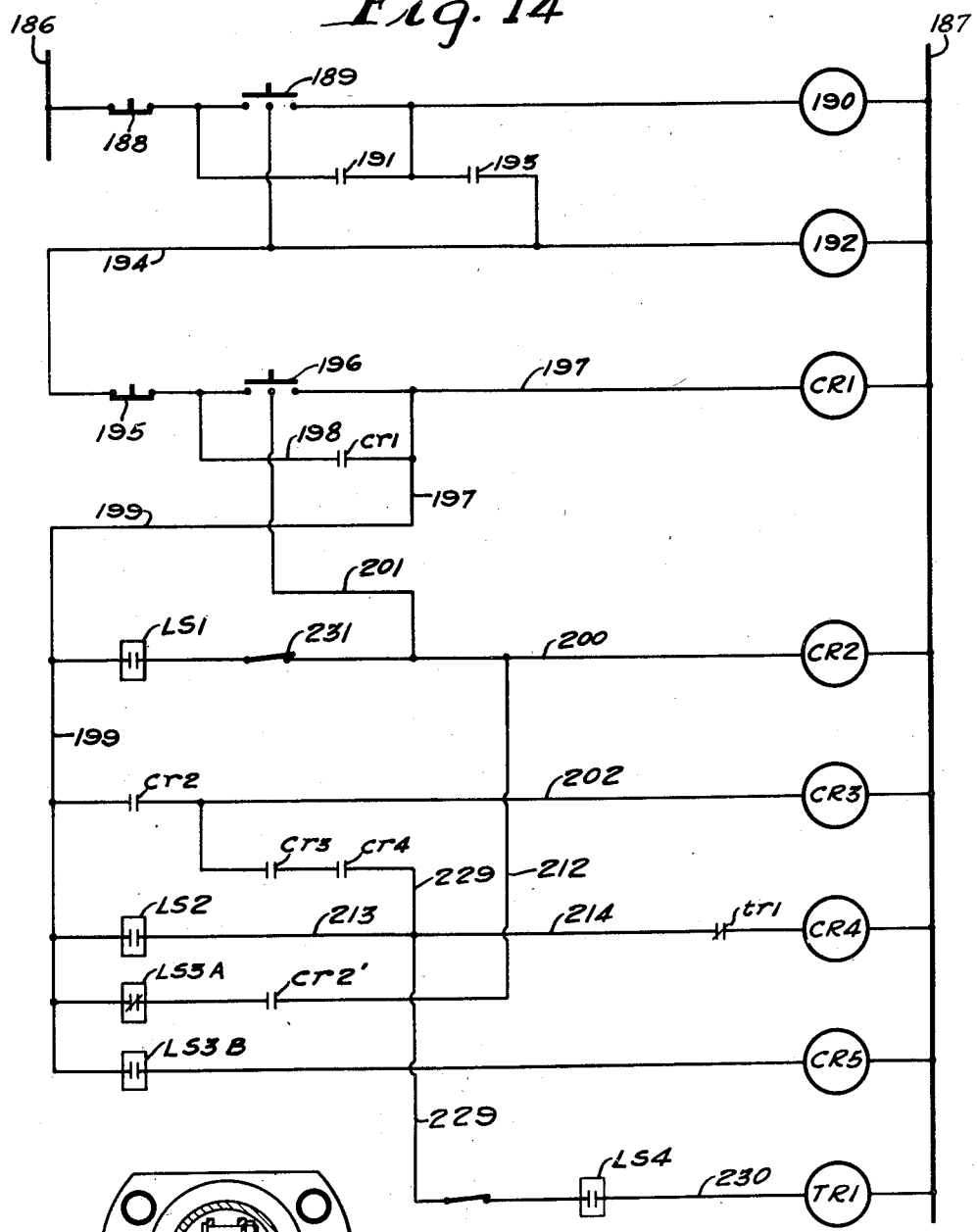
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GRINDING MACHINE

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Fig. 14



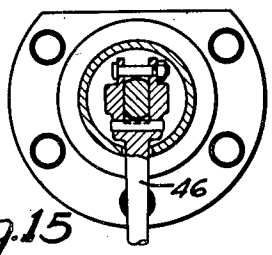


Fig. 15

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Patented Aug. 9, 1949

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UNITED STATES PATENT OFFICE

2,478,562

GRINDING MACHINE

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Application March 12, 1947, Serial No. 734,080

33 Claims. (Cl. 51—103)

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The invention relates to improvements in grinding machines and has particular reference to machines for the production of surfaces of revolution.

One of the objects of the present invention is the provision of a grinding machine particularly adapted for generation of external surfaces of revolution.

A further object of the present invention is the provision of a machine of this character having interrelated parts constructed and arranged to effect an automatic continuous cycle production of duplicate work pieces.

Another object is the provision of a machine in which the formed surface of revolution shall be in predetermined relation to a preformed terminal portion of the work.

An additional object of the invention is the provision of a machine which will effect automatic accurate positioning of successive work pieces for corresponding action of the grinding wheel with respect thereto.

Another object of the invention is the provision of a simplified structure adapted for use in connection with various grinding machines but especially in connection with machines of the type herein illustrated and described which will facilitate the accurate varying of the height or relationship of the work axis to the grinding wheel axis without disturbing the rigidity of mounting or the relationship of the other elements of the machine.

The invention further contemplates the provision of simplified means for accurately effecting the multiplicity of adjustments essential for precision production of work accurate to a fractional part of .0001".

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

Figure 1 represents a plan view of a machine constructed in accordance with and embodying the principles of this invention.

Figure 2 represents a transverse vertical sectional view taken as on the line 2—2 of Figure 1.

Figure 3 is a longitudinal vertical sectional view as on the line 3—3 of Figure 1.

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

Figure 5 is a detail view of the driver truing mechanism.

Figure 6 is a fragmentary sectional view on the line 6—6 of Figure 3.

Figure 7 is a longitudinal vertical sectional view as on the line 7—7 of Figure 1.

Figure 8 is a vertical sectional view through the work loading and ejecting mechanism showing the parts in work ejecting position.

Figure 9 is a similar view illustrating the position occupied by the parts during the loading operation.

Figure 10 is a fragmentary front elevation illustrating the automatic work clamping mechanism.

Figure 11 is a horizontal section as on the line 11—11 of Figure 3.

Figure 12 is a fragmentary view of the compensator portion of the work clamping mechanism.

Figure 13 is a diagrammatic view of the hydraulic circuit and controls therefor.

Figure 14 is a diagram of the electrical controls for cyclic operation of the machine, and

Figure 15 is a fragmentary sectional view as on the line 15—15 of Figure 2.

In the drawings in which similar characters of reference are employed to denote corresponding parts throughout the several views, the numeral 20 designates the base or bed of the machine which is of conventional hollow or ribbed form.

Rising from the bed is a platform 21 on which is rigidly mounted the grinding wheel base 22 having a trunnion 23 oscillatably supporting the swinging grinding wheel unit 24. This unit, as indicated in Figure 1, includes the spindle 25 for grinding wheel 26 and a motor unit 27 operatively connected with the spindle 25 as by the series of driving belts 28.

The bed is further provided in subtending relation to the forward portion of the grinding wheel unit 24 with vertical ways as at 29 formed on the rib 30. Rib 30 is additionally slotted as at 31 to receive guide block 32 oscillatably supported in the slot by trunnion 33.

A substantially L-shaped intermediate bed plate 34 has an elongated narrow portion which extends lengthwise of the bed 20 and has a surface or way 35 interengaged with one of the ways 29, being held in close interfitting engagement therewith as by the adjustable taper gib 36 engaging the way on the opposite face of the

rib and locked to the member 34 as by the adjusting screw 37.

At the left hand portion of the machine, as viewed in Figures 1 and 3, the supplemental bed portion is of increased width as indicated at 38 and provides a support for the work supplying, holding, and driving mechanisms as hereinafter described.

By reference particularly to Figures 2 and 7 it will be noted that extending transversely of the main bed unit 20 is a shaft 39 rotatably journaled in the bed as at 40 and 41 and provided with eccentric bearing portions 42 and 43 on which are journaled the discs 44 and 45. Secured on the shaft 39, as indicated in Figures 2 and 15, is the operating handle 46 oscillatable relative to the shaft for tightening or releasing of the cam clamp 47 restraining the shaft against rotation, and, when moved to release position, angularly adjustable to rotate shaft 39 and thus determine the position of the eccentrics 42 and 43. By reference to Figures 2 and 3, it should be apparent that this rotary adjustment of shaft 39 by varying the position of cam portions 42 and 43 will correspondingly raise or lower the upper effective surfaces 48 and 49 of the discs 44 and 45. Disc 44 extends upwardly through slot 50 in auxiliary guide rib 51, and disc 45 correspondingly extends upward through slot 52 in the main guide rib 30 for the supplemental bed. Rotary adjustment of shaft 39 by raising or lowering of discs 44 and 45 will effect corresponding movement of the widened portion 38 of the supplemental bed unit riding thereon, the unit as an entirety oscillating about the supporting trunnion 33.

In order that the supplemental bed unit and parts carried thereby may be longitudinally adjusted on the bed, and therefore with respect to the grinding wheel 26, member 32 is threaded to receive adjusting screw 53 whose outer end is swiveled in plate 54 carried by the right hand end of the supplemental bed. Secured on the projecting portion 55 is a cupped plate 56 provided with an actuating handle 57 for rotation of the plate and adjusting screw. This cup is formed with the internal gear 58 with which meshes pinion 59 on adjusting screw 60 which extends longitudinally of the bed and has mounted on its opposite end the adjusting hand wheel 61. By this construction the longitudinal movement of the supplemental bed with respect to the main bed may be effected by the operator from either the right or left hand end of the machine.

It will be apparent that the present machine is primarily intended for plunge cut or infeed grinding, that is to say, operations in which the grinding or stock removal is effected by relative shifting of the work and grinding wheel in a direction one toward the other as distinguished from intermittent relative advance of the parts with additional relative traverse as in the production of long cylindrical or like surfaces. It will be understood, however, that the principles of the invention as hereinafter described are equally applicable to machines employing not only infeed but also relative traverse of work and grinding wheel during the machining operation. In the form chosen for purposes of illustration, means have been provided for insuring absolutely accurate positioning of the work for performance of the grinding operation and additional means for shifting the wheel in a direction toward the work for performance of the grinding operation.

In this embodiment, the mechanism for adjustment of the supplemental bed is therefor employed only for the accurate setting up or positioning of the work although it will be understood that it could be additionally employed for effecting the relative feeding movement between work and grinding wheel if so desired.

It is to be particularly noted that the supplemental bed or table member is fully guided by the interengagement of the ways on the underside of the member with the rib of the bed to prevent any movement of the parts so that the table is shiftable in a direct linear direction on the bed. It will further be noted that the arrangement of the parts is such that adjustment of the eccentrically supported rollers 45 effects an upward tilting movement of the table member for effecting a raising or lowering of the work piece supports, and thus the work piece with respect to the periphery of the grinding wheel for varying the radial contact position of the work with the grinding wheel. When so adjusted by the members 45, the longitudinal shifting of the table member 34 will be substantially along this radial line and at an angle to the horizontal plane of the bed, thus maintaining the relative relationship of the operative face of the grinding wheel and the work piece for different longitudinal adjustments of the table.

Work positioning mechanism

The present machine is particularly adapted for the performance of grinding operations in accordance with the principles disclosed in pending application, Serial No. 662,191. Being intended for the production of work of a high degree of accuracy, it is essential that the work supporting device be capable of minute accurate adjustments in a multiplicity of directions, and at the same time with a simplification of parts, facilitating manufacture and reducing to a minimum the possible error introducible by employment of undue multiplicity of slides. In attainment of this result, the portion 38 is provided with an arcuate T slot as at 62 to receive the head of the guide and locking stud 63 mounted in slide block 64 adjustably fitting within recess 65 of the work unit bed plate 66.

The bed plate is further provided with a pivot stud 67 interfitting with guide block 68 slidable in recess 69 of the bed plate unit 66.

By reference to Figure 2 it will be noted that tightening of clamp screw 70 will draw stud 67 downward, thus securely locking the block 68 in place, while loosening of screw 70 will permit of swinging of 66 about said stud as a pivot. Similarly, tightening of clamp screw 71 will lock block 64 and stud 63 in position against arcuate movement as guided by 62 while loosening of this clamp will permit the unit 66 to be swung as an entirety about the pivot 67. This angular adjustment makes possible a lining up of the work holder mechanism in absolute parallelism with the grinding wheel spindle or of setting the parts in any desired angular relationship as when cone surfaces of bearings or other angular parts are to be produced.

At the same time the structure thus described renders possible a limited transverse adjustment of the base unit 66 with respect to the fixed position determining members 63 and 67 without in any way varying the angular setting which has been affected. This is accomplishable in that with the stud 63 locked in position by screw 71, loosening of the nut 72 will free the clamping

plate 73 so that the left hand portion of unit 66 may be moved relative to the locked stud 63 to the extent permitted by slot 74 and recess 65. Carried by member 66 is the screw adjusting mechanism 75 shown at the right hand portion of Figure 2, terminating in the screw 76 engaged with block 68. It will thus be seen that with both the pivot stud 67 and the T slot stud 63 securely locked in place with respect to the bed 38, a limited adjustment may be imparted to the bed plate 66.

Mounted upon the bed plate 66 are the work driving and the automatic work feeding and holding mechanisms. The work driving mechanism includes a slide 77 guided for transverse movement by the rib 78 and securable in adjusted positions as by the guide and clamp studs 79, a clamp screw 80 being shown and cooperating with one of the studs 79 for clamping thereof. This transverse adjustment is preferably effected by a screw 81 swiveled in bracket 82 carried by the slide and in threaded engagement with nut 83 mounted in the bed plate 66. A suitable pilot wheel 84 facilitates rotation of the screw.

The member 77 has journaled therein the spindle 85 driven as through belts 86 by motor 87. This spindle has mounted thereon the precision bearing collar 88 engaging the face 89 of the slide 77 to insure true running of the outer end of the spindle which is provided as with the abrasive cup or work driving member 90. A truing device 91 mounted on bracket 92 of the work holder is projectable to engage and form accurate terminal surface on the member 90.

Mounted on the bed plate 66 for adjustment relative thereto as by loosening of the bolt 93 is the bracket 94 to which the member 92 is secured as indicated in Figure 2. This bracket is provided with a segment 95 formed with T slot 96 to receive the bolts 97 and 98 for securing at any desired vertically and angularly adjusted position the work engaging shoes 99 and 100 respectively. These shoes are preferably positioned as described in co-pending application, Serial No. 662,191, so that the angled upper face of the shoe element 100 engages the peripheral portion of the work to be ground at a point closely adjacent the point of contact of the grinding wheel 26 therewith, while the shoe 99 engages the work at the opposite side of its axis from the shoe 100, the two together forming a trough in which the work may be rotated by the frictional driving engagement of the face of cup 90 therewith and being so relatively positioned as to prevent displacement of the work by the component thrust reactions of the rotary driving member and the grinding wheel thereagainst. It will be understood that in practice the shoe determined axis of the rotating work piece is displaced in a direction downwardly and toward the grinding wheel as respects the axis of rotation of the driving member so that the driving member will exert a rotary and downward thrust component on the work, tending to maintain it in engagement with the shoes both prior to and during the grinding operation.

For automatically successively supplying work pieces in corresponding grinding position in the machine and subsequently ejecting the completed work pieces, the bracket 94 is formed with ways 101 guiding a vertically reciprocating slide 102 coupled as by rod 103 with actuating piston 104 reciprocable in cylinder 105 carried by the bracket. The slide 102 has a central slot 106 of width to

receive an individual work piece and of appreciably greater length than the diameter of the work pieces.

At its lower end it is provided with the transverse angularly disposed carrier plate 107, providing a carrier and limiting stop for the work piece such as 108. It is further provided with a lateral gate or work piece movement limiting member 109.

The operation of these parts will be best understood by a comparison of Figures 8 and 9. In Figure 8 the slide is shown in raised position. In this position the laterally extending pin 110 engages collar 111 on the spring depressed stop element 112 raising the same against the action of spring 113. The stop element proper has been shown in the form of an adjustable screw 114 so that its lowermost or effective position may be readily adjusted for suitable engagement with different diameters of work pieces.

In this position of the parts, while the stop member 114 is raised, permitting the innermost of a series of work pieces to move inward by gravity in the trough 115 secured to the side of bracket 94, the gate 109 extends transversely of the discharge end of the trough, holding back the innermost work piece. At this time the carrier plate 107 is substantially aligned with the discharge trough 116 so that the work piece 108*a* just completed will roll by gravity from member 107 into the trough. For convenience of assembly and operation, this trough has been shown mounted as through the medium of adjusting bolt 117 in suitable position on the segment 95.

As the plunger or slide 102 is lowered through the intermediate position shown in Figure 9, the gate 109 unblocks the discharge end of the feeding trough 115, permitting the innermost work piece 108*b* to roll forwardly into slot 106. At the same time the disengagement of collar 111 by pin 110 permits the adjustable stop 114 to move downwardly, retarding the inward movement of the sequential pieces of the feed chute, while the position of gate 109 is such as to prevent accidental discharge into trough 116 of the work piece to be ground. It will be evident that continued downward movement of the plunger to the position shown in Figure 3 will place the carrier plate 107 at a point below the effective work grinding position as determined by shoes 99 and 100 so that the work will rest freely on these shoes and the carrier plate will be out of engagement therewith. On reverse movement of the parts, the carrier will again lift the work piece from the supporting shoes into the position indicated by 108*a*, Figure 9, so that the work piece can be discharged and upon reverse movement a new work piece will be placed in position.

To retain the work during the grinding operation there has been shown pivoted to the member 94 as at 118, the clamp arm 119 having at its upper end roller 120 engageable by cam 121 carried by the plunger 102. As the plunger reaches lowermost position, this cam presses roller 120 and thus the upper portion of the arm outward, swinging the lower cylindrical portion 122 thereof inward against the retracting action of spring 123.

The cylindrical portion 122, as will be best understood by reference to Figures 11 and 12, has slidably keyed therein bushing 124 locked in axially adjustable relation to the cylindrical portion 122 as by the disc nuts 125. Slidable within this bushing is the member 126 pressed inwardly or in the direction of work engaging member 90 by spring 127 whose pressure may be variably de-

termined by adjustment of screw 128. Cross pin 129 riding in slots 130 of bushing 124 prevent rotation of 126 within 124. Member 126 is bifurcated or slotted as at 131 to receive the threaded stud 132 swiveled on pin 129 and bearing the pair of rollers 133 and 134 for engagement with face of a work piece 108 whereby the same is resiliently held against member 90 in a manner to permit it automatically to conform to the face thereof.

In order that the clamp device may be readily adapted for use in connection with different diameters of work pieces, the rollers 133 and 134 may be axially adjusted along stud 132 and secured in said adjusted position by nuts 135.

It will thus be seen that when the work piece is deposited in position upon the supporting shoes 99 and 100 the continued downward movement of the work delivering slide will, through cam 121, swing arm 119 to effect a resilient clamping of the work piece against the work driving member.

Conversely, the initial retracting or upward movement of the work delivery plunger will release the cam pressure, when spring 123 will move the clamp into disengaging position, leaving the work piece free to be elevated to the discharge position by engagement of member 107 with the work, as shown by the dotted line work piece 108*a* in Figure 8.

The grinding wheel unit

In the form of the invention shown for purposes of illustration, the grinding wheel has been indicated as movable in a direction toward and from the accurately positioned work piece for performance of the grinding operation. While this movement could be effected by a direct linearly moving slide or the like, it has been found preferable for accuracy of performance and cyclic control to mount the grinding wheel unit 24 on the trunnion 23 which is secured in fixed position with respect to the bed 20. The unit 24 includes a cylindrical portion 136 providing the hydraulic cylinder 137 in which is slidably mounted piston 138 having a projecting abutment rod 139 at one end and a recess or socket 140 at the other. To facilitate adjustment of the stroke or movement of piston 138, there is preferably provided within the cylinder intermediate the piston and cylinder wall a sleeve 141 which may be adjusted axially in a downward direction in the cylinder by means of screw 142. This sleeve is provided with the cap 143 having abutment lug 144 for engagement in the recess 140 of piston 138, the position of the sleeve and its abutment lug variably limiting the upward movement of piston 138. Intermediately connected to 136 is the hydraulic conduit 145 communicating at one end with a control valve 146, and at the other with the interior of the cylinder 137 and by way of circumscribing groove 147 and port 148 with the interior of the sleeve. In this manner the reaction of hydraulic pressure between the cylinder cap and end of the piston may be variably determined by positioning of valve 146, while the projecting abutment lug 144 insures that there will be at all times an inlet clearance at port 148 between the sleeve cap and piston so that the hydraulic pressure may properly react as respects the parts.

At its lower end rod 139 engages the rounded anvil or abutment lug 149 carried by one arm of the lever 150 which is of substantially T-shape or double bellcrank formation having a lower depending arm 151 engaging an adjustable abutment 152 carried by piston 153 and a second laterally extending arm 154 interengaged with the abutment piston 155.

It will be noted that the piston 153 is of relatively large diameter as respects pistons 138 and 155 and is shiftable toward the right in cylinder 156 as by hydraulic pressure introduced through conduit 157. Movement of the piston to the right will correspondingly rock the lower end of lever arm 151 to a position which may be adjustably limited by the stop 158 in threaded engagement with bracket 159 on the bed 20 which has a terminal abutment portion 160 slidable through bracket 161 and engageable with the face 162 of lever arm 151. Introduction of pressure into the chamber 163 of sleeve 141, due to the relative small diameter of the parts will cause a rapid movement of piston 138 to the position shown in Figure 7, thus rocking the wheel unit counterclockwise about trunnion 23 moving the wheel in the direction of the work. Subsequent movement of piston 153 toward the right at a feed rate as determined by throttle 164 will then cause a slow continued feeding movement which is controlled by the resistance of the back pressure or hydraulic spring effect produced by introduction of pressure through conduit 165 into chamber 166 where it reacts on piston 155 urging same upward against portion 154 of the rock lever.

To limit the amount of this feeding movement or oscillation of the wheel head unit 24, it is provided with a bore or guiding passage at 167 within which is slidably mounted the stop bar 168 keyed against rotation relative to the bore as by plunger 169. This stop bar has a shouldered portion or head 170 at its lower end underlying the abutment 171 of unit 22. At its upper end member 168 has an internally threaded bore 172 receiving adjusting screw 173 swiveled in cap unit 174 which may be provided with graduations as at 175 to denote adjusted position of the stop. A hand wheel 176 facilitates adjustment of the screw and thus of the stop position. Formed axially of the adjusting screw and stop bar are aligned passages to receive the locking rod 177. A clamping screw 178 threaded into the upper portion of the adjusting screw serves to force this rod downward so that its beveled end 179 will react against face 180 of lock plunger 181 which, in turn, reacts against the lower portion of the stop guide, positively to lock the guide in its adjusted position.

Machine operation

The manner of automatic cyclic operation of the machine will be best understood by reference to diagrammatic views 13 and 14, the hydraulic actuating and control devices being particularly illustrated in Figure 13 and the sequentially functioning electrical devices and related circuits in Figure 14. As shown in Figure 13, there is provided a reservoir 182 from which pump 183 is supplied with suitable hydraulic medium to create a volume of fluid in supply line 184 under a pressure determined by relief valve 185. The electrical system, as indicated in Figure 14, may be considered for purposes of understanding of the invention as including the main electrical supply leads 186 and 187. When the machine is to be operated, stop switch 188 is in normally closed position, and starting switch 189 is temporarily closed to energize the hydraulic pump control relay 190 maintained in continuing operation by the controlled switch 191. At the same time, the control relay 192 for the grinding wheel

motor 87 is energized and maintained in this position by the controlled switch 193.

The closing of these switches also energizes the conductor 194 extending to the cycle control mechanisms. This conductor includes a normally closed cycle stop switch 195 and normally opened temporary manually closable cycle starting switch 196. Upon closing of the cycle start switch 196 line 197 to controller CR1 for cyclic operation is energized, closing and maintaining closed the switch *cr1*.

As a result, the circuit from 195 will be maintained closed to 197 by way of 198 after release of the cycle starting switch 196. At the same time, lead 199 is energized from 197 while lead 200 is activated through 201 from the cycle starting switch, thus energizing control relay CR2 and closing switches *cr2* and *cr2'*. The closing of switch *cr2* completes the circuit through 202, energizing control relay CR3 which closes switch *cr3* and also causes activation of solenoid 203, which is coupled with valve element 204. When deenergized, spring 205 maintains valve in the position shown in Figure 13 in which pressure fluid from 184 may be discharged by way of the valve spool 206 and conduit 207 into the lower end of cylinder 105, raising piston 104 and the work controlling slide 102 to the position shown in Figure 8.

When the solenoid 203 is energized, groove 206 connects conduit 207 with discharge or reservoir conduit 208 while groove 209 couples pressure conduit 184 with conduit 210 at the upper end of the cylinder, moving the piston 104 and associated parts into the depressed or work loading position shown in Figure 3. In this manner a work piece is automatically placed in position in the machine and there secured by the spring pressed clamp rollers 133 and 134 as previously described. Plunger 102 is diagrammatically shown as provided with the switch operating arm 211 which, when the plunger reaches its upper end of movement, holds limit switch LS1 in closed position. During cyclic operation of the machine each time that the plunger is raised, if cycle selector switch 231 is closed, operation of switch 211 will energize relay CR2 as just described for its energization by closing of cycle starting switch 196. In either event upon the completion of this circuit a holding circuit for CR2 is established through the closed side of LS3A and *cr2'* and conductor 212.

As the plunger moves downward through work loading position arm 211 contacts and closes limit switch LS2 and through leads 213, 214, and normally closed timer relay switch *tr1* energizes control relay CR4 which, in turn, causes energization of solenoid 215 to depress valve spool 216 of valve 146 from the position shown in Figure 13 where conduit 145 is connected to exhaust 208, in which position the valve is normally moved by spring 217. Upon energization of the solenoid the valve moves downward, closing off the connection with 208 and coupling pressure conduit 184 with conduit 145 whereby unrestricted pump pressure is introduced into the space 147. As rod 139 is firmly seated against 149 in its depressed position, as shown in Figure 13, the introduction of this pressure will swing the unit 24 in a counterclockwise direction until piston 138 reaches its limit of movement as indicated in Figure 7, this effecting a rapid approach or "rapid traverse" infeed movement of the grinding wheel. Member 24 is provided with the switch actuating arm or cam 218 which, as the unit 24 moves upward, closes and holds in closed position the spring openable limit switch LS3. In its open position LS3 through LS3A and *cr2'* completed the holding circuit from 199 to 212 for CR2, but as LS3A is opened and LS3B is closed, CR2 is deenergized, opening the holding circuit through *cr2* for CR3. Alternatively, however, this holding circuit has been completed through LS2, *cr4*—*cr3* and 202 so that CR3 and solenoid 203 remain energized. At the same time, completion of the circuit through LS3B energizes control relay CR5 for activation of solenoid 219. This solenoid 219 is coupled with valve 220 normally urged as spring 221 into position to couple conduit 157 by way of 222, groove 223, and return conduit 224 to reservoir.

However, when solenoid 219 is energized, this valve will be raised, coupling pressure conduit 184 by way of valve groove 225 to conduit 226, and thence through pressure control valve 227 and variable throttle 164 to conduit 157 for introduction of fluid at a throttle determined rate into cylinder 156. In this position of the parts the lower portion of the valve closes off reservoir connection 224 from 222 and the hydraulic actuating medium flows through throttle 164 into cylinder 156. The large terminal area of the piston facilitates extreme accurate control of rate of feeding movement by throttle 164.

The feeding movement of the grinding wheel, as has been described, is limited by interengagement of stop flange 170 with abutment 171 irrespective of the ultimate relative movements of the actuating pistons and intermediate motion transmitting element 150. After the parts 170 and 171 have been positively interengaged, due to the greater piston diameter, and thus total effective pressure within cylinder 156, continued movement of piston 153 to the right will force piston 138 up in its cylinder, backing out actuating pressure through conduit 145. In this manner, a very rigid holding of the wheel in exact stop determined position for sparking out or other finishing operations is attained, eliminating the irregular final springing movements or the like incident to employment of ordinary adjusting slides and screw or other actuating mechanisms.

For final termination of the grinding operation use is preferably made of an automatic timing device which may be set in operation either by limit switch LS3 or by the additional limit switch LS4, the latter having been indicated in diagrammatic view, Figure 14. This limit switch LS4 is carried by the bed 20 in position to be engaged as by arm 228 on member 50. Closing of this switch completes a circuit from 213 by way of 229 and 230 to the tarry timer relay TR1, which may be of conventional commercial type, either hydraulic or electrical, and which, a predetermined period after its energization, opens the normally closed switch *tr1* in the lead 214 to CR4 controlling solenoid 215 for reversal of hydraulic actuating conditions as respects the piston 138. Upon functioning of the tarry timer mechanism solenoid 215 is deenergized, when piston valve 216 will be restored to the position shown in Figure 13 by spring 217, coupling conduit 145 to reservoir when the weight of the right hand portion of unit 24 will oscillate same in a clockwise direction, rapidly retracting the grinding wheel with respect to the work. This movement releases limit switch LS3, opening the holding circuit of CR5 and deenergizing solenoid 219. Spring 221 moves valve 220 to the position shown in Figure 13, shutting off pressure from 226, and

at the same time couples 157—222 to reservoir through groove 223 and conduit 224. This bypasses throttle 164 so that the rapid movement of 24 may continue, reacting through the bellcrank lever 150 to restore piston 153 to the position shown in Figure 13.

The holding circuit *cr2* and *cr2'* having been previously deenergized, as described, the remaining holding circuit for CR3 in effect has been through 213, 229 and the series disposed switch elements *cr3* and *cr4*. Deenergization of *cr4* by operation of the tarry timer switch *tr1* also deenergizes 229 and CR3, permitting spring 205 to restore the valve elements to the position shown in Figure 13 where the pressure conduit 184 is connected through 207 to the loader cylinder, causing upward movement of plunger or slide 102 to work discharging position as shown in Figure 8. As this takes place, LS2 is released and opened while LS1 is eventually closed and in the event that cycle selector switch 231 is in closed position will reinitiate succeeding cyclic operation.

Attention is invited to the fact that, while for clarity of diagrammatic understanding of the operation, the elements LS1 and LS2 have been shown as disposed respectively above and below the plunger actuating arm 211, in the actual machine structure, as indicated in Figure 3, these switches are disposed on opposite sides of the chamber 105, the plunger pin 232 being contacted by the slide in its upward movement for actuation of LS1 and a corresponding plunger 233 being coupled with LS2 having a head 234 directly engaged by the arm or flange 211 to exert a downward pull rather than direct push against the switch actuating arm, the principle of operation, however, being identical in the two instances.

From the foregoing description it will be evident that there has been provided an improved precision grinding machine in which by employment of a multiplicity of fine adjustments the work holding elements may be most accurately located with respect to a prospective grinding position. Furthermore, that there has been provided an improved manner of grinding wheel mounting and hydraulic control for successive rapid advance and controlled oscillatory feed movements of the grinding wheel with respect to the predetermined preset work position, for definitely limiting the extent of movement of the grinding wheel, maintaining same for a desired period of time in firmly locked position, not subject to the creep or inaccuracy potentially inherent in ordinary slide and adjusting mechanisms.

It will further be noted that there has been provided an improved control mechanism for a grinding machine of this character which will insure the proper rapid continuous cyclic presentation of work pieces in self-stabilized position for grinding within the machine, for effecting the sequential movements of the work presenting and holding mechanisms, and the sequence of operative movements of the grinding wheel with respect thereto, together with automatic control mechanism for effecting interlocked, rapid and slow retracting movements of the grinding wheel, removal of a completed work piece and its replacement with a fresh work piece in continuous consequence.

What is claimed is:

1. An automatic grinding machine of the character described, including a work driving means and a work support means disposed adjacent thereto, a reciprocable work shifting device movable to deposit a work piece on the work supporting means, a work clamping element, means actuable by continued unidirectional movement of the work shifting means for effecting the clamping of the work piece against the work driving means, a work grinding element movable in a direction toward and from the work supporting means, means actuable by the said unidirectional movement of the work loading means for effecting sequential rapid and feeding movements of the grinding wheel in the direction of the work supporting means for operation on a work piece carried thereby, means for limiting the extent of feeding movement of the grinding wheel, a time delay reverse for effecting subsequent retraction of the grinding wheel, and means actuable on retracting movement of the grinding wheel for effecting a reverse shifting of the work loading means to retract and discharge a completed work piece.

2. In a grinding machine of the character described, the combination with a bed or support, of a grinding wheel carrier oscillatably mounted thereon, a trunnion remotely supported by the bed at one side of the grinding wheel, a table having a portion pivotally supported by the trunnion at one side of the grinding wheel, said table having a work supporting portion projecting to the opposite side of the grinding wheel, a work support carried by the projecting portion in opposition to the adjacent portion of the grinding wheel, and means carried by the bed and subtending the work support for determining the position of the table with respect to the bed.

3. In a grinding machine of the character described, the combination with a bed or support, of a grinding wheel carrier oscillatably mounted thereon, a trunnion remotely supported by the bed at one side of the grinding wheel, a table having a portion pivotally supported by the trunnion at one side of the grinding wheel, said table having a work supporting portion projecting to the opposite side of the grinding wheel, a work support carried by the projecting portion in opposition to the adjacent portion of the grinding wheel, means carried by the bed and subtending the work support for determining the position of the table with respect to the bed, and means for adjusting the supporting means to shift the table about its trunnion and variably position the work support with respect to the grinding wheel.

4. In a grinding machine of the character described, the combination with a bed or support, of a grinding wheel carrier oscillatably mounted thereon, a trunnion remotely supported by the bed at one side of the grinding wheel, a table having a portion pivotally supported by the trunnion at one side of the grinding wheel, said table having a work supporting portion projecting to the opposite side of the grinding wheel, a work support carried by the projecting portion in opposition to the adjacent portion of the grinding wheel, means carried by the bed and subtending the work support for determining the position of the table with respect to the bed, said table supporting means being in the form of rollers, and means to longitudinally adjust the table on the rollers to vary the separation between the work support and the grinding wheel.

5. In a grinding machine of the character described, the combination with a bed or support, of a grinding wheel carrier oscillatably mounted thereon, a trunnion remotely supported by the

bed at one side of the grinding wheel, a table having a portion pivotally supported by the trunnion at one side of the grinding wheel, said table having a work supporting portion projecting to the opposite side of the grinding wheel, a work support carried by the projecting portion in opposition to the adjacent portion of the grinding wheel, means carried by the bed and subtending the work support for determining the position of the table with respect to the bed, said supporting means including a transverse shaft having eccentrics thereon, supporting rollers journaled on the eccentrics and in engagement with the table whereby rotation of the shaft will vary the elevation of the rollers and thus the angular relationship between the bed and table, and means for longitudinally adjusting the table with respect to the bed to vary the separation between the work support and grinding wheel, whereby the rollers will provide anti-friction supports facilitating said longitudinal adjustment of the table.

6. In a grinding machine of the character described, the combination with a bed or support, of a grinding wheel carrier oscillatably mounted thereon, a trunnion remotely supported by the bed at one side of the grinding wheel, a table having a portion pivotally supported by the trunnion at one side of the grinding wheel, said table having a work supporting portion projecting to the opposite side of the grinding wheel, a work support carried by the projecting portion in opposition to the adjacent portion of the grinding wheel, means carried by the bed and subtending the work support for determining the position of the table with respect to the bed, said supporting means including a transverse shaft having eccentrics thereon, supporting rollers journaled on the eccentrics and in engagement with the table whereby rotation of the shaft will vary the elevation of the rollers and thus the angular relationship between the bed and table, means for longitudinally adjusting the table with respect to the bed to vary the separation between the work support and grinding wheel, whereby the rollers will provide anti-friction supports facilitating said longitudinal adjustment of the table, said projecting portion of the table having a portion thereof formed to provide an arcuate guideway, a pivot carried by the table and disposed concentric with the guideway, means interconnecting the pivot and work support, and additional means on the work support engaging the guideway for securing the work support in desired angularly adjusted position about the pivot with respect to the adjacent operative portion of the grinding wheel carried by the bed.

7. A grinding machine of the character described, including a bed, a work support adjustably mounted thereon, a trunnion carried by the bed, a grinding wheel pivotally mounted on the trunnion for oscillation in a direction toward and from the work support, means for effecting a controlled rapid approach and subsequent feeding movement of the grinding wheel toward the work support including a power transmitting element, a hydraulic piston and cylinder mechanism including a small diameter piston associated with the oscillatable grinding wheel carriage and acting against the element whereby on hydraulic actuation thereof a rapid relative movement between carriage and power transmitting element will be effected, a second large diameter piston reacting against the power element for effecting joint movement of the element and first-mentioned piston, a hydraulic resistor for said movement, and means for variably determining the volumetric reaction of a hydraulic medium as respects the large piston to determine the rate of feed imparted thereby.

8. A grinding machine of the character described, including a bed, a work support adjustably mounted thereon, a trunnion carried by the bed, a grinding wheel pivotally mounted on the trunnion for oscillation in a direction toward and from the work support, means for effecting a controlled rapid approach and subsequent feeding movement of the grinding wheel toward the work support including a power transmitting element, a hydraulic piston and cylinder mechanism including a small diameter piston associated with the oscillatable grinding wheel carriage and acting against the element whereby on hydraulic actuation thereof a rapid relative movement between carriage and power transmitting element will be effected, a second large diameter piston reacting against the power element for effecting joint movement of the element and first-mentioned piston, a hydraulic resistor for said movement, means for variably determining the volumetric reaction of a hydraulic medium as respects the large piston to determine the rate of feed imparted thereby, and means for variably limiting the amount of oscillatory movement impartable to the carriage whereby additional movement of the large piston will be absorbed by yielding of the smaller piston and the oscillatory grinding wheel carriage will be positively locked in unyielding position for accurate sparking-out operations.

9. In an automatic grinding machine of the character described, including a work support and an opposed grinding wheel support, a grinding wheel carried thereby a loader mechanism for positioning a work piece in the operative position on the work support, means actuable by the loader for clamping the work in operative position, a first means for effecting movement of the grinding wheel toward the work support, a second means for effecting corresponding feeding movement at a slower rate, means actuable by the continued movement of the work loading device for initiating operation of the first grinding wheel moving means, additional means actuable on movement of the grinding wheel into prescribed position for initiating actuation of the second grinding wheel moving means, means for positively limiting the extent of movement of the grinding wheel, and distinct means actuable by movement of the grinding wheel feeding means independent of the positioning of the grinding wheel for effecting a reversal of the power actuation thereof.

10. In an automatic grinding machine of the character described, including a work support and an opposed grinding wheel support, a grinding wheel carried thereby a loader mechanism for positioning a work piece in the operative position on the work support, means actuable by the loader for clamping the work in operative position, a first means for effecting movement of the grinding wheel toward the work support, a second means for effecting corresponding feeding movement at a slower rate, means actuable by the continued movement of the work loading device for initiating operation of the first grinding wheel moving means, additional means actuable on movement of the grinding wheel into prescribed position for initiating actuation of the second grinding wheel moving means, means for

positively limiting the extent of movement of the grinding wheel, distinct means actuable by movement of the grinding wheel feeding means independent of the positioning of the grinding wheel for effecting a reversal of the power actuation thereof, and means independent of the reversal controlling mechanism for variably determining the limit of power movement of the grinding wheel in a feeding direction.

11. In an automatic grinding machine of the character described, including a work support and an opposed grinding wheel support, a grinding wheel carried thereby a loader mechanism for positioning a work piece in the operative position on the work support, means actuable by the loader for clamping the work in operative position, a first means for effecting movement of the grinding wheel toward the work support, a second means for effecting corresponding feeding movement at a slower rate, means actuable by the continued movement of the work loading device for initiating operation of the first grinding wheel moving means, additional means actuable on movement of the grinding wheel into prescribed position for initiating actuation of the second grinding wheel moving means, means for positively limiting the extent of movement of the grinding wheel, distinct means actuable by movement of the grinding wheel feeding means independent of the positioning of the grinding wheel for effecting a reversal of the power actuation thereof, means operable on reversal of grinding wheel movement for effecting a subsequent reversal of movement of the work feeding mechanism, and a cycle control mechanism actuable on retraction of the work feeding mechanism for initiating the subsequent cyclic operation of the parts.

12. A mechanism of the character described, including a bed or support, a trunnion carried thereby, a grinding wheel carriage pivotally mounted on the trunnion and having its mass disposed to one side of the trunnion, an operating lever pivoted to the bed and having a plurality of angularly related abutment arms, a first hydraulic motor having an abutment rod engaging one of the arms for actuation of the lever in one direction about its pivotal support, said first hydraulic motor being carried by the grinding wheel carriage and having its abutment shiftable relative to said carriage, a second hydraulic motor carried by the bed and having a shiftable abutment portion reacting against the lever to oscillate the same about its pivot in a direction opposite to that of the first hydraulic motor, whereby actuation of the second motor will through the lever and first motor effect an augmented movement of the grinding wheel carriage, a source of hydraulic actuating medium, and a control valve mechanism intervening the source and said hydraulic motors for effecting sequential actuation of the respective motors.

13. A mechanism of the character described, including a bed or support, a trunnion carried thereby, a grinding wheel carriage pivotally mounted on the trunnion and having its mass disposed to one side of the trunnion, an operating lever pivoted to the bed and having a plurality of angularly related abutment arms, a first hydraulic motor having an abutment rod engaging one of the arms for actuation of the lever in one direction about its pivotal support, said first hydraulic motor being carried by the grinding wheel carriage and having its abutment shiftable relative to said carriage, a second hydraulic motor carried by the bed and having a shiftable abutment portion reacting against the lever to oscillate the same about its pivot in a direction opposite to that of the first hydraulic motor, whereby actuation of the second motor will through the lever and first motor effect an augmented movement of the grinding wheel carriage, a source of hydraulic actuating medium, a control valve mechanism intervening the source and said hydraulic motors for effecting sequential actuation of the respective motors, a third hydraulic motor reacting on the lever in opposition to the second hydraulic motor, and means for coupling hydraulic pressure to said third hydraulic motor to impart a continuous unidirectional urge to the lever.

14. A mechanism of the character described, including a bed or support, a trunnion carried thereby, a grinding wheel carriage pivotally mounted on the trunnion and having its mass disposed to one side of the trunnion, an operating lever pivoted to the bed and having a plurality of angularly related abutment arms, a first hydraulic motor having an abutment rod engaging one of the arms for actuation of the lever in one direction about its pivotal support, said first hydraulic motor being carried by the grinding wheel carriage and having its abutment shiftable relative to said carriage, a second hydraulic motor carried by the bed and having a shiftable abutment portion reacting against the lever to oscillate the same about its pivot in a direction opposite to that of the first hydraulic motor, whereby actuation of the second motor will through the lever and first motor effect an augmented movement of the grinding wheel carriage, a source of hydraulic actuating medium, a control valve mechanism intervening the source and said hydraulic motors for effecting sequential actuation of the respective motors, a third hydraulic motor reacting on the lever in opposition to the second hydraulic motor, and means for coupling hydraulic pressure to said third hydraulic motor to impart a continuous unidirectional urge to the lever, said three hydraulic motors being in the form of reciprocable pistons, the combined effective areas of the pistons of the first and third hydraulic motors being less than the effective area of the piston of the second hydraulic motor whereby when power is applied to the several motors the second hydraulic motor will control the direction of movement of the lever.

15. A mechanism of the character described, including a bed or support, a trunnion carried thereby, a grinding wheel carriage pivotally mounted on the trunnion and having its mass disposed to one side of the trunnion, an operating lever pivoted to the bed and having a plurality of angularly related abutment arms, a first hydraulic motor having an abutment rod engaging one of the arms for actuation of the lever in one direction about its pivotal support, said first hydraulic motor being carried by the grinding wheel carriage and having its abutment shiftable relative to said carriage, a second hydraulic motor carried by the bed and having a shiftable abutment portion reacting against the lever to oscillate the same about its pivot in a direction opposite to that of the first hydraulic motor, whereby actuation of the second motor will through the lever and first motor effect an augmented movement of the grinding wheel carriage, a source of hydraulic actuating medium, a control valve mechanism intervening the source and said

hydraulic motors for effecting sequential actuation of the respective motors, a third hydraulic motor reacting on the lever in opposition to the second hydraulic motor, means for coupling hydraulic pressure to said third hydraulic motor to impart a continuous unidirectional urge to the lever, said three hydraulic motors being in the form of reciprocable pistons, the combined effective areas of the pistons of the first and third hydraulic motors being less than the effective area of the piston of the second hydraulic motor whereby when power is applied to the several motors the second hydraulic motor will control the direction of movement of the lever, and means independent of the hydraulic motors for limiting the extent of movement of the grinding wheel carriage effectable by said motors.

16. In a machine of the character described, the combination with a work driving member, of work positioning members disposed adjacent thereto for peripheral engagement with a work piece, means for sequentially positioning a series of work pieces in operative position in the machine including a bracket adjacent the work supports, a feeding plunger reciprocably supported by the bracket and having a work piece receiving recess, oppositely angularly disposed loading and discharge chutes carried by the bracket and adapted to communicate with said recess, an inclined terminal carrier portion subtending the recess and adapted when in raised position to substantially coincide with the lower wall of the discharge magazine and when in depressed position to subtend the work position as defined by the work supports, said slide having an intermediate gate portion positioned to block off the discharge aperture of the feeding magazine when in raised position and to block off the discharge magazine when in position to release the work piece from the feeding magazine whereby the released work piece will roll over the gate onto the carrier as the slide is lowered but may be discharged from the carrier to the discharge magazine when the slide is raised and the gate is in upper work piece restraining position.

17. In a machine of the character described, the combination with a work driving member, of work positioning members disposed adjacent thereto for peripheral engagement with a work piece, means for sequentially positioning a series of work pieces in operative position in the machine including a bracket adjacent the work supports, a feeding plunger reciprocably supported by the bracket and having a work piece receiving recess, oppositely angularly disposed loading and discharge chutes carried by the bracket and adapted to communicate with said recess, an inclined terminal carrier portion subtending the recess and adapted when in raised position to substantially coincide with the lower wall of the discharge magazine and when in depressed position to subtend the work position as defined by the work supports, said slide having an intermediate gate portion positioned to block off the discharge aperture of the feeding magazine when in raised position and to block off the discharge magazine when in position to release the work piece from the feeding magazine whereby the released work piece will roll over the gate onto the carrier as the slide is lowered but may be discharged from the carrier to the discharge magazine when the slide is raised and the gate is in upper work piece restraining position, a spring plunger engageable with work piece in the feed magazine for limiting movement thereof in the direction of the feed slide, and means carried by the slide and reacting against the plunger to shift the plunger into work releasing position when the gate is in position to restrain the movement of the work piece.

18. In a machine of the character described, the combination with a work driving member, of work positioning members disposed adjacent thereto for peripheral engagement with a work piece, means for sequentially positioning a series of work pieces in operative position in the machine including a bracket adjacent the work supports, a feeding plunger reciprocably supported by the bracket and having a work piece receiving recess, oppositely angularly disposed loading and discharge chutes carried by the bracket and adapted to communicate with said recess, an inclined terminal carrier portion subtending the recess and adapted when in raised position to substantially coincide with the lower wall of the discharge magazine and when in depressed position to subtend the work position as defined by the work supports, said slide having an intermediate gate portion positioned to block off the discharge aperture of the feeding magazine when in raised position and to block off the discharge magazine when in position to release the work piece from the feeding magazine whereby the released work piece will roll over the gate onto the carrier as the slide is lowered but may be discharged from the carrier to the discharge magazine when the slide is raised and the gate is in upper work piece restraining position, a work clamping member carried by the bracket having a clamp portion disposed for terminal engagement with a deposited work piece on the work supporting members, and a cam means on the slide positioned to react on the clamping element subsequent to deposit of the work piece on the supporting elements by the carrier and to disengage the clamp on retraction of the slide prior to reengagement of the carrier with the work piece.

19. A grinding machine of the character described, including a bed or a support, a grinding wheel carriage mounted thereon, a work supporting table carried by the support, means for effecting adjustment of the table in a first transverse plane and in a second vertical plane as respects the grinding wheel, a pivot stud carried by the table and adjustable therewith, an arcuate guideway formed on the table and in concentric relation to the stud, a work supporting unit mounted on the table having a portion interengaged with the stud and a restraining member interengageable with the arcuate way, means for effecting a radial adjustment of the unit with respect to the stud and restraining member, a work driving means slide mounted on the work supporting unit, means for effecting transverse adjustment of the slide with respect to the unit, a work driver carried by the slide, a bracket mounted on the unit and extending upward in proximity to the work driving member on the slide, work supporting elements mounted on the bracket and adjustable relative thereto for determining the positioning of a work piece with respect to the driving unit, and means for effecting a bodily adjustment of the bracket and work supporting elements as respects the driving element on the slide.

20. In a machine of the character described, the combination with a bed having longitudinally extending guideways, of a table having vertical ways interfitting with the ways on the bed, a

trunnion carried by the bed intermediate the ways, a guide block oscillatably supported by the trunnion, said block having guide portions interengaged with the table, adjusting means carried by the bed at a point remote from the trunnion and engaging the table for variably positioning the same about the trunnion, and means for effecting longitudinal movement of the table with respect to the bed along an angular path defined by said adjusting means and the trunnioned supporting block.

21. In a machine of the character described, the combination with a bed having longitudinally extending guideways, of a table having vertical ways interfitting with the ways on the bed, a trunnion carried by the bed intermediate the ways, a guide block oscillatably supported by the trunnion, said block having guide portions interengaged with the table, adjusting means carried by the bed at a point remote from the trunnion and engaging the table for variably positioning the same about the trunnion, means for effecting longitudinal movement of the table with respect to the bed along an angular path defined by said adjusting means and the trunnioned supporting block, a grinding wheel overlying an intermediate portion of the table, and work supporting means mounted on the table and extending upwardly into opposition to the grinding wheel whereby longitudinal movement of the table will effect adjustment of the work support in an angular direction as respects the opposed grinding wheel.

22. A machine of the character described including a grinding wheel and opposed work rest means for supporting a work piece during action thereon by the grinding wheel, a fixed end stop adjacent the work rest means for limiting the axial movement of a work piece during a grinding operation, a work loading device reciprocable in a direction toward and from the work rest means for depositing a work piece on the work rest means, an end clamp supported adjacent the work rest means in position to longitudinally urge a work piece in the direction of the end stop, and interacting means on the work loading device and the end clamp for forcing the clamp against the work piece on continued movement of the work loading means in a work depositing direction.

23. A machine of the character described including a grinding wheel and opposed work rest means for supporting a work piece during action thereon by the grinding wheel, a fixed end stop adjacent the work rest means for limiting the axial movement of a work piece during a grinding operation, a work loading device reciprocable in a direction toward and from the work rest means for depositing a work piece on the work rest means, an end clamp supported adjacent the work rest means in position to longitudinally urge a work piece in the direction of the end stop, and interengageable cam and cam follower means on the end clamp and work loading means for shifting the end clamp in direction to longitudinally move a work piece on the rest against the fixed end stop during continued movement of the work loading means in a work depositing direction.

24. A grinding machine including a bed and a grinding wheel support carried by the bed, a table member translatably mounted on the bed, work supporting means carried by the table member for movement toward and from the grinding wheel support upon translation of the table, means for determining the longitudinal path of translation of the table, and additional means for angularly adjusting the table with respect to the bed to vary the resultant angle of longitudinal translation of the table with respect to the grinding wheel support.

25. A grinding machine including a bed and a grinding wheel support carried by the bed, a table member translatably mounted on the bed, work supporting means carried by the table member for movement toward and from the grinding wheel support upon translation of the table, means for determining the longitudinal path of translation of the table, and additional means for angularly adjusting the table with respect to the bed to vary the resultant angle of longitudinal translation of the table with respect to the grinding wheel support, said means for determining the longitudinal path of movement of the table including vertical guideways formed on the bed and cooperating interfitting guideways formed on the underside of the table and interfitting with the ways on the bed.

26. A grinding machine including a bed and a grinding wheel support carried by the bed, a table member translatably mounted on the bed, work supporting means carried by the table member for movement toward and from the grinding wheel support upon translation of the table, means for determining the longitudinal path of translation of the table, additional means for angularly adjusting the table with respect to the bed to vary the resultant angle of longitudinal translation of the table with respect to the grinding wheel support, said means for determining the longitudinal path of movement of the table including vertical guideways formed on the bed and cooperating interfitting guideways formed on the underside of the table and interfitting with the ways on the bed, and said means for determining the angular path of translation of the table with respect to the bed including a trunnioned support carried by the bed for one end of the table.

27. A grinding machine including a bed and a grinding wheel support carried by the bed, a table member translatably mounted on the bed, work supporting means carried by the table member for movement toward and from the grinding wheel support upon translation of the table, means for determining the longitudinal path of translation of the table, additional means for angularly adjusting the table with respect to the bed to vary the resultant angle of longitudinal translation of the table with respect to the grinding wheel support, said means for determining the longitudinal path of movement of the table including vertical guideways formed on the bed and cooperating interfitting guideways formed on the underside of the table and interfitting with the ways on the bed, said means for determining the angular path of translation of the table with respect to the bed including a trunnioned support carried by the bed for one end of the table, and vertically adjustable supports carried by the bed and engaging a portion of the underside of the table remote from the trunnion support.

28. A grinding machine including a bed and a grinding wheel support carried by the bed, a table member translatably mounted on the bed, work supporting means carried by the table member for movement toward and from the grinding wheel support upon translation of the table, means for determining the longitudinal path of translation of the table, additional means for angularly adjusting the table with respect to the bed to vary the resultant angle of longitudinal translation of the table with respect to the grinding wheel sup-

port, said means for determining the longitudinal path of movement of the table including vertical guideways formed on the bed and cooperating interfitting guideways formed on the underside of the table and interfitting with the ways on the bed, said means for determining the angular path of translation of the table with respect to the bed including a trunnioned support carried by the bed for one end of the table, and vertically adjustable supports carried by the bed and engaging a portion of the underside of the table remote from the trunnion support, said adjustable supports including rollers facilitating longitudinal translation of the table.

29. A grinding machine including a bed and a grinding wheel support carried by the bed, a table member translatably mounted on the bed, work supporting means carried by the table member for movement toward and from the grinding wheel support upon translation of the table, means for determining the longitudinal path of translation of the table, additional means for angularly adjusting the table with respect to the bed to vary the resultant angle of longitudinal translation of the table with respect to the grinding wheel support, said means for determining the longitudinal path of movement of the table including vertical guideways formed on the bed and cooperating interfitting guideways formed on the underside of the table and interfitting with the ways on the bed, said means for determining the angular path of translation of the table with respect to the bed including a trunnioned support carried by the bed for one end of the table, and adjusting means intervening the table and the trunnioned support for effecting longitudinal translation of the table in any angularly adjustable position thereof.

30. A machine of the character described, including a bed, a work support and an opposed grinding wheel support carried by the bed, a loader mechanism for positioning a work piece in operative position on the work support, means actuable by the loader mechanism for clamping the work in operative position, a first hydraulic motor for effecting movement of the grinding wheel in the direction of the clamped work piece, an electric control operable by movement of the loader for activating said hydraulic motor, a second hydraulic motor for effecting additional movement of the grinding wheel in the direction of the work, an electric control for said second hydraulic motor, a source of hydraulic power connectible with said motors for actuation thereof, trip means actuable by the first hydraulic motor to operate the electrical control and initiate movement of the second hydraulic motor, positive mechanical stop means for limiting the movement of the grinding wheel in a direction of the work support, electrical stop means activated by movement of the grinding wheel in the direction of the work support, and means to disconnect the power source from the motors when the electrical stop means are actuated.

31. In a grinding machine of the character described including a work support and an opposed grinding wheel support, a loader mechanism for positioning a work piece in operative position on the work support, work clamping means, cam means actuable by movement of the loader to move the clamp into work engaging position, a source of hydraulic actuating medium, a first hydraulic motor for effecting movement of the grinding wheel support toward the work support at one rate, a second hydraulic motor for effecting corresponding directional movement of the grinding wheel support at a slower rate, valve means for controlling the coupling of the actuating medium with the first motor, valve means for coupling the actuating medium with the second motor, means actuable by movement of the loader mechanim for shifting the valve to initiate operation of the first hydraulic motor, additional means actuable on movement of the grinding wheel support into prescribed position for initiating actuation of the valve for coupling the hydraulic actuating medium to the second motor, means for positively limiting the extent of movement of the grinding wheel support, separate means actuable by movement of the grinding wheel support independent of its position for effecting a reversal of the power actuation thereof, and means independent of the reversal controlling mechanism for variably determining limit of power movement of the grinding wheel support in a feed direction.

32. In a grinding machine of the character described, a work support and an opposed grinding wheel support, a loader mechanism for positioning a work piece in operative position on the work support, a source of hydraulic actuating medium, a first hydraulic motor for effecting movement of the grinding wheel support toward the work support, a valve for controlling the coupling of the hydraulic medium to said motor, a solenoid control for the valve, an electric trip mechanism having a portion disposed in the path of the loading device whereby movement of the loading device will actuate the trip mechanism to effect solenoid determined positioning of the valve to couple the actuating medium with the first hydraulic motor, a second hydraulic motor for effecting continued movement of the grinding wheel support, a control valve for coupling hydraulic medium to said motor, a solenoid for determining the operative position of said second valve, an electrical trip device for determining the activation of the solenoid, said device including a trip portion engageable by the grinding wheel support when the latter is actuated by the first motor to trip the control for movement of the valve to energize the second hydraulic motor, adjustable stop means positively to limit the movement of the grinding wheel support in a direction toward the work support, a tarry trip actuable by movement of the grinding wheel support, and connections between the tarry trip and the valve controlling solenoids to effect shifting of the valves to disconnect the hydraulic actuating medium from said first and second grinding wheel support actuating hydraulic motors.

33. In a grinding machine, the combination with a bed, of a work support carried thereby, a grinding wheel supported by the bed, means for effecting relative approach and retracting movement of the parts including a movable member mounting one of said elements, a hydraulic motor for effecting movement of the element with respect to the bed, and means for determining the extent of such movement including interengaging abutment members, one of such abutment members being carried by the bed and the other by the movable support, means for rigidly mounting one of said abutment members on its supporting element, the other abutment member including a sliding member having an L-shaped portion interlocking with the fixed abutment, screw means for effecting longitudinal sliding

movement of the abutment, said abutment having a transverse passage formed in the L-shaped portion thereof, a transversely shiftable locking member contained in the passage, said abutment having a longitudinal bore formed therein and a threaded clamp member extending through the bore into engagement with the locking member in the passage for forcing the latter into abutment locking position.

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