B. M. W. HANSON.

GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463.

Patented May 16, 1922.

11 SHEETS—SHEET 1.

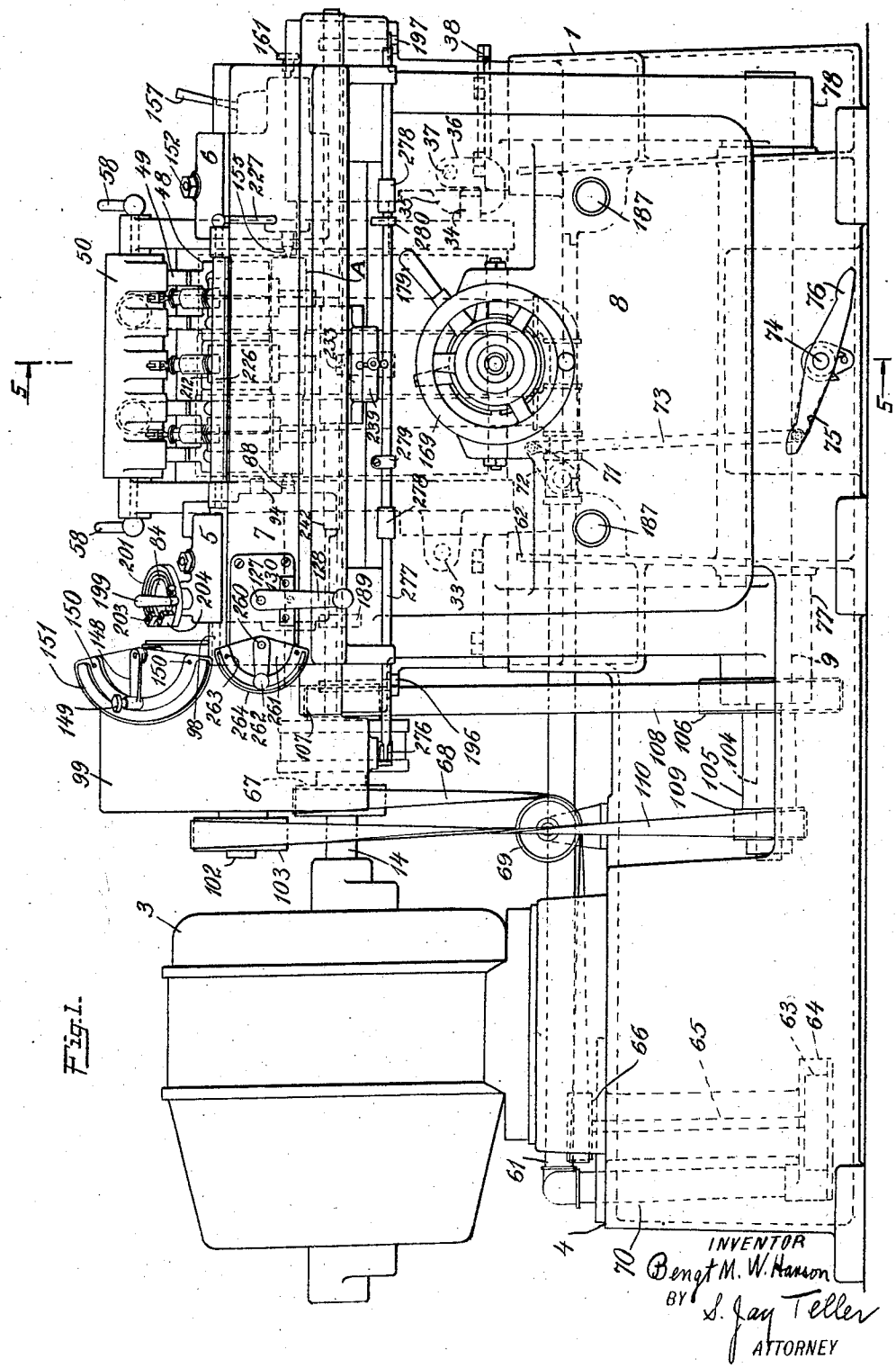


Fig. 1.

INVENTOR
Bengt M. W. Hanson
BY
S. Jay Teller
ATTORNEY

B. M. W. HANSON.

GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463. Patented May 16, 1922.

11 SHEETS—SHEET 2.

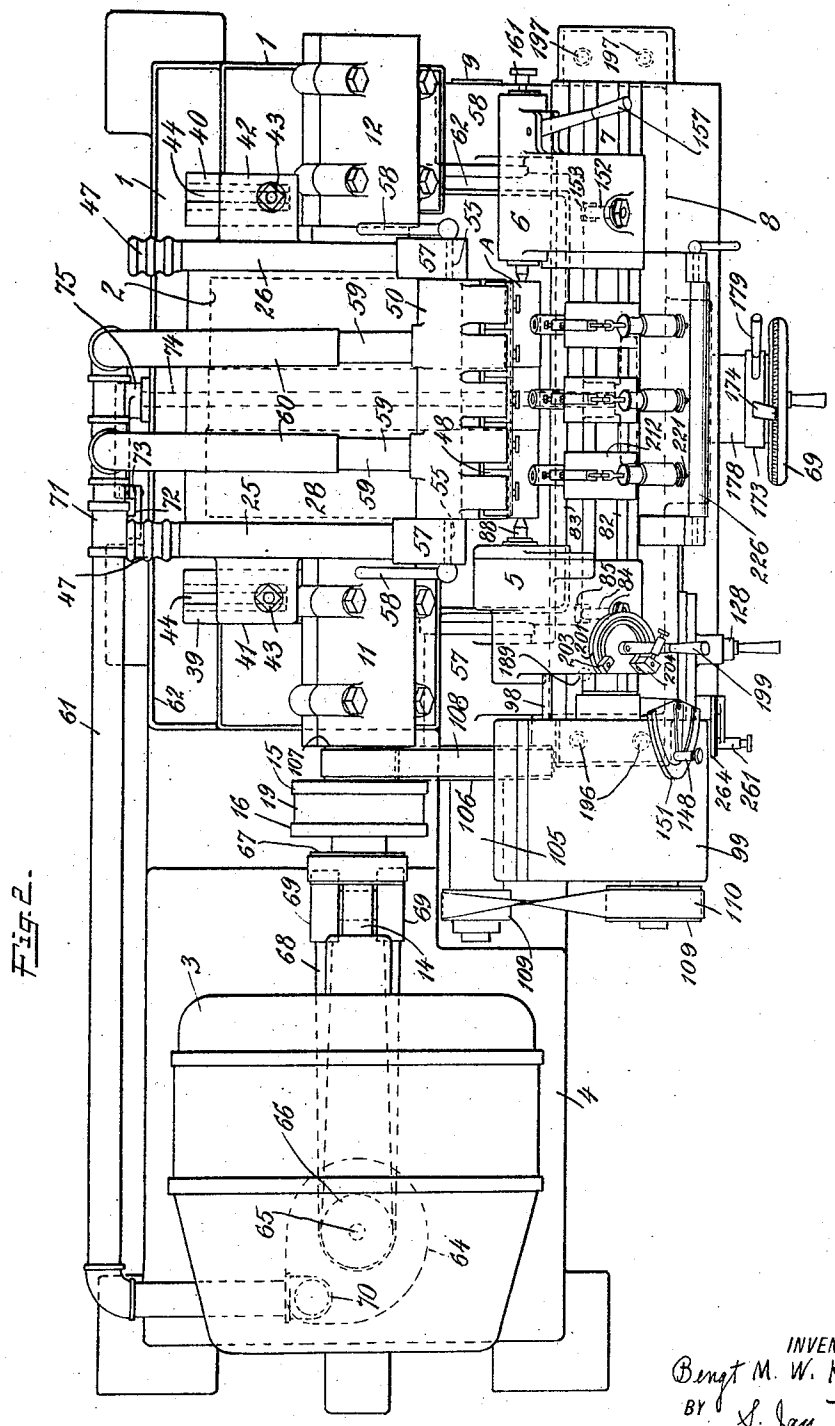


Fig. 2.

INVENTOR
Bengt M. W. Hanson
BY S. Jay Teller
ATTORNEY

B. M. W. HANSON.

GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463. **Patented May 16, 1922.**

11 SHEETS—SHEET 3.

Fig. 3.

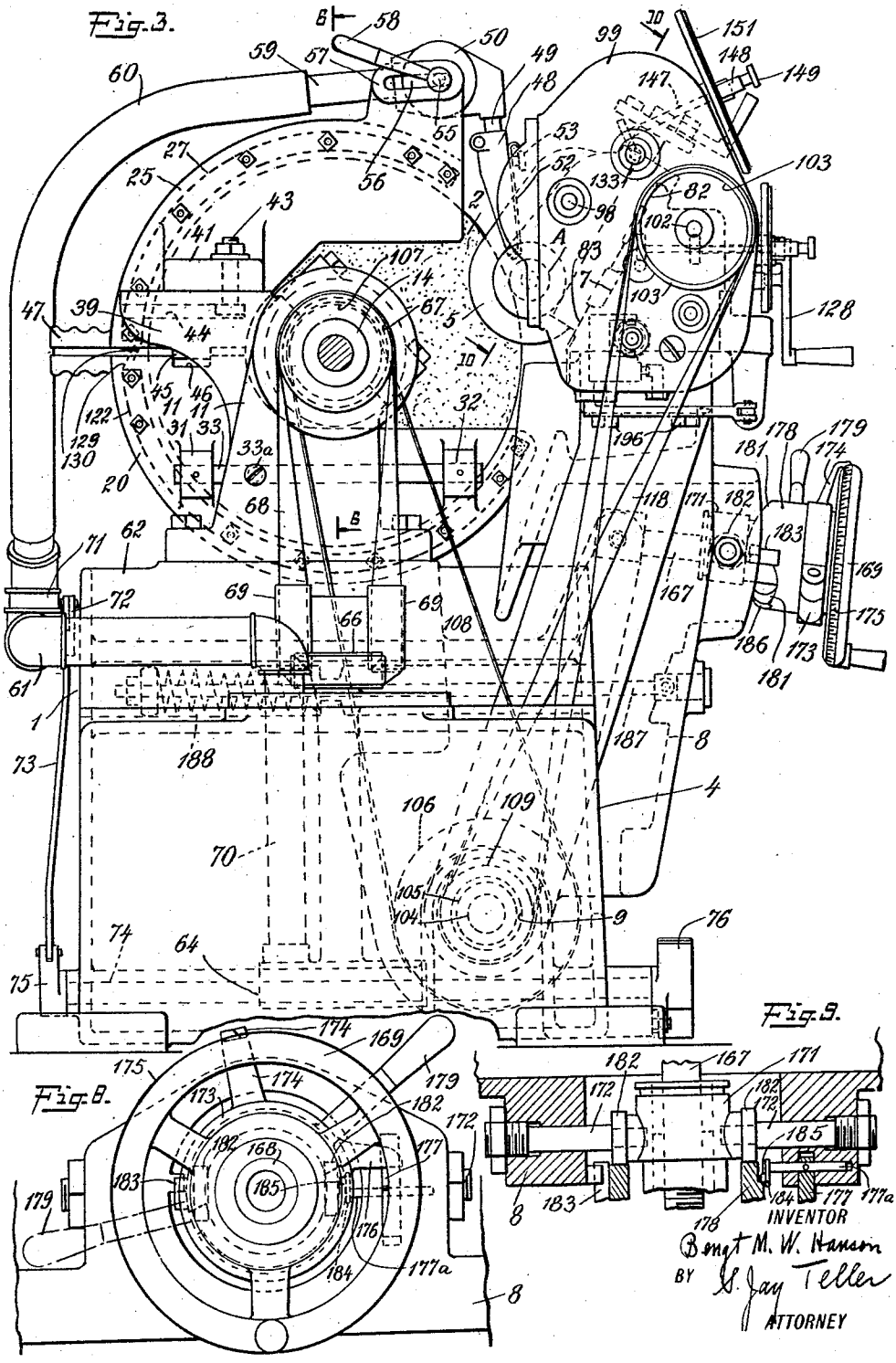


Fig. 8.

Fig. 9.

INVENTOR

Bengt M. W. Hanson

BY G. Jay Teller

ATTORNEY

B. M. W. HANSON.

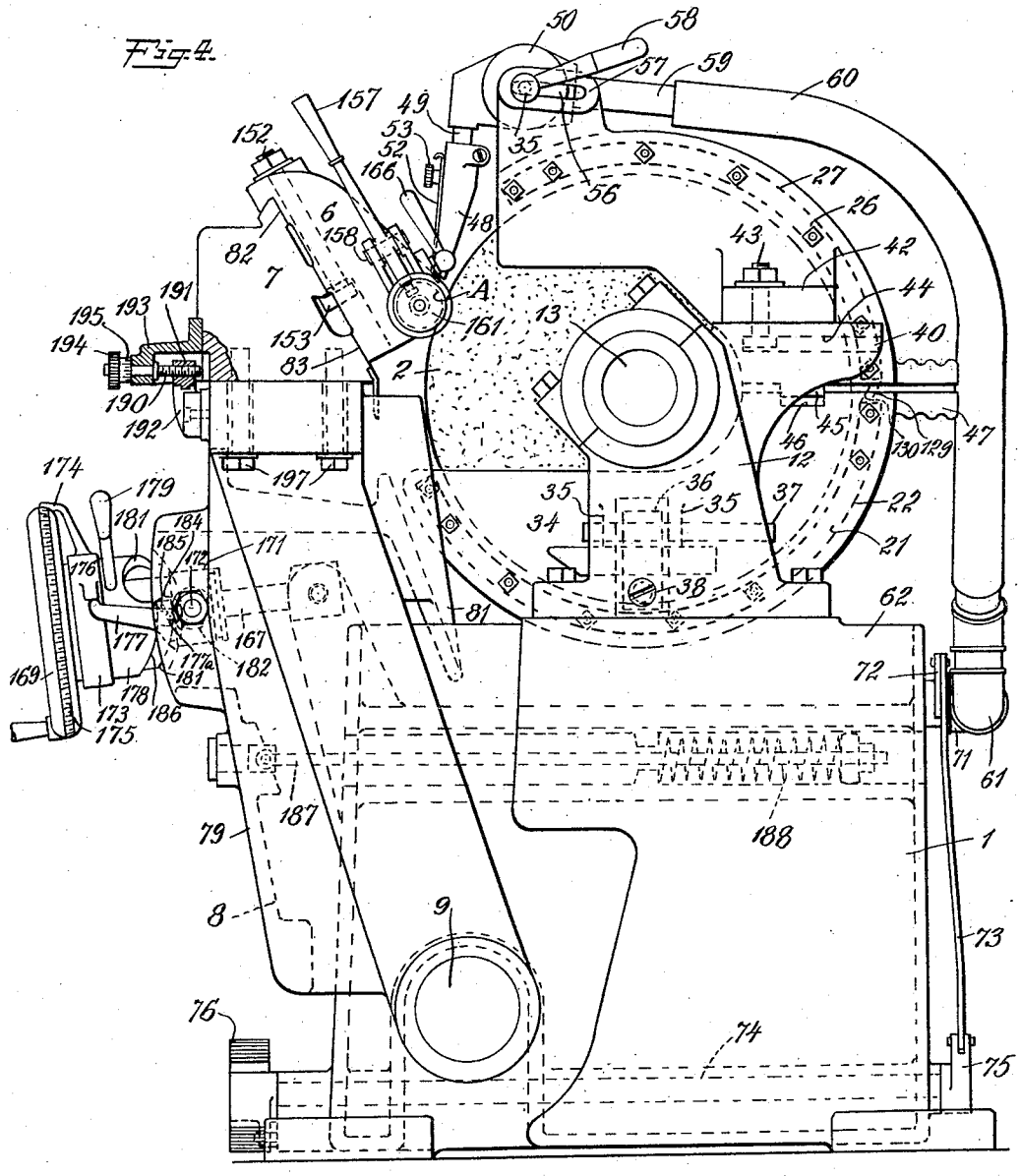
GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463. **Patented May 16, 1922.**

11 SHEETS—SHEET 4.

Fig. 4.



INVENTOR

Bengt M. W. Hanson

BY S. Jay Teller

ATTORNEY

B. M. W. HANSON.

GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463.

Patented May 16, 1922.

11 SHEETS—SHEET 5.

Fig. 5.

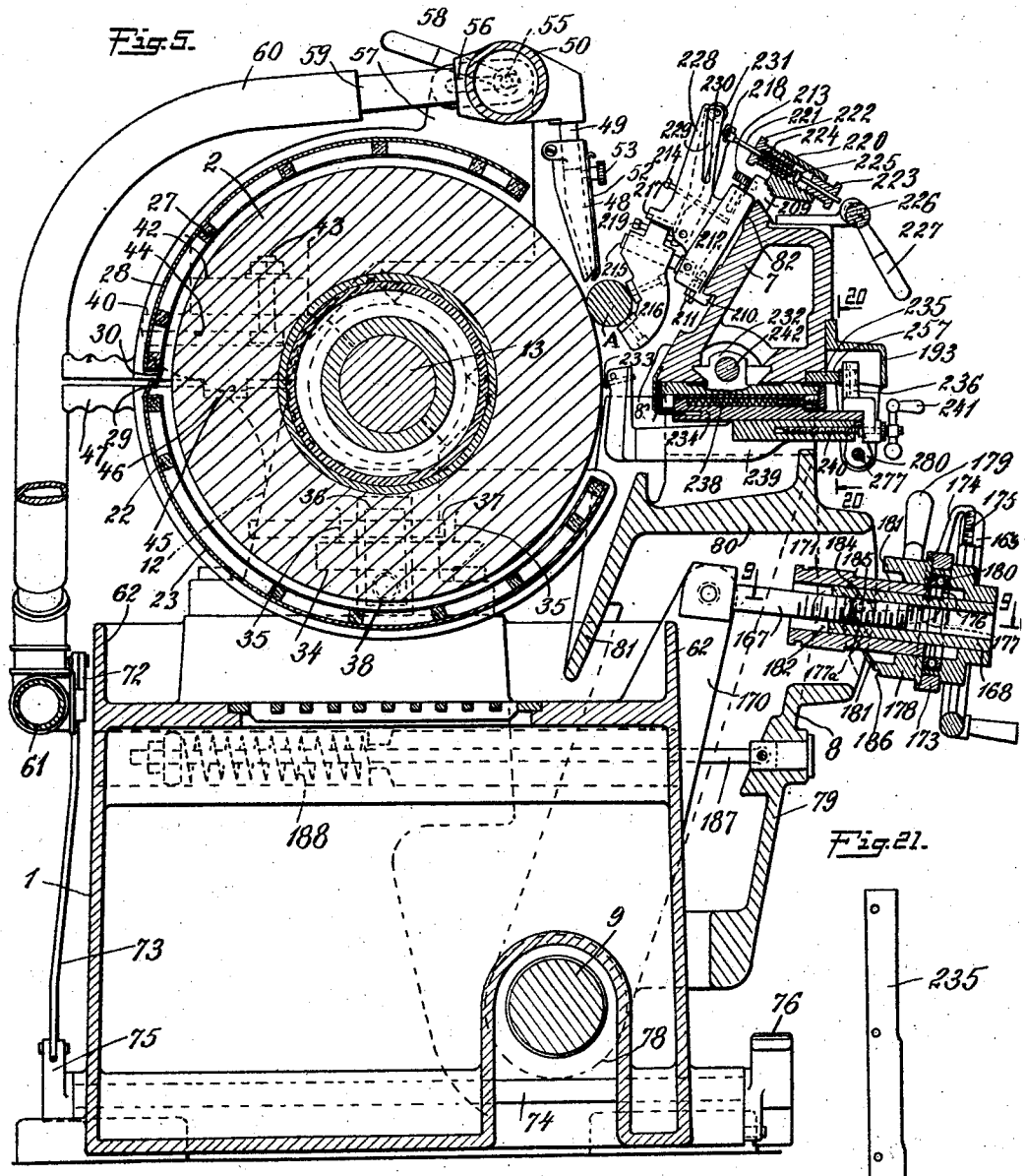
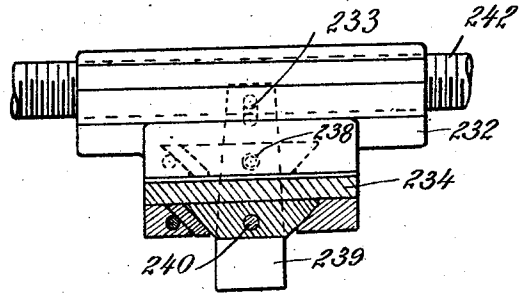


Fig. 21.

Fig. 20.



INVENTOR

Bengt M. W. Hanson

BY S. Jay Teller

ATTORNEY

B. M. W. HANSON.

GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463.

Patented May 16, 1922.

11 SHEETS—SHEET 6.

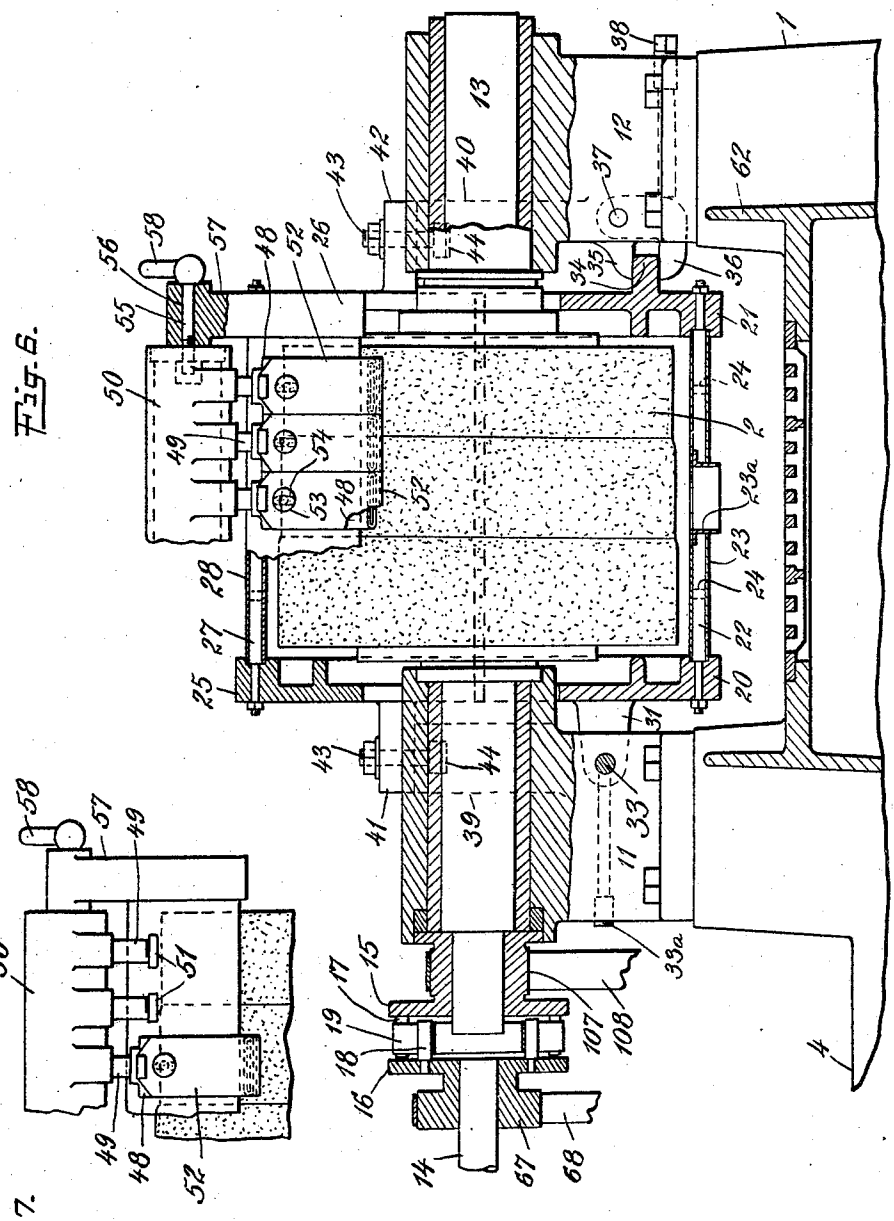


Fig. 6.

Fig. 7.

INVENTOR

Bengt M. W. Hanson

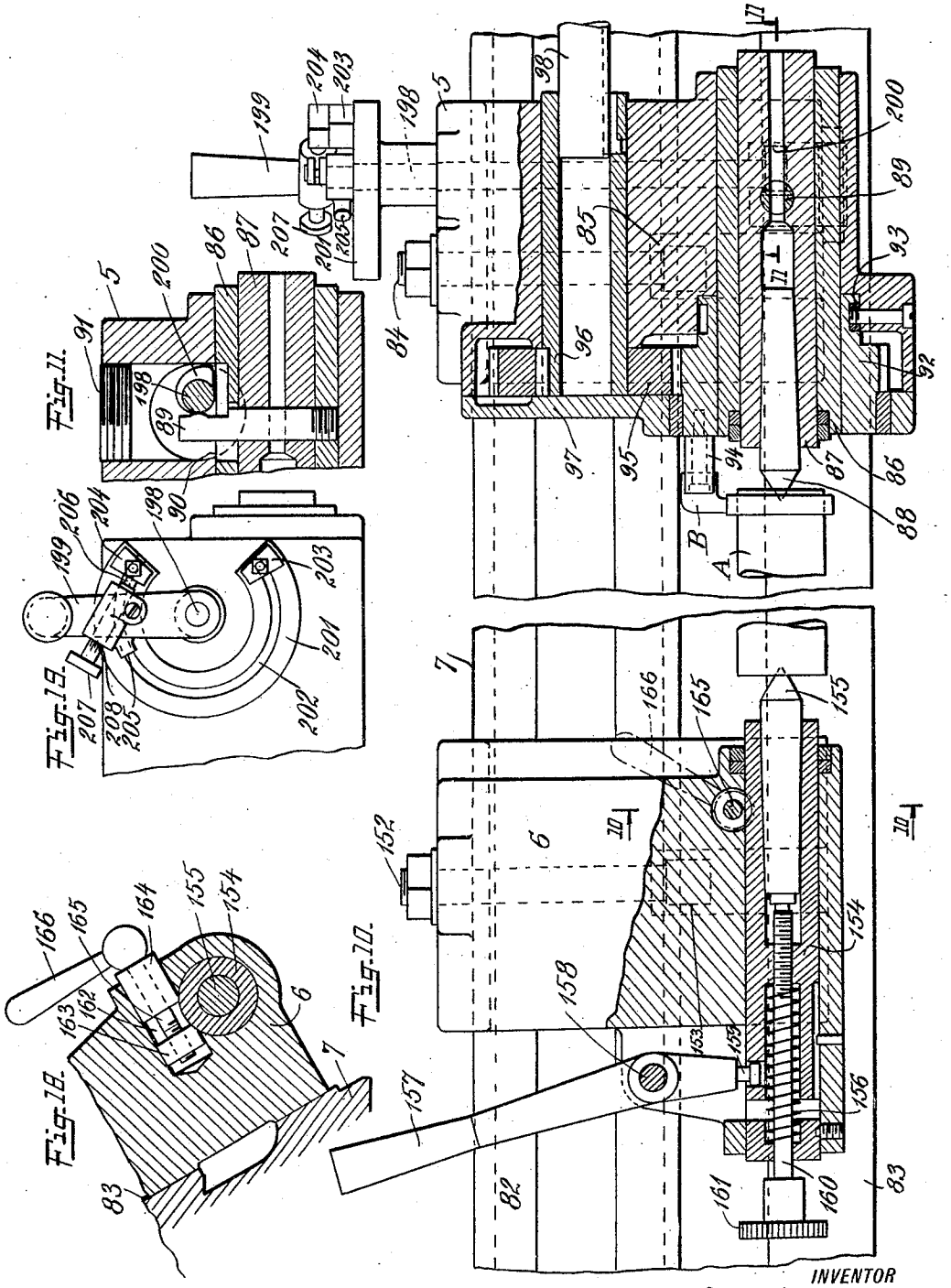
BY S. Jay Teller

ATTORNEY

B. M. W. HANSON.
GRINDING MACHINE.
APPLICATION FILED JULY 31, 1918.

1,416,463. **Patented May 16, 1922.**

11 SHEETS—SHEET 7.



INVENTOR
Benjt M. W. Hanson
BY S. Jay Teller
ATTORNEY

B. M. W. HANSON.

GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463.

Patented May 16, 1922.

11 SHEETS—SHEET 8.

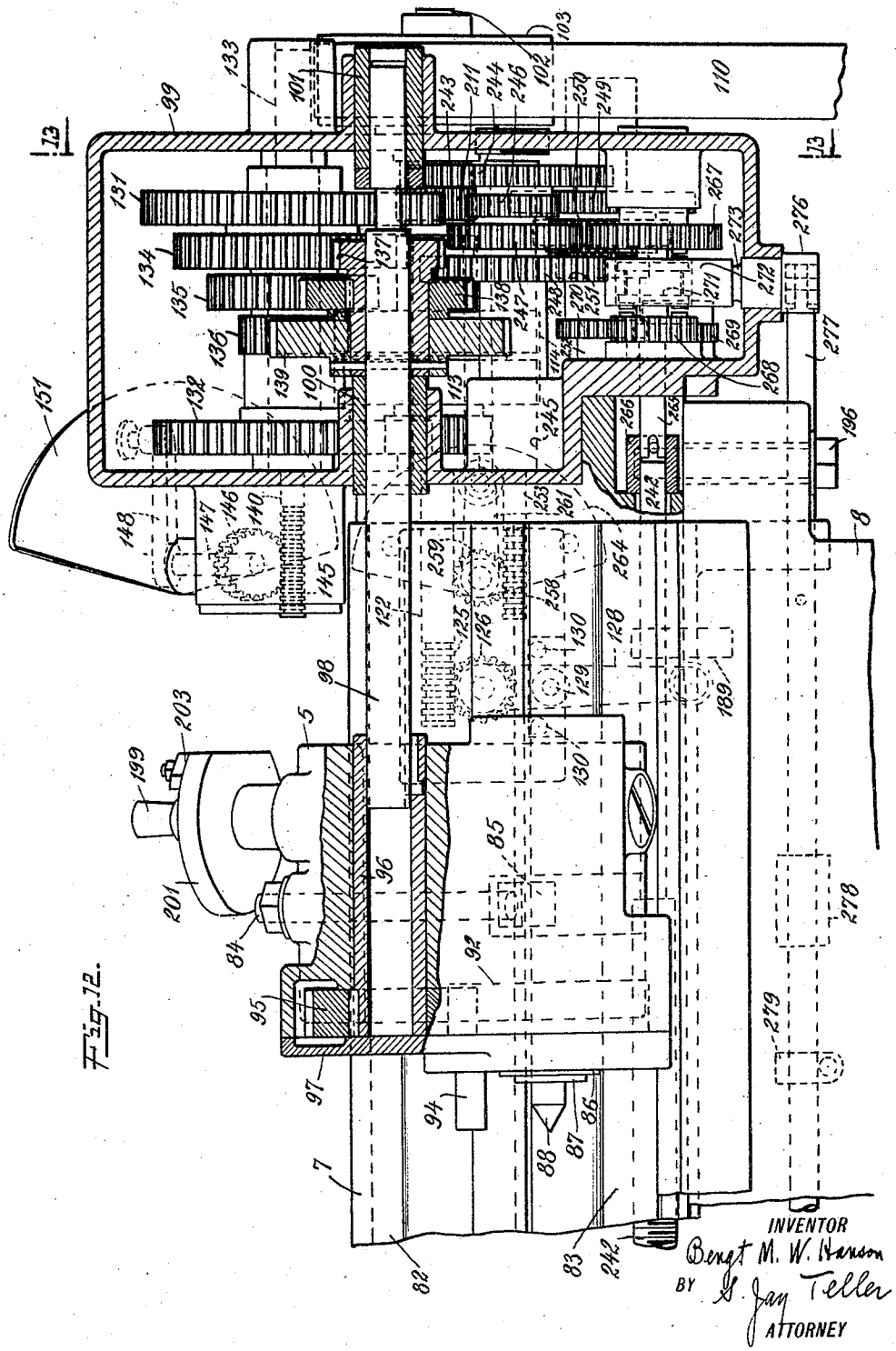


Fig. 12.

INVENTOR

Bengt M. W. Hanson

BY S. Jay Teller

ATTORNEY

B. M. W. HANSON.

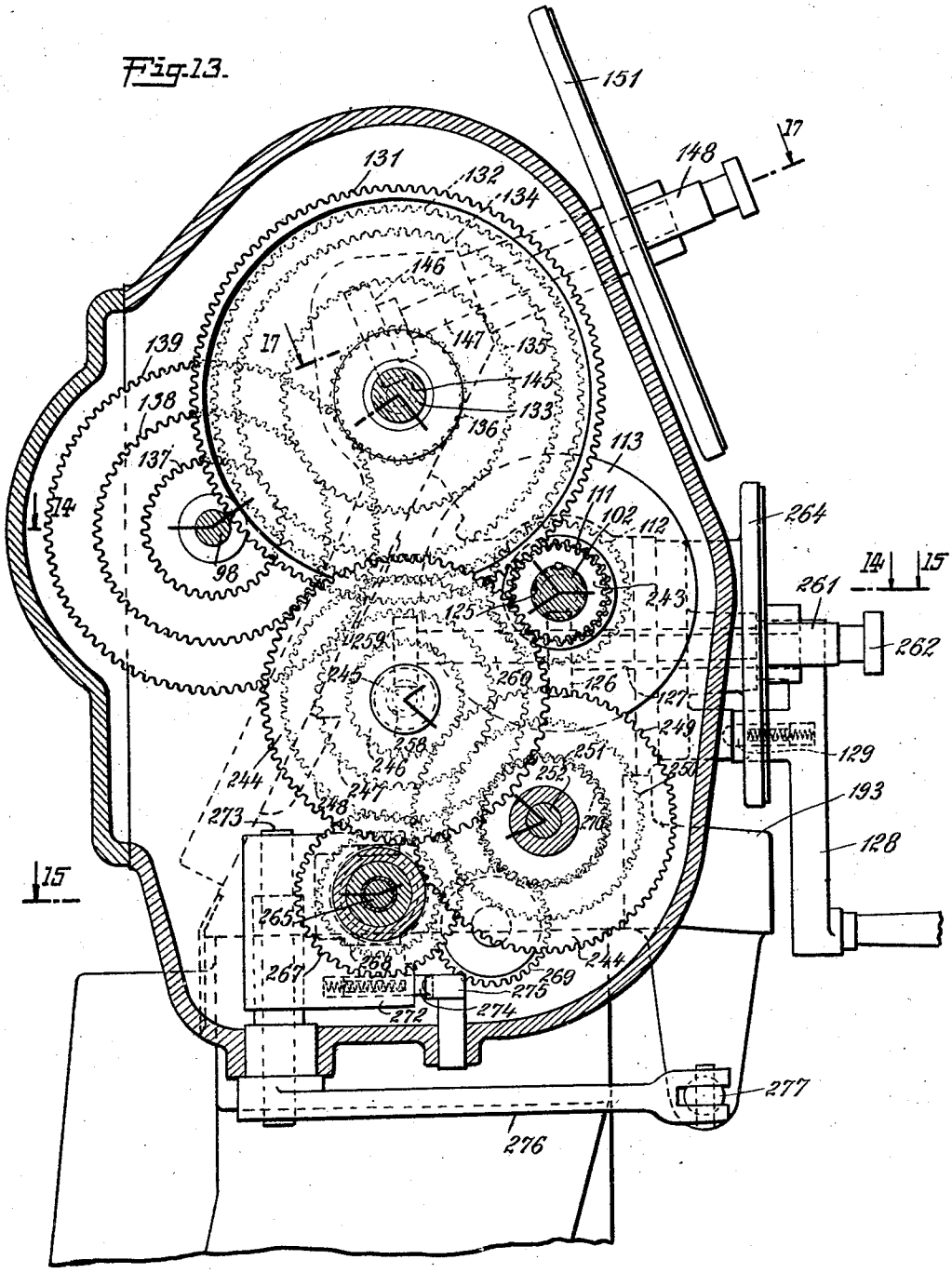
GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463. **Patented May 16, 1922.**

11 SHEETS—SHEET 9.

Fig. 13.



INVENTOR

Bengt M. W. Hanson

BY S. Jay Teller

ATTORNEY

B. M. W. HANSON.

GRINDING MACHINE.

APPLICATION FILED JULY 31, 1918.

1,416,463. **Patented May 16, 1922.**

11 SHEETS—SHEET 10.

Fig. 14.

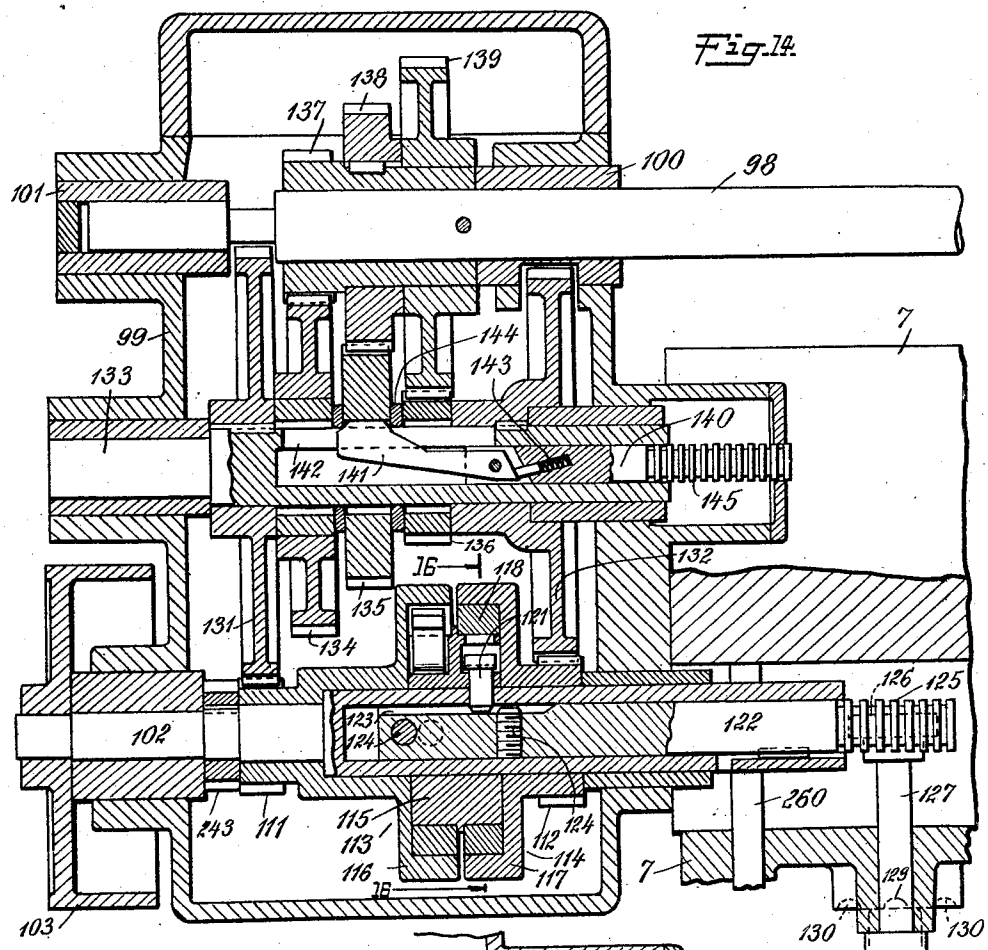


Fig. 16.

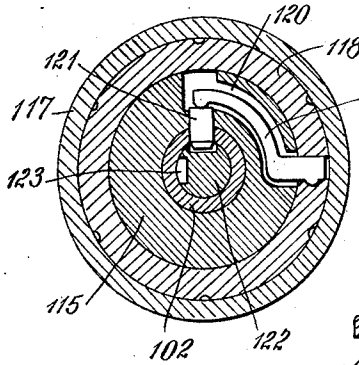
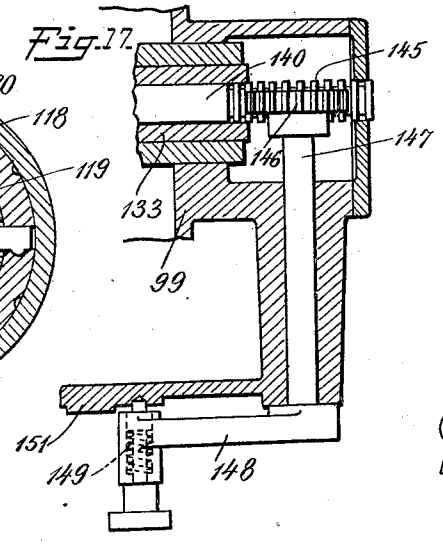


Fig. 17.



INVENTOR

Bengt M. W. Hanson

BY S. Jay Teller

ATTORNEY

B. M. W. HANSON.

GRINDING MACHINE.

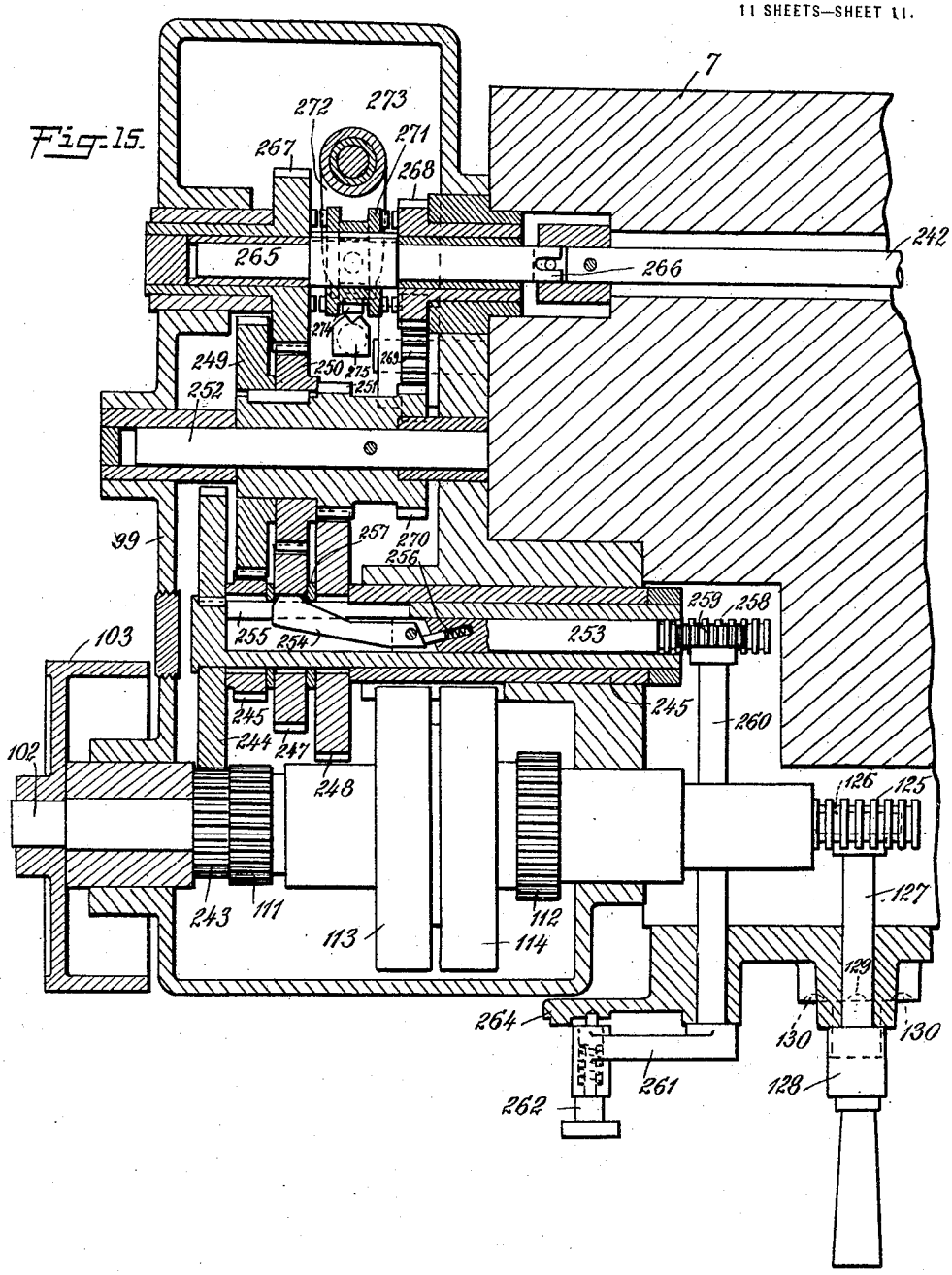
APPLICATION FILED JULY 31, 1918.

1,416,463.

Patented May 16, 1922.

11 SHEETS—SHEET 11.

Fig. 15.



INVENTOR

Bengt M. W. Hanson.

BY S. Jay Teller

ATTORNEY

UNITED STATES PATENT OFFICE.

BENGT M. W. HANSON, OF HARTFORD, CONNECTICUT, ASSIGNOR TO PRATT & WHITNEY COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

GRINDING MACHINE.

1,416,463. Specification of Letters Patent. Patented May 16, 1922.

Application filed July 31, 1918. Serial No. 247,634.

To all whom it may concern:

Be it known that I, BENGT M. W. HANSON, a citizen of the United States, residing at Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Grinding Machines, of which the following is a specification.

The invention relates to grinding machines of the type set forth in my copending application for grinding machines, Serial No. 247,632, filed on even date herewith. Machines of this type are adapted for grinding cylindrical bodies or other bodies which are circular in cross section but which have different diameters at different points. A machine embodying the invention is provided with a broad faced wheel having a width equal to or exceeding the length of the work to be ground.

One of the objects of the present invention is to provide an improved means for rotating the work during grinding. Another object of the invention is to provide improved means for controlling and directing the delivery of water to the grinding zone. Another object of the invention is to provide, in combination with other features, improved means for dressing the grinding wheel to any desired contour. Further objects of the invention will be apparent from the following specification and claims.

In the accompanying drawings I have shown the embodiment of the invention which I now deem preferable, but it will be understood that the drawings are to be considered as merely illustrative and are not to be construed as defining or limiting the scope of the invention, the accompanying claims being relied upon for that purpose:

Of the drawings:

Fig. 1 is a front elevation.

Fig. 2 is a plan view.

Fig. 3 is an end view on an enlarged scale taken from the left, the motor being removed.

Fig. 4 is an end view on the same scale as Fig. 3 taken from the right.

Fig. 5 is a vertical sectional view on the same scale as Figs. 3 and 4 taken along the line 5—5 of Fig. 1.

Fig. 6 is a fragmentary vertical sectional view taken along the line 6—6 of Fig. 3.

Fig. 7 is a fragmentary view similar to the upper right-hand part of Fig. 6 but showing a modified arrangement of parts.

Fig. 8 is an enlarged front view showing the mechanism for swinging the work carrying frame.

Fig. 9 is a fragmentary sectional view taken along the line 9—9 of Fig. 5.

Fig. 10 is a fragmentary sectional view taken along the line 10—10 of Fig. 3.

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

Fig. 12 is a fragmentary rear view, partly in section and partly in elevation, showing the headstock and parts of the gearing associated therewith.

Fig. 13 is a vertical sectional view taken along the line 13—13 of Fig. 12.

Fig. 14 is a sectional view taken along the broken line 14—14 of Fig. 13.

Fig. 15 is a sectional view taken along the broken line 15—15 of Fig. 13.

Fig. 16 is a detail sectional view taken along the line 16—16 of Fig. 14.

Fig. 17 is a fragmentary sectional view taken along the line 17—17 of Fig. 13.

Fig. 18 is a detail view taken along the line 18—18 of Fig. 10.

Fig. 19 is a detail view showing the mechanism for moving the headstock center.

Fig. 20 is a fragmentary sectional view taken along the line 20—20 of Fig. 5.

Fig. 21 is a detail view of the former.

A machine embodying the invention comprises a main frame 1 upon which is mounted a grinding wheel 2 rotatable about a longitudinal horizontal axis. The wheel has a broad working face which preferably extends the full length of the work to be ground. Mechanism is provided for rotating the wheel, this consisting in the present instance of an electric motor 3 mounted on an extension 4 of the main frame. The machine is primarily intended for grinding work which is circular in cross section, but its use is not necessarily limited to the grinding of work of this character. There is provided a suitable work support for holding the work to be ground, such as shown at A. Preferably the work support comprises centers carried respectively, by a headstock 5 and a tailstock 6, which are longitudinally adjustable along horizontal ways formed on a table 7. Means is provided for causing relative approaching and separating movements between the work

support and the wheel for initially bringing the work into contact with the wheel and for feeding. In order to provide a rigid support for the wheel which will hold it against vibration, and in order that the wheel may be directly connected with the motor I prefer to mount the wheel in fixed bearings and to move the work support toward and from the wheel. When the wheel is thus mounted the table 7 is carried by a frame 8 which is moved to bring the work into or out of operative engagement with the wheel. Preferably this frame is pivoted near its bottom to the main frame 1, as, for instance, by means of a bearing shaft or trunnion 9, which extends from one end of the frame to the other.

Having now briefly outlined some of the more important elements of the machine, I will now proceed to a more detailed description of the several parts.

As shown most clearly in Fig. 6, there are provided two bearing brackets 11 and 12 which project upward from the main frame 1 and which carry a rotatable spindle 13. Secured to this spindle, by any usual or preferred means, and positioned between the bearings, is the aforesaid grinding wheel 2. The motor 3 is mounted with its drive shaft 14 in alinement with the spindle 13, and carried respectively by the spindle 13 and the shaft 14 are flanges 15 and 16. The flanges are provided respectively with oppositely projecting pins 17 and 18 and an endless flexible belt 19 is laced back and forth over the pins 17 and 18. The mechanism which I have described constitutes a yieldable flexible coupling between the shaft 14 and the spindle 13.

I provide a suitable guard which partly surrounds the grinding wheel. As concerns many of the features of the invention the guard can be of any usual or preferred construction, but I prefer a guard such as is shown in the drawings and will be described.

The guard is constructed in a manner to provide a high tensile strength which will enable it to resist breakage in case of breakage of the grinding wheel. Preferably this tensile strength is provided by forming the sides of the guard of sheet metal. By preference in order that the guard may be easily opened to permit access to the wheel it is formed with a top section which is readily separable from the bottom section.

As illustrated, the lower section comprises two similar oppositely disposed end plates 20 and 21 positioned adjacent the bearing brackets 11 and 12 respectively. These plates 20 and 21 are connected by rods 22 which extend through suitable apertures in the plates, these apertures being spaced at intervals along the outer edges. Preferably, as shown in Fig. 5, the portions of the rods 22 between the plates are square. A double sheet metal casing 23 is secured to these rods, this casing preferably consisting of a single sheet of metal which extends from the rear and engages the outer surfaces of the several rods and is looped around the front rod. From this front rod the sheet extends rearward engaging the inner surfaces of the rods. The sheet metal is secured to the rods in any suitable manner, as, for instance, by means of rivets 24 extending through apertures in the rods. Preferably the end plates 20 and 21 are provided with grooves, as shown in Fig. 6, into which the edges of the sheet metal 23 extend, thus making a tight joint. Preferably the lower section of the guard is provided with a drain aperture as shown at 23^a.

The upper section of the guard is constructed similarly to the lower section, this upper section comprising end plates 25 and 26 which are connected by rods 27. Secured to the rods 27 is a sheet metal casing 28 similar to the sheet metal casing 23 already described. The two sections of the guard are separated at their front edges, as shown, to provide access to the wheel, but their rear edges are closely adjacent. Preferably the sheet metal of the two casing sections is extended, as shown at 29 and 30, to overlap and prevent the escape of water between the two sections.

In order that the guard may be moved to accommodate wheels of different diameters and to compensate for changes in the diameter of a single wheel due to wear, I provide means whereby both sections of the wheel may be moved backward or forward.

The end plate 20 of the lower section of the guard is provided with apertured ears 31 and 32 which carry a horizontal pin 33. The pin extends through a bearing aperture in the body part of the bearing bracket 11. The opposite end plate 21 is provided with a horizontal lug 34 which fits between lugs 35 carried by the bearing bracket 12 and a latch 36 pivoted to the bearing bracket at 37. As shown in Fig. 3, the length of the pin 33 between the ears 31 and 32 is considerably greater than the width of the bearing bracket 11, thus permitting the pin to slide in the aperture. The construction at the right-hand end also permits forward and backward movement and the entire lower section can thus be adjusted. After adjustment the section can be locked in adjusted position by means of a screw 33^a which engages the pin 33 and by means of a screw 38 which engages the latch 36 and forces it into firm engagement with the lug 34.

The upper section of the guard is preferably supported entirely independently of the lower section. As illustrated extensions 39 and 40 are formed respectively on the bearing brackets 11 and 12. The plates 25 and 26 are provided respectively with lugs

41 and 42 which rest on these extensions and are capable of sliding movement therealong. Each of the lugs is provided with a T-bolt 43 which engages a T-slot 44 in the corresponding extension. By means of these T-bolts the upper section of the guard can be secured in place after adjustment. It will be noted that by removing the nuts on the T-bolts 43 the entire upper section of the guard is loosened so that it can be freely removed to expose the wheel and to permit the wheel with its spindle to be taken out if necessary.

Preferably interlocking means are provided for insuring the uniform movement of the two guard sections forward and backward. As illustrated, this interlocking means comprises projections 45 on the upper plates 25 and 26, these projections extending into grooves 46 in the lower plates 20 and 21.

For convenience in moving the guard forward or backward, there are preferably provided two handles 47. Each of the handles is constructed in two parts formed respectively on the upper and lower plates of the guard.

In order that water may be delivered to the grinding wheel and uniformly distributed along its entire length, I provide a series of nozzles 48 as shown clearly in Figs. 2 and 6. It will be observed that these nozzles are provided with elongated discharge orifices and that the nozzles are placed close together so as to provide a substantially continuous sheet of water from one end of the wheel to the other. These nozzles are connected, by means of short nipples 49, with a manifold 50 which extends the entire length of the wheel.

If a wheel 2 is to be used which is shorter than the full length for which the machine is designed, one or more of the nozzles 48, at either or both ends, may be removed as indicated in Fig. 7. In this case the corresponding nipples 49 are closed by means of caps 51.

In order that the stream of water may be confined and directed more accurately to the grinding zone, I preferably provide each nozzle 48 with a sheet metal guide 52. This is turned inward at its lower edge as shown in Fig. 5. The guide is held in place by means of a screw 53 which extends through a vertical slot 54, thus permitting vertical adjustment.

The manifold 50 is supported by means of screws 55, 55 which extend respectively through slots 56, 56 formed in brackets 57, 57 carried respectively by the end plates 25 and 26 of the guard. These slots permit the manifold with the nozzles to be moved circumferentially of the wheel. In this way the nozzles can be adjusted in accordance with the diameter of the work being ground. After adjustment the manifold with the nozzles can be clamped in adjusted position by tightening the screws 55, 55 by means of handles 58, 58 secured to the ends thereof. Inasmuch as the nozzles 48 are carried by the guard, it will be clear that they will be moved forward or backward to accommodate wheels of different diameters when the guard is moved. When the upper section of the guard is taken off to expose the wheel the manifold and the nozzles are carried with it.

Water is supplied to the manifold 50 through two pipes 59 which are connected by means of flexible hose sections 60, 60 with a supply pipe 61. Water may be supplied to the pipe 61 from any desired source, but I prefer to provide a pump which is constructed and connected as a permanent part of the machine. As illustrated, the extension 4 of the main frame which carries the motor 3 is constructed in the form of a tank arranged to receive the water which is discharged from the wheel. For guiding the water into the tank the main frame is provided with edge flanges 62, 62. Positioned in the tank is a pump which is preferably of the centrifugal type. The rotor 63 of the pump is positioned in a casing 64 and is connected with a vertical drive shaft 65 which carries at its upper end a belt pulley 66. A belt pulley 67 is mounted on the motor shaft 14 and a belt 68 passes over and around the two pulleys 66 and 67 to transmit power from the frame to the latter. Suitable idler pulleys 69, 69 are provided for guiding the belt. The discharge side of the pump is connected by means of a pipe 70 with the aforesaid supply pipe 61. By means of this construction water may be supplied under proper pressure to the manifold 50 and to the nozzles whenever the machine is in operation.

By preference, I provide means whereby the operator can readily control the flow of water. For this purpose I provide a valve 71 in the pipe 61. The valve has an operating lever 72 to which is pivotally connected a link 73. Extended from the front of the machine to the back near the bottom is a rock shaft 74. At its rear end the rock shaft is provided with an arm 75 connected with the lower end of the link 73. At its front end the rock shaft is provided with a double foot treadle 76 by means of which the shaft can be turned in either direction to open or close the valve and start or stop the flow of water.

As already stated, the machine is provided with a swinging frame 8 which carries the work. The frame is provided at its ends with two large depending lugs 77 and 78 which are connected with the aforesaid trunnion 9. The trunnion is seated in suitable bearing apertures in the main frame. The swinging frame 8 is preferably of skeleton construction, having a thin front plate 79

which joins near its top with a horizontal plate 80. A plate or apron 81 extends diagonally downward from the inner edge of the plate 80 and overlaps the front flange 62 on the main frame, as clearly shown in Fig. 5. This apron assists in preventing the escape of water and serves to guide it downward into the space between the flanges 62. The table 7 is supported above the plate 80 and between the table and the plate there is provided a long clear open space for a purpose which will presently appear.

The table 7 is provided with longitudinal ways 82 and 83. The headstock 5 is slidably mounted on the ways 82 and 83 and is adapted to be held in place and clamped by means of a bolt 84 having an enlarged head 85 engaging the lower inner side of the way 83. As shown most clearly in Fig. 10, the body of the headstock carries a longitudinal bushing 86 which is fixed against relative movement. Mounted in the bushing 86 is a sleeve 87 which carries a center 88 adapted to engage and support one end of the work. The sleeve 87 is preferably longitudinally slidable and is held against rotative movement by means of a pin 89 which enters a slot 90 in the bushing 86. The wall of the body part of the headstock is provided with an aperture through which the pin 89 may be put in place or removed, this aperture being normally closed by a plug 91.

The headstock is provided with power operated means for rotating the work. Preferably this comprises a gear 92 rotatably mounted on the bushing 86. The hub of the gear is extended toward the right and is provided with an annular groove into which fits a shoe 93 serving to hold the gear in place. The hub of the gear is also extended toward the left and carries a pin 94 adapted to engage a dog B secured to the work A. The gear 92 meshes with a gear 95 mounted on a rotatable sleeve 96. Preferably a plate 97 is provided for covering the two gears. The sleeve 96 is rotatable in a suitable bearing aperture in the body of the headstock and is splined to a longitudinal shaft 98. Mounted on the end of the table 7 is a housing 99 into which the shaft 98 extends having bearings at 100 and 101. The splined connection between the shaft 98 and the sleeve 96 permits the headstock to be adjusted along the table without interfering in any way with the power connection.

Rotatably mounted in the housing 99 is a drive shaft 102. This shaft at its left-hand end projects outside of the housing and carries a belt pulley 103. As indicated in Fig. 1, the trunnion 9 is provided at its left-hand end with an extension 104 upon which is rotatably mounted a sleeve 105. This sleeve carries a belt wheel 106 which is in register with a belt wheel 107 on the grinding wheel spindle 13. A belt 108 passes over and connects these two pulleys. Also connected to the sleeve 105 is a belt pulley 109 which is in register with the belt pulley 103 on the shaft 102. A belt 110 passes over and connects these two pulleys. It will be clear that by means of this construction power is transmitted from the spindle 13 to the shaft 102, the construction being such that the frame 8 may be swung without interfering in any way with the power connection.

Independently rotatably mounted on the shaft 102 are two differently diametered gears 111 and 112. Associated respectively with the gears 111 and 112 are clutches 113 and 114 by means of which either of the gears may be operatively connected with the shaft. Rigidly connected with the shaft is a hub 115 and connected respectively with the gears are annular flanges 116 and 117 which extend over and partly enclose the hub. As shown more clearly in Fig. 16, an expansible ring 118 is located in the space between the hub 115 and each of the flanges, as for instance the flange 117. A knuckle lever 119 is positioned within a slot 120 formed in the hub and the end portion of the lever extends into the space between the ends of the ring. Mounted in a radial aperture in the hub 115 is a plunger 121 adapted to engage the lever 119 and move it in such a manner as to expand the ring into frictional engagement with the flange 117, thus clutching the flange together with the attached gear to the shaft. The shaft 102 is provided with a longitudinal central aperture in which is slidably mounted a rod 122, this rod having longitudinal grooves 123 into which project the beveled ends of screws 124. The plungers 121 extend respectively into the aforesaid grooves 123 and are beveled at their ends and are adapted to be engaged respectively by the ends of the screws 124 when the rod 22 is moved longitudinally. As shown, the rod 122 is in its central or neutral position, but it will be clear that by moving the rod in one direction or the other either of the screws 124 may be engaged with the corresponding plunger 121 to expand the corresponding ring and clutch the corresponding gear to the shaft. Formed at the left-hand end of the rod 122 is an annular rack 125 which meshes with a gear 126 mounted at the inner end of a rock shaft 127. This rock shaft has a bearing in the table 7 and is provided at its outer end with a hand lever 128. By means of this lever the rock shaft can be turned to move the rod 122 in one direction or the other and thus operate the clutches. Preferably the lever 128 is provided with a spring-pressed plunger 129 which is adapted to be seated in one or another of holes 130 formed in the table. The plunger cooperat-

ing with these holes serves to hold the lever either in its central neutral position or in one or the other of its operative positions.

The gears 111 and 112 mesh respectively with gears 131 and 132 which are secured to a shaft 133 rotatable in bearings in the housing 99. Loosely mounted on the shaft 133 are three differently diametered gears 134, 135 and 136 which mesh respectively with gears 137, 138 and 139 rigidly secured to the aforesaid shaft 98. The shaft 133 is provided with a longitudinal central aperture in which is slidably mounted a rod 140. Pivotally connected with the rod 140 is a key 141 which projects through a slot 142 in the shaft and is adapted to enter keyways formed in the gears 134, 135 and 136. A spring 143 tends to press the key into engagement with the gears. Between each two adjacent gears is a ring 144 which engages the key and swings it inward when it is being moved from one gear to the next, thus preventing the key from engaging two gears at the same time.

The rod 140 is provided with an annular rack 145 which meshes with a gear 146 on a rock shaft 147 which is shown clearly in Fig. 17. The shaft 147 is supported in a suitable bearing aperture in the housing 99 and is provided at its upper forward end with a hand lever 148. The hand lever 148 is provided with a spring-pressed plunger 149 adapted to enter notches 150 in a segment 151 carried by the housing. By adjusting the lever to seat the plunger in one or another of these notches, the key 141 may be moved into engagement with any one of the gears 134, 135 or 136.

It will be seen that by means of the clutches 113 and 114 the shaft 133 may be driven at either of two speeds. By means of the gears 134 to 139 the shaft 98 may be driven from the shaft 133 at any one of three relative speeds. It is possible, therefore, for the operator by properly manipulating the two levers 128 and 148 to cause the shaft 98 to be driven at any one of six speeds, as desired. Inasmuch as the shaft 98 serves to drive the work, the speed of the work may be changed in the manner stated.

The tailstock 6 is slidable along the aforesaid ways 82 and 83 on the table and the tailstock can be clamped in adjusted position by means of a bolt 152 having an enlarged head 153 engaging the lower inner side of the way 169. Carried by the body of the tailstock is a sliding sleeve 154 which carries a center 155 in alinement with the center 88. The outer end of the sleeve 154 is recessed to receive a spring 156 which normally tends to move the sleeve toward the headstock. For moving the sleeve in the opposite direction there is provided a lever 157 pivoted at 158 and provided with a finger 159 which engages the walls of an aperture in the sleeve. Preferably a screw 160 is threaded into the sleeve and is provided with a knob 161. This screw is used for ejecting the center 155 when necessary.

The machine is primarily intended for use in grinding a large number of pieces of the same character and size and when it is to be so used the headstock and the tailstock are first adjusted to the proper distance apart. The work to be ground is first dogged and then the dogged end is placed in engagement with the center 88. By means of the lever 157 the operator draws back the center 155 against the pressure of the spring 156. The work is then swung into alinement with the centers and the center 155 is permitted to move under the action of the spring into engagement with the work. In this way the work is engaged by the centers with predetermined pressure.

It is frequently possible to rely entirely upon the spring 156 for holding the center 155 in engagement with the work during grinding. It sometimes happens, however, for work requiring a heavy pressure against the grinding wheel, that it is desirable to firmly lock the tailstock center against any possible backward movement. A suitable locking mechanism is shown in Fig. 18. As illustrated, the tailstock casting is provided with an aperture 162 which intersects the aperture in which the sleeve 154 is positioned. Slidable within the aperture 162 are two shoes 163 and 164 which are adapted to engage the sleeve 154 as shown. A screw 165 has engagement with these two shoes and carries a handle 166 by means of which it may be turned to draw the shoes together. Thus the operator, by turning the handle 166 can move the two shoes toward each other and force them into engagement with the sleeve 154, thereby locking the sleeve and the center in adjusted position.

From the description that has already been given it will be understood that in the preferred embodiment of the invention the wheel is fixed against bodily movement and that the work is moved by means of the swinging frame into and out of engagement with the wheel. For swinging the frame to effect feeding I provide a draw bolt or screw 167 which extends through an aperture in the front of the frame. This screw engages a threaded nut 168 carrying a hand wheel 169. The inner end of the screw is horizontally pivoted to a bracket 170 carried by the main frame and projecting into the space between the plate 79 and the apron 81 of the swinging frame. The apron serves to prevent water from reaching the pivot for the screw. Surrounding the nut 168 is a sleeve 171 which is supported by pivot studs 172 extending inward from opposite sides of the aperture in the swinging frame, as

shown in Fig. 9. Suitable means is provided for connecting the threaded nut 168 and the hand wheel 169 with the swinging frame so that rotative movement of the wheel will serve to move the frame forward or backward on its pivotal axis as required. The operator, by turning the hand wheel 169, can change the position of the frame as required to move the work into or out of engagement with the grinding wheel and to feed the work during the grinding operation. Preferably, in order that the amount of feed may be accurately observed, there is provided a ring 173 which has frictional engagement with an annular flange on the hand wheel. The ring 173 carries a pointer 174 which cooperates with a scale 175 on the periphery of the wheel. The ring 173 also carries a finger 176 which is adapted to engage a stop 177 which projects outward from the swinging frame. In practice, the operator turns the hand wheel in the clockwise direction until the work is brought into contact with the wheel and is reduced to the required size. In turning, the finger 176 comes into contact with the stop 177 and thereafter the ring 173 slips on the flange of the hand wheel and remains stationary. When grinding is completed the wheel is turned in the counterclockwise direction to remove the work from contact with the wheel and the finished work is removed. When a new piece is put in place to be ground the operator again turns the hand wheel in the clockwise direction until the finger 176 again engages the stop 177. The engagement of the finger with the stop constitutes notice to the operator that the work is ground approximately to the required size. If it is found that because of wear of the wheel or for some other reason further grinding is required, this can be effected by still further turning the hand wheel, the amount of turning being measured by the graduations of the scale 175.

As already stated, the grinding wheel 2 extends substantially the entire length of the work, and for this reason it is difficult for the operator to remove the finished work and put a new piece in place when the work is close to the wheel. There is danger that the operator will accidentally engage the work with the wheel in putting it in or taking it out and thus mar it, and there is further danger that he will allow his hands to contact with the wheel, thus seriously injuring himself. In order to avoid these difficulties, I have provided means whereby the swinging frame may be moved quickly through a considerable angle to remove the axis of the centers from the wheel a distance sufficient to enable the operator to put the work in place and remove it with entire safety.

With this end in view the connection between the nut 168 and the sleeve 171 preferably comprises means whereby relative movement may be effected without turning the nut. In the preferred embodiment of the invention, I provide a cam collar 178 which is rotatably and relatively slidably mounted on the sleeve 171 and which is provided with a handle 179 by means of which it may be turned. The collar 178 at its outer end is associated with the hand wheel 169, a ball bearing 180 preferably being interposed. At its inner end the collar 178 is provided with two oppositely positioned similarly formed cam surfaces 181. These two surfaces respectively engage rollers 182 carried by the aforesaid studs 172. When the cam collar 178 is in the position shown in Figs. 5 and 8 the highest points of the cam surfaces are in engagement with the rollers, and in this way the swinging frame is supported in its normal operative position. By moving the handle 179 to the position indicated by dotted lines in Fig. 8, the rollers will be made to travel relatively downward along the cam surfaces 181, thus preventing the frame to swing outward and separate the axis of the centers from the wheel. It will be noted that the hub of the hand wheel is recessed to permit the outer end of the sleeve 171 to travel outward without interference when the cam collar 178 is turned. After the finished work has been taken out and a new piece put in, the handle 179 is returned to the position shown by full lines in Fig. 8, thus restoring the table to exactly its former position. Preferably, as shown in Figs. 3, 8 and 9, the cam collar 178 carries a stop 183 which serves to accurately limit the movement of the collar and of the handle in the clockwise direction.

By preference the aforesaid stop 177 is not rigidly secured to the swinging frame but is pivotally mounted by means of a pivot pin 177^a. This pivot pin carries a crank arm 184 having a finger 185. The finger 185 engages a cam surface 186 formed on the cam collar 178. The cam surface 186 is so shaped that it engages the finger 185 and turns the pin 177^a to swing the stop 177 upward whenever the collar 178 is turned to swing the frame backward. Thus when the table is moved to its outer position the stop 177 is automatically swung upward out of the path of the finger 176. This permits the hand wheel 169 to be turned indefinitely in either direction for additional movement of the swinging frame without disturbing in any way the adjustment of the friction ring 173 and of the finger 176 carried thereby. When the collar 178 is turned to swing the frame forward the stop 177 may be returned to operative position.

Preferably, in order to partly counterbalance the weight of the swinging frame

and of the parts attached thereto, I provide two links 187 which are pivoted to the swinging frame at their front ends and which are engaged at their rear ends by coil springs 188. These springs serve to tension the links and to apply to the frame a force tending to swing it upward and rearward. This construction enables the operator to more easily swing the frame by means of the handle 179.

Preferably the table 7 is not fixedly connected to the swinging frame but is adjustably connected thereto so as to be capable of a slight pivotal movement about a pivot pin 189 shown by dotted lines in Fig. 1. For swinging the table about this pivot there is provided a screw 190 threaded into a nut 191 which is held against rotation and which has a tongue-and-groove engagement with a bracket 192 carried by the swinging frame. The screw extends through a bearing aperture in a bracket 193 carried by the table and is held against longitudinal movement with respect to the bracket. The screw carries a knob at 194 for turning it. By turning the screw 190 the table can be swung slightly in either direction to properly position the axis of the centers in parallelism with the axis of the grinding wheel; or, if required for tapered work, to position the axis of the centers at a slight angle to the axis of the wheel. Preferably the hub of the knob 194 is provided with graduations at 195 to indicate the amount of turning of the screw and thus indicate the amount of adjustment of the table. After adjustment, the table can be clamped in place by means of bolts 196 and 197.

It sometimes happens that the surface of the grinding wheel is not entirely even and has small circumferential depressions or grooves. When such depressions are present they tend to cause corresponding ridges on the work and thus diminish the accuracy of the finished product. To avoid such inaccuracies I preferably provide means whereby the work may be moved a short distance longitudinally during grinding. As shown in Figs. 10, 11 and 19 a transverse rock shaft 198 is mounted in a suitable aperture in the body of the headstock. This rock shaft is provided at its forward upper end with a hand lever 199 and at its lower end it is provided with a cam 200. The cam 200 is positioned to engage the end of the before mentioned pin 89 carried by the sleeve 87. The operator, by turning the lever 199, can turn the cam 200 and thus move the sleeve 87 toward the tailstock. The movement of the sleeve effects the movement of the work in the same direction, the tailstock center 155 yielding against the action of the spring 156 to permit such movement. As soon as movement of the cam 200 permits, the work is moved in the opposite direction under the action of the spring 156. By this means the operator can slowly reciprocate the work longitudinally, thus entirely avoiding the possibility of ridges or irregularities thereon.

When cylindrical work is being ground, the exact extent of longitudinal movement is immaterial, but in the case of work having different diameters, as shown, the longitudinal movement must be exactly limited in one direction or the other, or in both directions. The work may be moved far enough to bring the shoulder of the work into engagement with the shoulder of the wheel, but it will be obvious that any further movement would injure the work. In order that the longitudinal movement may be thus limited, I provide stops, which are preferably adjustable, for limiting the movement of the hand lever 199. Adjacent the lever is mounted a segment 201 having a T-slot 202 which is concentric with the axis of the rock shaft 198. Adjustably mounted on the segment 201 and held in place by bolts entering the slot 202, are two stops 203 and 204. The stop 203 is adapted to be engaged by a lug 205 formed integrally with the lever. The stop 204 is adapted to be engaged by the end of a micrometer screw 206 carried by the lever. The screw carries a knob 207 provided with a scale 208. It will be seen that by means of the stops 203 and 204 the movement of the lever 199 can be limited so as to stop the movement of the work in either direction at any desired point. The micrometer screw enables the operator to secure minute adjustments of the limit of movement in one direction as may be necessary when a shoulder of the work is to be accurately ground.

I provide suitable means in the form of back-rests for supporting the work during grinding. Preferably there are several back-rests positioned at intervals along the work. The back-rests are independently movable so that they may be properly positioned in accordance with the character of the work.

As illustrated, each back-rest comprises a bed plate 209 which fits and is adjustable along the way 82. For clamping the bed plate 209 in position there is provided a clip 210 adapted to be pressed against the bottom of the way 82 by means of a screw 211. A frame member 212 is provided which is adjustable on the bed plate 209 toward and away from the grinding wheel. The movement of the frame member is effected by means of a screw 213. After adjustment the frame member can be locked by means of the set screw 214.

Projecting outward from the frame member 209 is a guide pin 215 which extends into and fits an aperture in a shoe support 216. This shoe support is slidable along the pin

215 and is provided with two shoes which engage the work. The shoe support has a tongue-and-groove engagement with the frame member at 217 which prevents it from turning on the pin. For moving the shoe support there is provided a lever 218 which is pivoted near its lower end to the frame member 212. The lever 218 at its lower end engages the inner end of a screw 219 which has threaded engagement with the shoe support 216. It will be obvious that when the lever is turned in the clockwise direction the shoe support will be forced outward along the pin 215. The position of the shoe support with respect to the lever can be changed by adjusting the screw 219.

At the upper end of the bed plate 209 there is provided a boss 220 formed with a threaded aperture through which extends a rod 221. The upper left-hand end of the rod carries a pivot pin which extends through a slot in the upper right-hand end of the lever 218. Surrounding the rod 221 and having threaded engagement with the aperture in the boss 220 are two bushings 222 and 223. Surrounding the rod 220 and positioned within the upper bushing 222 is a coil spring 224. This spring abuts at its upper end against a part of the bushing 222 and at its lower end abuts against a collar 225 secured to the rod 221. This spring tends to move the rod downward toward the right and thus tends to swing the lever 218 in the clockwise direction and press the shoes against the work. The lower bushing 223 may be adjusted to be engaged by the collar 225 at the proper time to limit the movement of the rod 221 and thus limit the movement of the shoes.

In order that the finished work may be easily removed and new work put in place, it is desirable to provide means whereby the several back-rests may be easily and quickly withdrawn simultaneously. I provide an eccentric rock shaft 226 which is positioned adjacent the lower ends of the rods 221 and which is rotatably mounted in bearings carried by the table 7. A handle 227 is secured to the rock shaft at one end for turning it. When the rock shaft is turned by the handle it engages the rods 221 to move them rearward and upward, thus withdrawing the shoes from engagement with the work.

Each of the back-rests as thus far described is adapted to apply a uniform spring pressure to the work during grinding, the shoes yielding as required to permit inequalities of the work to pass. It is sometimes desirable, however, to provide a rigid support for the work which does not permit any backward movement of the shoes. In order that such a rigid support may be secured, the frame member 212 is provided with an extension 228 which is provided with slots 229 for guiding a pin 230 carrying a roller 231. The slots 229 are provided at their upper ends with notches adapted to engage the pin and hold the roller in its upper position, as shown. When the pin 230 is disengaged from the notches, the roller 231 is permitted to move downward by gravity and to engage the upper surface of the lever 218 and prevent the movement of the lever in the counter-clockwise direction. The lever can freely move in the clockwise direction to advance the shoes but the roller moves downward at each such movement of the lever and prevents it from being turned in the opposite direction.

The surface of the grinding wheel 2 must conform to the shape of the work to be ground. For cylindrical or uniformly tapered work the wheel is preferably cylindrical throughout. For work other than straight tapered work which varies in diameter the wheel must be dressed to a contour corresponding to the contour of the work. In order that the dressing of the wheel, whether for cylindrical grinding or for contour grinding, may be easily and accurately effected, I provide a special wheel dressing mechanism which constitutes a permanent part of the machine. The wheel dressing mechanism by itself is not claimed as a part of this invention, being covered by my co-pending application for wheel dressing mechanism, Serial No. 247,637 filed on even date herewith.

Formed in the bottom of the table 7 is a longitudinal dovetailed recess which forms a guideway. Fitted in this recess for sliding movement is a slide 232. The slide 232 carries a wheel dressing tool 233 of any usual or preferred construction. The slide is adapted to be moved longitudinally of the table in the space between the bottom of the table and the top of the plate 80. When it is so moved the tool 233 travels along the surface of the wheel to properly dress and true it. In order that the wheel may be dressed to any desired contour the tool 233 is not carried directly by the slide 232 but is mounted on a second slide 234 which is transversely movable with respect to the slide 232. I provide means whereby the slide 234 may be moved forward or backward simultaneously with the longitudinal movement to enable the tool to dress the wheel to the required contour. This means comprises a former plate or bar 235 (shown in detail in Fig. 21) which is secured in a rabbet formed at the lower front edge of the table. The front edge of the former is shaped to conform to the required contour of the wheel and it will be understood that the former 235 can be removed and another former substituted having a different contour. The slide 234 is provided with means for engaging the former 235, this means preferably comprising a bracket 236 projecting

upward from the front end of the slide and a roller 237 carried by the bracket. A coil spring 238 is provided for pressing the slide forward and holding the roller in engagement with the former 235. Preferably there is a cover secured to the table and extending over the former and the roller to protect them and exclude dirt. As shown the aforesaid bracket 193 is formed to constitute this cover.

In order that the wheel may be given exactly the same contour as the former, it is necessary for the point of the tool to move in a plane which passes through the axis of the wheel. As shown in Fig. 5, the swinging frame 8 is so positioned that the slide 234 is horizontal, the point of the tool 233 being at the same level as the axis of the wheel. After the wheel has been worn to a smaller diameter, the tool 233 must be moved rearward in order to engage the wheel. This rearward movement might be effected by swinging the frame 8, but obviously this swinging movement would incline the slide 234 so that the tool 233 would move in a plane not passing through the wheel axis. The result would be that the contour of the wheel would not conform exactly to the contour of the former. When the required contour is such that the variations in the diameter of the wheel are slight, the inaccuracy resulting from the movement above described would probably be so small as to be negligible; but, in order that the machine may be adapted for the dressing of wheels to contours causing widely different diameters, I prefer to provide means whereby the tool 233 may be adjusted without moving the frame 8 or inclining the slide 234. As illustrated, the tool 233 is connected with the slide 234 by means of a second transverse slide 239. This slide is movable under the control of a screw 240 provided with a handle 241. By means of the slide 239 the tool 233 can be moved to compensate for differences in diameter of the wheel without moving the frame 8 in such a way as to incline the slide 234.

It will be understood that it is necessary to keep the slide 234 horizontal only when the wheel is being dressed to different diameters in accordance with a given contour. When the wheel is being dressed to a simple cylindrical form the exact position of the slide 234 is immaterial. Even in this case, however, the supplemental slide 239 is advantageous as it enables the dressing tool 233 to be adjusted in accordance with work of different diameters. It will be seen that the work support must occupy different positions in accordance with the diameters of the work and that by means of the slide 239 the dressing tool can be adjusted so as to lie in close proximity to the wheel, notwithstanding the position of the work support.

For moving the slide 232 longitudinally of the table. I preferably provide a longitudinal threaded shaft or screw 242 which is mounted at its ends in suitable bearings in the table. This screw extends through an aperture in the slide 232 and has threaded engagement therewith. It will be seen that when the screw is turned the slide will be moved longitudinally, carrying with it the slides 234 and 239 which are at the same time moved forward or backward under the control of the former 235. I prefer to provide power mechanism for rotating the threaded shaft or screw 242, this mechanism preferably being associated with the mechanism in the housing 99 for rotating the work.

Mounted on the shaft 102, preferably adjacent the gear 111, is a gear 243 which meshes with a gear 244 secured to a shaft 245 rotatable in a bearing in the housing 99. Rotatably mounted on the shaft 245 are three differently diametered gears 246, 247 and 248 which mesh respectively with gears 249, 250 and 251 rigidly secured to a shaft 252 rotatable in bearings in the housing. The shaft 245 is provided with a central longitudinal aperture in which is mounted a rod 253 to which is pivoted a key 254 projecting through a slot 255 in the shaft. This key is adapted to enter keyways formed in the gears 246, 247 and 248. A spring 256 tends to swing the key outward into engagement with the gears. It will be seen that when the rod 253 is moved longitudinally the key may be engaged with any one of the gears. Between each two adjacent gears is mounted a ring 257 which serves to swing the key inward when it is being moved and thus prevents it from being engaged with two of the gears at the same time. The rod 253 is provided at its right-hand end with an annular rack 258 which meshes with a gear 259 on a rock shaft 260. This rock shaft is suitably mounted in the table 7 and is provided at its outer end with a hand lever 261. The hand lever carries a spring-pressed plunger 262 which is adapted to engage one or another of three notches 263 formed in a segment 264 carried by the table. By moving the lever to bring the plunger into register with one or another of the notches the key 254 may be engaged with any one of the gears 246, 247 or 248, as desired.

Mounted in suitable bearings in the housing 99 is a shaft 265 which is in alinement with the threaded shaft 242. These two shafts are connected by a suitable coupling 266. Loosely mounted on the shaft 265 are two differently diametered gears 267 and 268. The gear 267 meshes with a gear on the shaft 252 which may be the aforesaid gear 250, as shown. The gear 268 meshes with an idler gear 269 which in turn meshes

with a gear 270 secured to the shaft 252. Splined on the shaft 265 between the gears 267 and 268 is an annularly grooved clutch collar 271. This collar is provided at its sides with sets of teeth adapted respectively to engage corresponding teeth formed on the gears 267 and 268. For moving the clutch collar 271 there is provided a forked lever 272 which is provided with projections fitting the groove of the collar. The forked lever 272 is secured to a vertical rock shaft 273 which is rotatably mounted in a suitable bearing in the housing 99. By moving the rock shaft 273 the collar 271 may be moved to engage either one of the gears 267 or 268. When the collar is in its central position both of the gears are disengaged. Preferably the lever 272 is provided with a pointed spring-pressed plunger 274 which is adapted to engage with a notched lug 275. The plunger, by reason of its engagement with the lug, serves to hold the clutch collar either in its central position or serves to move it into complete engagement with one or the other of the gears.

From the foregoing description it will be clear that the shaft 252 may be driven at any one of three speeds in accordance with the adjustment of the lever 261. The shaft 265 may be driven from the shaft 252 in either direction in accordance with the position of the clutch collar 271. As already stated, the shaft 265 is connected with the threaded shaft 242 which moves the tool-carrying slide. It is therefore possible to move the slide by power at any one of three speeds in either direction, as desired.

For convenience in moving the rock shaft 273, the shaft is provided at its lower end with a lever 276 which extends toward the front of the machine. At its front end the lever is connected with a rod 277 which is slidable longitudinally of the machine in suitable bearings carried by the swinging frame. This rod 277 is provided with handles 278 by means of which it can be moved longitudinally to move the lever 276 and thus operate the clutch 271. Preferably the rod 277 is positioned adjacent the slide 234, as shown in Fig. 5. Secured to the rod 277 are collars 279 and 280 which are adapted to be engaged by the slide as it moves. The engagement of one or the other of these collars by the slide 234 serves to move the rod in the direction to disengage the clutch 271 and thus stop the slide movement. Preferably the collar 279 is adjustable on the shaft so that the operator may change the position at which the slide is stopped.

As will be apparent from the foregoing description, the machine is primarily intended for the grinding of a large number of similar pieces of work. In the preliminary adapting and adjusting of the machine for the work to be done, it is first necessary to construct a former 235 having its effective edge shaped to conform to the required contour of the finished work. When such a former has been constructed it is put in place in the machine and is used for dressing the grinding wheel. For the dressing operation the frame 8 is adjusted to bring the slide 234 into a level position as shown in Fig. 5. Assuming that the slide 232 is in its left-hand position, the operator, by means of the handle 241 moves the slide 239 far enough rearward to bring the tool 233 into engagement with the wheel. Then the operator, by means of the rod 277, starts the movement of the slide 232 which carries the tool 233 toward the right. During this movement the position of the tool 233 is controlled by the former 235, and, because of the spring 238, the pressure of the tool against the wheel is definitely limited. After movement across the wheel the slide is automatically stopped by the right-hand collar 280. In initially dressing the wheel it may be necessary to move the tool across it several times. When this is required the operator by means of the rod 277, shifts the clutch 271 to move the slide 232 toward the left. During the movement toward the left the tool may remain in engagement with the wheel, but it is preferably withdrawn either by moving the frame 8 or by moving the slide 239. The slide is automatically stopped by the left-hand collar 279. Then the tool can be moved toward the right as before, and this operation can be repeated until the wheel has assumed a contour corresponding exactly to that of the former 235.

The headstock and the tailstock are properly position on the work support or table to engage and hold the work blanks. Before putting the blank in place the operator, by means of the lever 179, swings the work support forward. The blank is first fitted with a dog and then is engaged with the headstock center 88 and the tailstock center 155 is drawn backward and afterward released into engagement with the end of the blank.

The several back-rests are properly positioned to engage the blank at suitable intervals along its length and each of the back-rests is adjusted to apply the required spring-pressure to the work. While the work support is being put in place the back-rests are held inoperative by means of the eccentric shaft 226. After the blank is properly engaged by the centers the eccentric shaft 226 is turned to permit the shoes to engage the blank.

After the blank has been thus put in place and engaged, the operator turns the lever 179 to its right-hand position and thus swings the work support forward. Further forward movement of the work support is

effected by turning the hand wheel 169 in the clockwise direction. As the hand wheel is turned the finger 176 engages the stop 177 and during further movement of the hand wheel the ring 173 slips on its bearing. The hand wheel is turned until the work is reduced to size.

During the grinding operation the operator may, if he finds it necessary, reciprocate the work to a slight extent longitudinally by means of the hand lever 199. In the case of cylindrical work this longitudinal reciprocation may take place without restriction. However, in the case of shouldered work such as illustrated, the stops 203 and 204 and the micrometer screw 206 must be accurately adjusted to limit the movement at the proper points. The work blank must always be moved in the direction to carry the shoulder of the blank away from the corresponding shoulder of the wheel.

As soon as the work has been reduced to size the operator turns the lever 179 toward the left, thus swinging the work support forward. This forward movement of the work support carries the blank far enough away from the wheel to permit its easy removal and to permit the easy substitution of an unground blank.

After an unground blank has been put in place the handle 179 is again turned toward the right, the operator first, however, having given the hand wheel 169 a part of a turn in the counter-clockwise direction. In effecting grinding of the second blank, the operator again turns the hand wheel in the clockwise direction until the lug 176 again engages the stop 177. This engagement constitutes notice to the operator that the work is ground to size or approximately to size.

As the wheel wears and becomes reduced in diameter the guard may be moved backward correspondingly. When it becomes necessary to inspect the wheel this can be readily done by removing the drop section of the guard. It will be noted that inasmuch as the nozzles 48 are mounted on the guard they will be moved backward when the guard is moved backward and will also be removed when the top section of the guard is removed.

What I claim is:

1. In combination, a grinding wheel rotatable about a fixed axis, a table movable toward and from the wheel and provided with longitudinal ways, a headstock and a tailstock longitudinally adjustable along the ways on the table, mechanism carried by the headstock for rotating a work blank, a longitudinal shaft having splined engagement with the said mechanism, and driving mechanism for the shaft mounted on the end of the table and fixed against longitudinal movement, the said driving mechanism including change speed gearing.

2. In combination in a grinding machine, a main frame, a work support provided with devices for holding a work blank, an auxiliary frame carrying the work support and movable with respect to the main frame about an axis parallel to the axis of the blank, power actuated means movable with the auxiliary frame for rotating the blank, a grinding wheel rotatable about a fixed axis parallel with the axis of the work blank and having a broad face extending the full length of the blank, feed mechanism for moving the auxiliary frame about its pivotal axis toward or from the wheel, means whereby the blank may be longitudinally reciprocated to a slight extent during grinding independently of the auxiliary frame and without interfering with the application of power for rotative movement, and an adjustable stop for limiting the reciprocatory movement.

3. In combination in a grinding machine, a main frame, a work support provided with devices for holding a work blank, an auxiliary frame carrying the work support and movable with respect to the main frame about an axis parallel to the axis of the blank, power actuated means movable with the auxiliary frame for rotating the blank, a grinding wheel rotatable about a fixed axis parallel with the axis of the work blank and having a broad face extending the full length of the blank, feed mechanism for moving the auxiliary frame about its pivotal axis toward or from the wheel, means whereby the blank may be longitudinally reciprocated to a slight extent during grinding independently of the auxiliary frame and without interfering with the application of power for rotative movement, and two adjustable stops for limiting the reciprocatory movement in both directions.

4. In combination in a cylindrical grinding machine, a rotatable grinding wheel, a work support provided with alined centers for holding a work blank in operative relation to the wheel, means for rotating the work on the centers, feed mechanism for effecting a relative approaching or separating movement between the wheel and the work support, a spring for pressing one of the centers against the blank, a cam rotatable about an axis perpendicular to the axis of the blank for reciprocating the other center longitudinally, the cam acting in cooperation with the spring, a hand lever for operating the cam, a segment adjacent the lever, and stops adjustably mounted on the segment and adapted to engage the lever to limit the reciprocatory movement of the work.

5. In combination in a cylindrical grinding machine, a rotatable grinding wheel, a work support provided with alined centers for holding a work blank in operative re-

lation to the wheel, means for rotating the work on the centers, feed mechanism for effecting a relative approaching or separating movement between the wheel and the work support, a spring for pressing one of the centers against the blank, a cam rotatable about an axis perpendicular to the axis of the blank for reciprocating the other center longitudinally, the cam acting in cooperation with the spring, a hand lever for operating the cam, and a micrometer screw for limiting the movement of the lever in one direction to thereby limit the reciprocatory movement of the work.

6. In combination in a cylindrical grinding machine, a rotatable grinding wheel, a work support provided with alined centers for holding a work blank in operative relation to the wheel, means for rotating the work on the centers, feed mechanism for effecting a relative approaching or separating movement between the wheel and the work support, a spring for pressing one of the centers against the blank, a cam rotatable about an axis perpendicular to the axis of the blank for reciprocating the other center longitudinally, the cam acting in cooperation with the spring, a hand lever for operating the cam, a segment adjacent the lever, stops adjustably mounted on the segment and adapted to engage the lever to limit the reciprocatory movement of the work, and a micrometer screw carried by the lever and adapted to engage one of the stops.

7. The combination in a grinding machine, of a work support provided with devices for holding a work blank, a grinding wheel rotatable about an axis and having a broad face extending the full length of the blank, feed mechanism for effecting relative approaching and receding movements between the work support and the wheel, a wheel dressing tool, a tool carrying slide carried by and movable longitudinally of the work support, and power actuated mechanism carried in part by the work support and including change speed gearing for moving the slide.

8. The combination in a grinding machine, of a work support provided with devices for holding a work blank and mounted for pivotal movement about an axis parallel with the axis of the blank, means at one end of the work support for rotating the blank, a grinding wheel rotatable about a fixed axis parallel with the axis of the work blank and having a broad face extending the full length of the blank, feed mechanism for swinging the work support about its pivotal axis toward or from the wheel, a wheel dressing tool, a tool carrying slide carried by and movable longitudinally of the work support, and power mechanism carried in part by the work support for moving the slide, the said mechanism being located at the same end of the work support as the means for rotating the blank.

9. In combination, a grinding wheel rotatable about a fixed axis, a table movable toward and from the wheel and provided with longitudinal ways, a headstock and a tailstock longitudinally adjustable along the ways on the table, mechanism carried by the headstock for rotating a work blank, a longitudinal shaft having splined engagement with the said mechanism, a wheel dressing tool, a tool carrying slide movable longitudinally of the table, a screw for moving the slide, and driving mechanism for the shaft and the screw mounted on one end of the table and fixed against longitudinal movement.

10. The combination in a grinding machine, of a work support provided with devices for holding and rotating a work blank, a grinding wheel rotatable about a fixed axis parallel with the axis of the work blank and having a broad face extending the full length of the blank, mechanism for moving the work support toward or from the wheel, a wheel dressing tool, a tool carrying slide carried by and movable longitudinally of the work support, a former for moving the tool toward or from the wheel axis as the slide is moved longitudinally, and means supplemental to the former for moving the tool toward or from the wheel independently of the work support.

11. The combination in a grinding machine, of a work support provided with devices for holding and rotating a work blank, the said work support being mounted for pivotal movement about an axis parallel with the axis of the blank, a grinding wheel rotatable about a fixed axis parallel with the axis of the work blank and having a broad face extending the full length of the blank, feed mechanism for swinging the work support about its pivotal axis toward or from the wheel, a slide carried by and movable longitudinally of the work support, a wheel dressing tool so mounted on the slide that its plane of movement extends through the wheel axis when the work support is in a predetermined position of adjustment, a former for moving the tool toward or from the wheel axis as the slide is moved longitudinally, and means supplemental to the former for moving the tool toward or from the wheel independently of the work support, whereby the tool may be brought into engagement with the wheel without moving the work support from its aforesaid predetermined position.

12. The combination in a grinding machine, of a work support provided with devices for holding and rotating a work blank, a grinding wheel rotatable about a fixed axis parallel with the axis of the work blank and having a broad face extending the full

length of the blank, feed mechanism for moving the work support toward or from the wheel, a slide carried by and movable longitudinally of the work support, a second slide carried by the first slide and movable transversely thereof, a former for moving the second slide toward or from the wheel axis as the slide is moved longitudinally, a third slide carried by the second slide and movable parallelly therewith toward or from the wheel independently of the former and independently of the work support, and a wheel dressing tool mounted on the third slide.

In testimony whereof, I hereto affix my signature.

BENGT M. W. HANSON.