Sept. 3, 1935. M. H. ARMS 2,013,122

GRINDING MACHINE

Filed Nov. 8, 1932 7 Sheets-Sheet 1

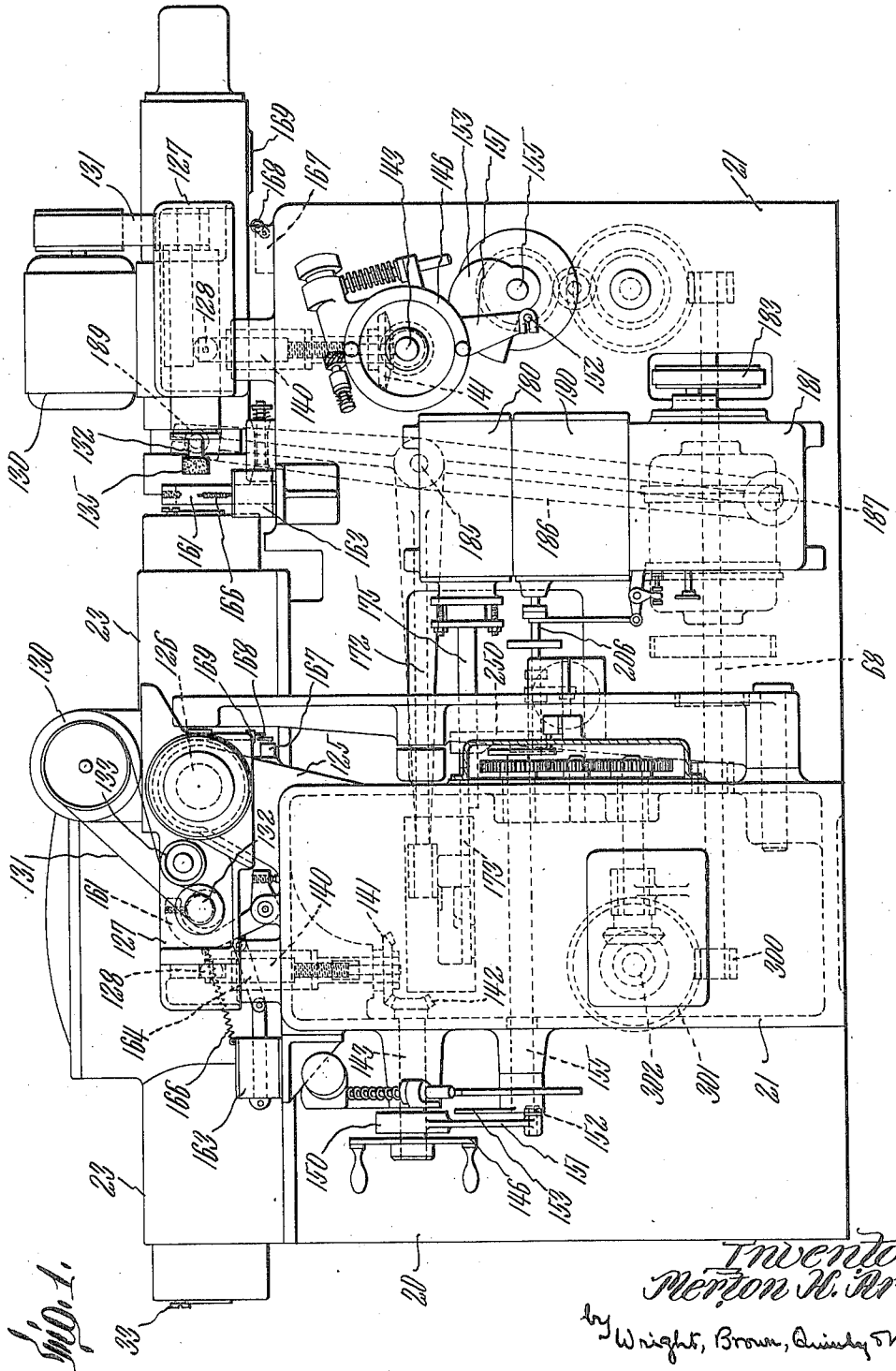

Fig. 1.

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GRINDING MACHINE

Filed Nov. 8, 1932 7 Sheets-Sheet 2

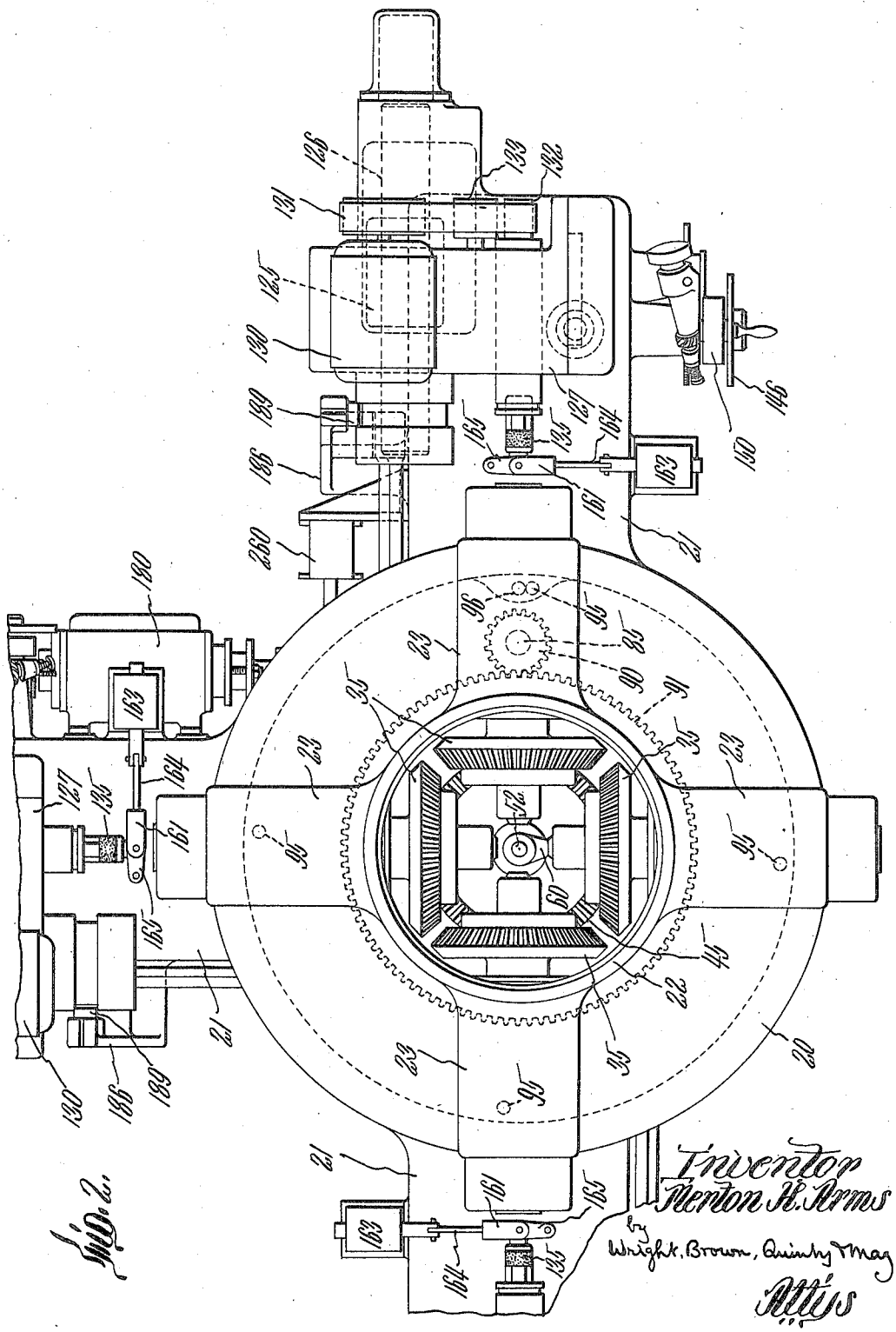

Fig. 2.

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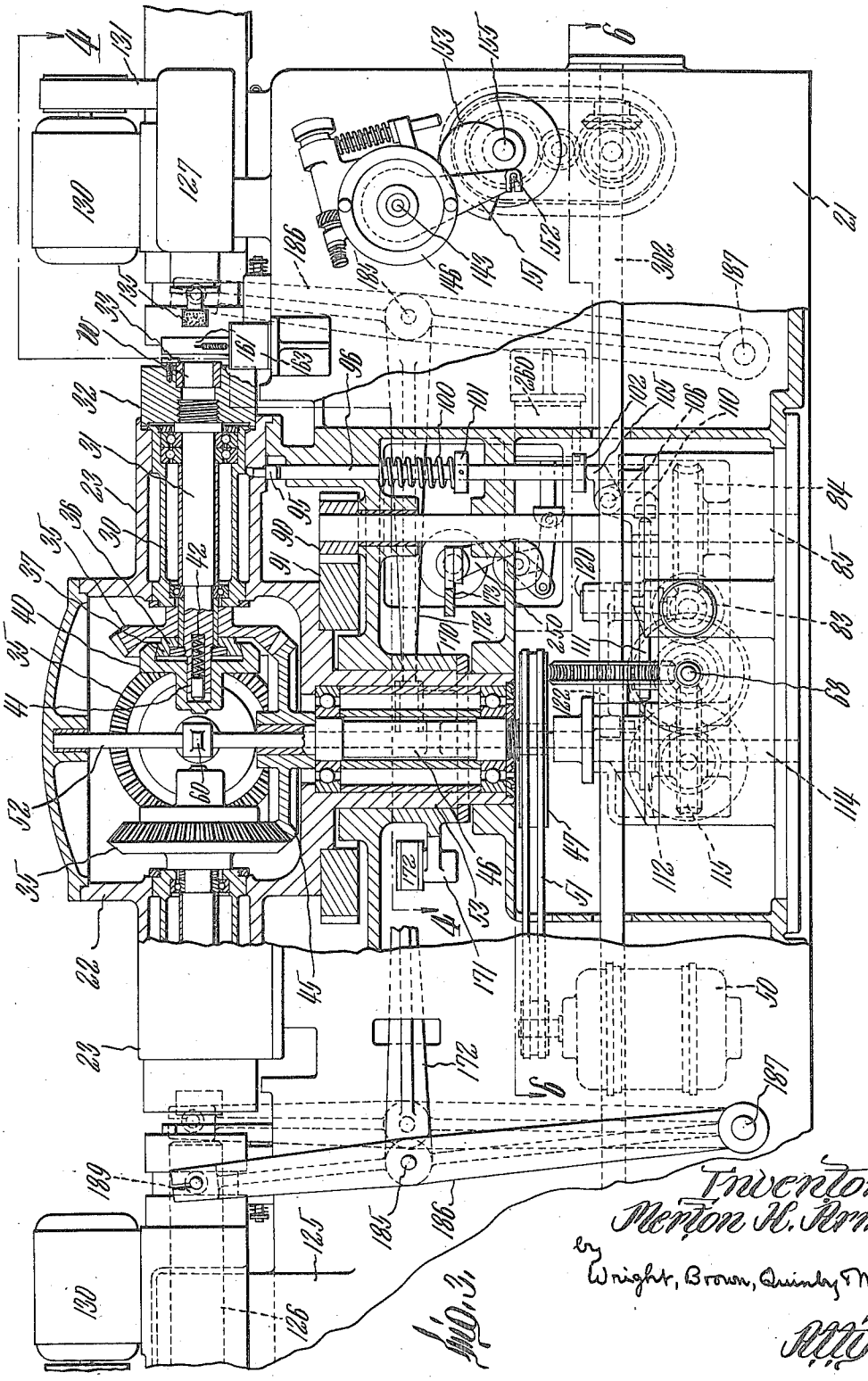
GRINDING MACHINE

Filed Nov. 8, 1932 7 Sheets-Sheet 3



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GRINDING MACHINE

Filed Nov. 8, 1932 7 Sheets-Sheet 4

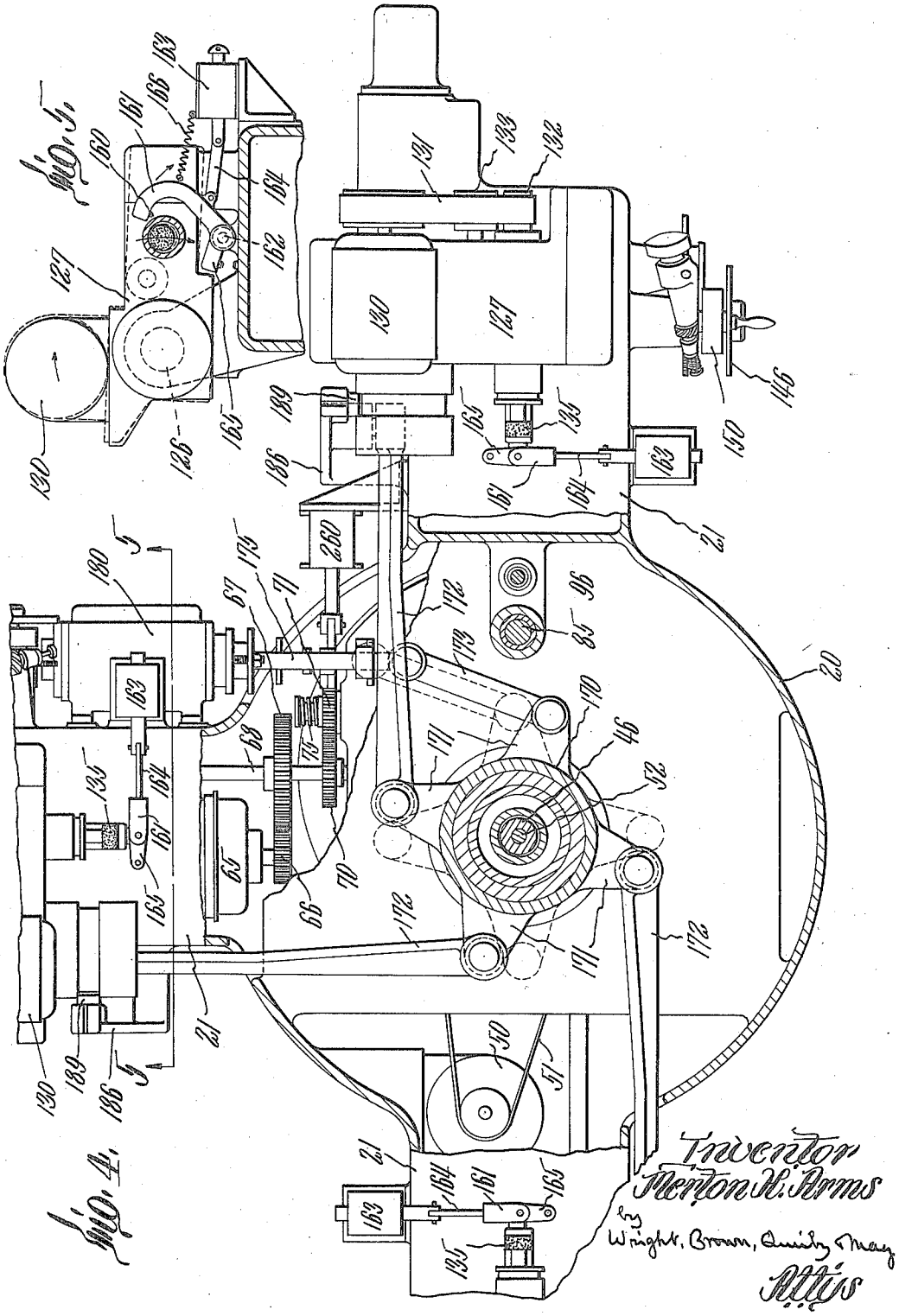

Fig. 4.

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GRINDING MACHINE

Filed Nov. 8, 1932 7 Sheets-Sheet 5

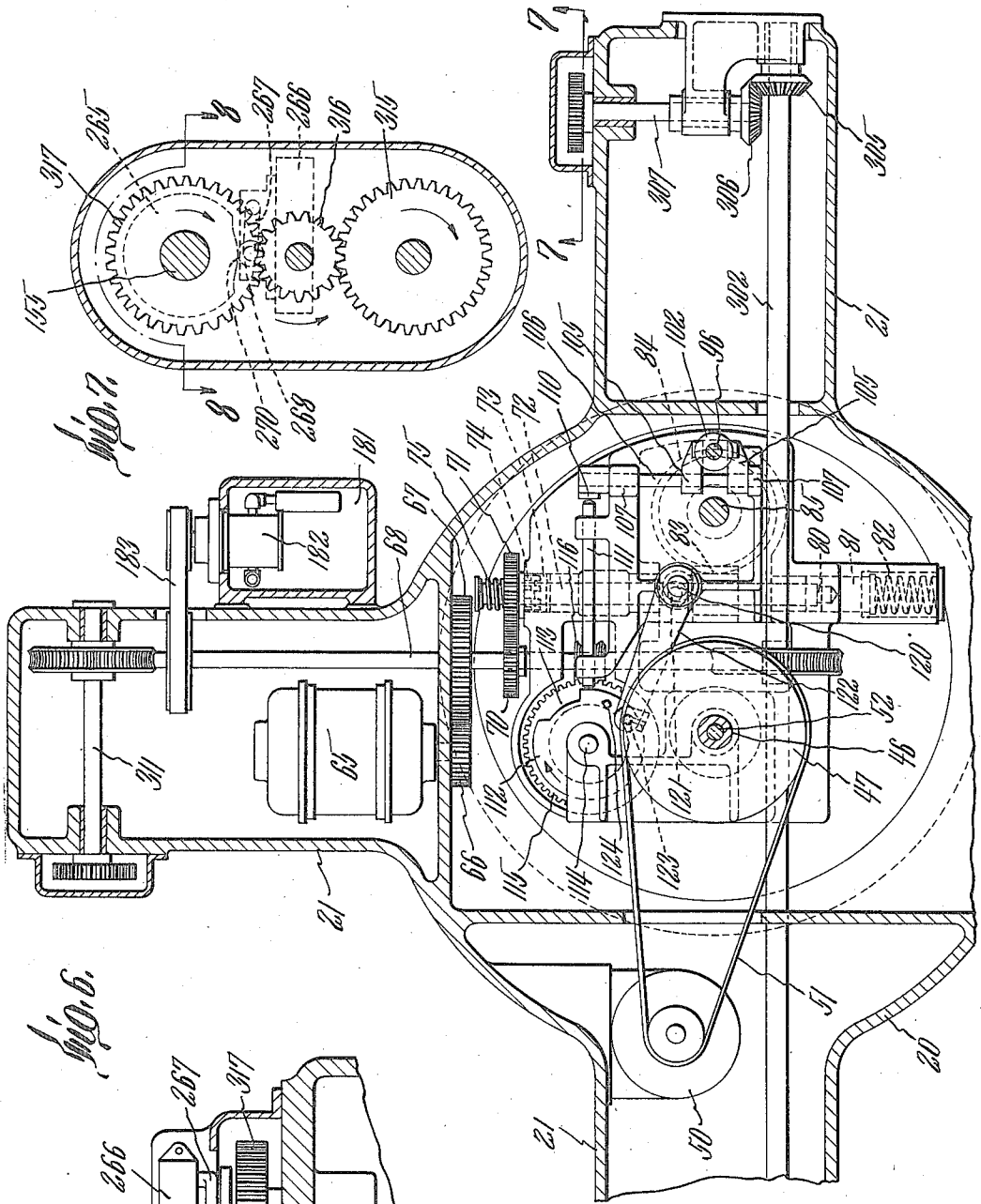

Fig. 7.

Fig. 8.

Fig. 6.

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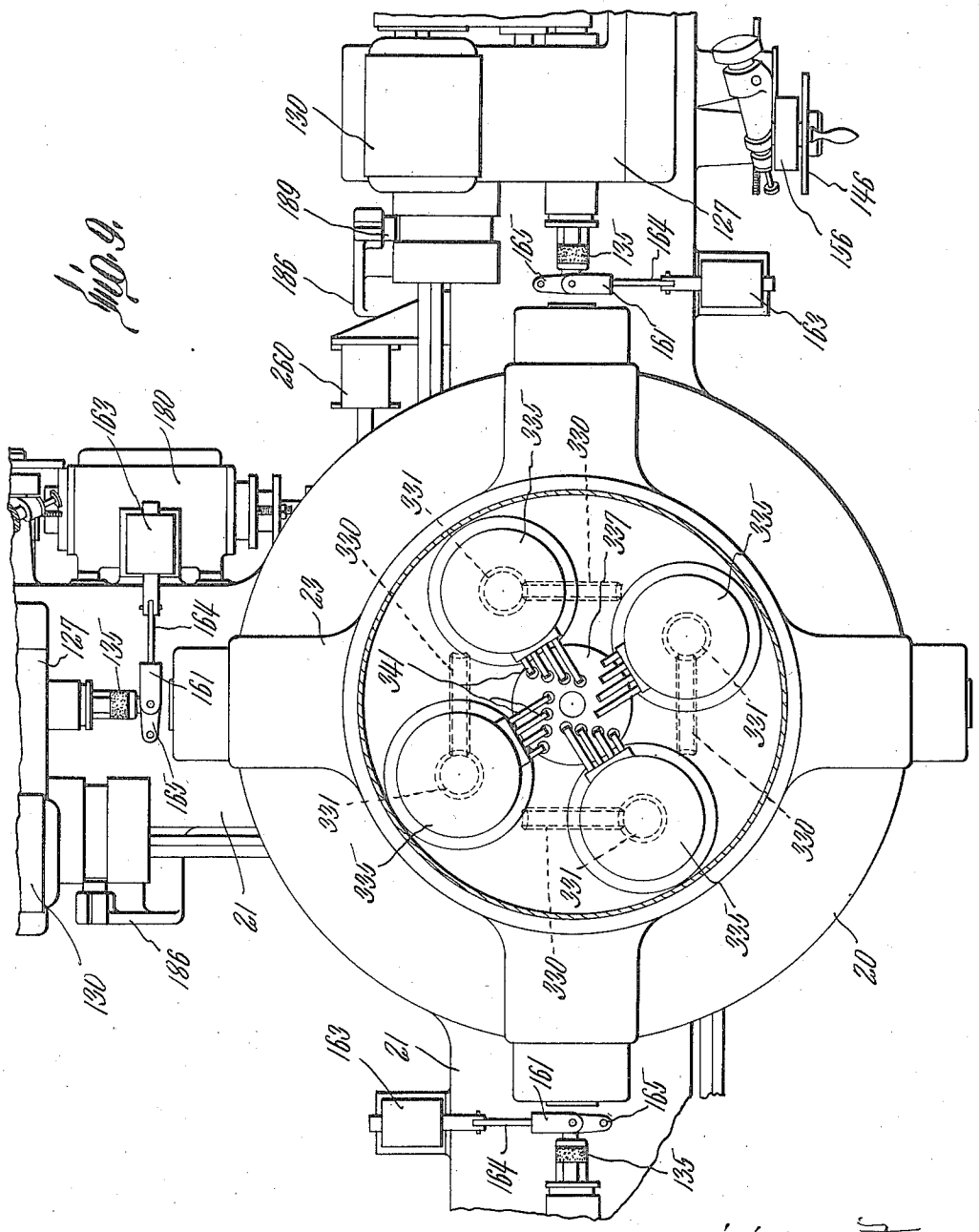
GRINDING MACHINE

Filed Nov. 8, 1932 7 Sheets-Sheet 6



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GRINDING MACHINE

Filed Nov. 8, 1932 7 Sheets-Sheet 7

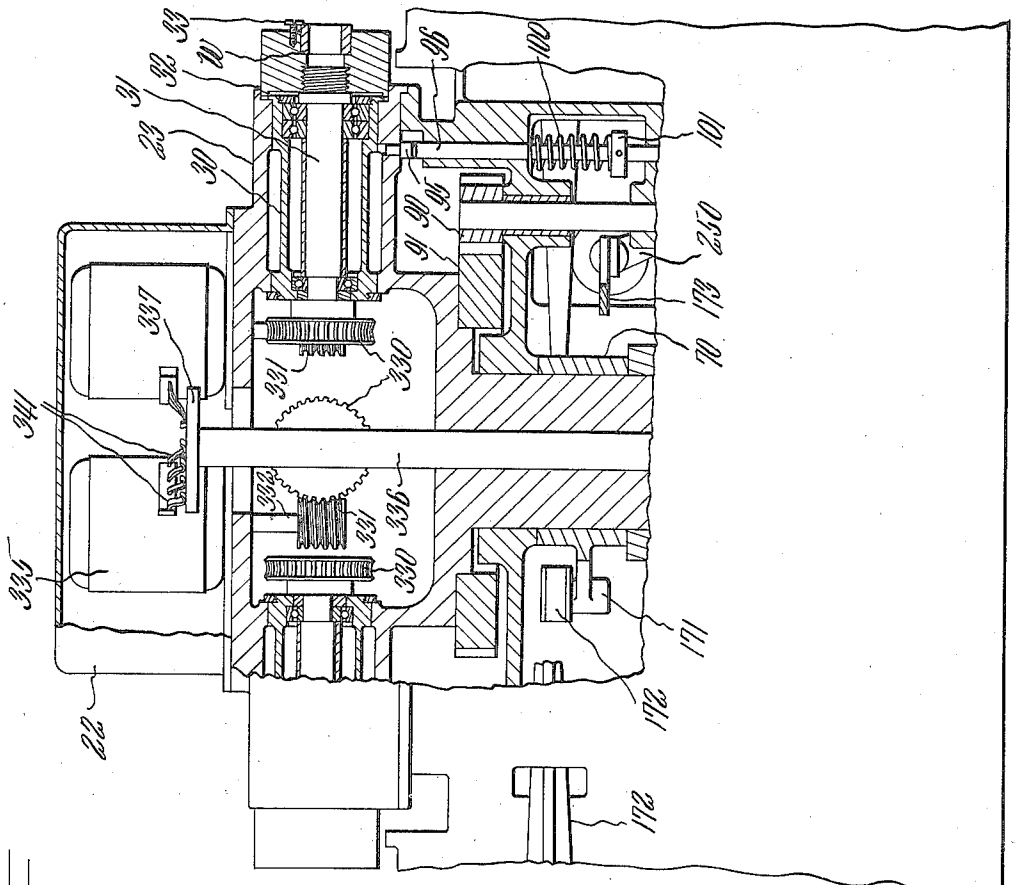

Fig. 10.

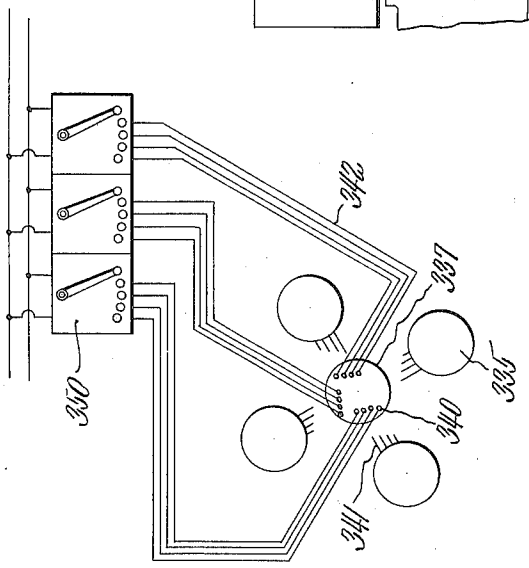

Fig. 11.

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Patented Sept. 3, 1935

2,013,122

UNITED STATES PATENT OFFICE

2,013,122

GRINDING MACHINE

Merton H. Arms, Springfield, Vt., assignor to Bryant Chucking Grinder Company, Springfield, Vt., a corporation of Vermont

Application November 8, 1932, Serial No. 641,733

24 Claims. (Cl. 51—53)

This invention relates to a multiple spindle grinding machine or the like having work-holders mounted in a turret for simultaneous presentation of a plurality of pieces of work to the several tools. The embodiment of the invention hereinafter described includes tool carriages with improved mountings for feeding the tools laterally against the work, improved mechanism for reciprocating the tools to and from the work, and a truing device for each tool automatically moving into and out of operative position as the carriages withdraw the tools from the work or advance them thereto.

Various other novel and advantageous features and combinations will be apparent to one skilled in the art from the disclosure of the invention in the embodiment thereof hereinafter described and illustrated on the drawings, of which,—

Figure 1 is a side elevation of a grinding machine embodying the invention.

Figure 2 is a plan view of the same with the lid of the turret removed.

Figure 3 is a front elevation of the same, a portion being cut away to show interior working parts in section.

Figure 4 is a section on the line 4—4 of Figure 3.

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

Figure 6 is a section on the line 6—6 of Figure 3.

Figure 7 is a section on the line 7—7 of Figure 6.

Figure 8 is a section on the line 8—8 of Figure 7.

Figure 9 is a plan view of a modified form of the invention.

Figure 10 is a fragmentary elevation of the same, a portion of the casing being broken away to show the working parts within.

Figure 11 is a wiring diagram for the motors for driving the work-holders, illustrated in Figure 10.

The invention may be embodied in a machine including a bed casting 20 having a number of wings 21 extending laterally therefrom. On the body portion of the bed is mounted a turret 22 to rotate on a vertical axis. The turret and wings carry work-holders and tools in such a way that when the turret is in any one of its indexed positions, the tools can be presented to pieces of work carried by work-holders adjacent to the respective tools. In the embodiment of the invention illustrated on the drawings, the work-holders are shown as radially arranged on the turret, the tools being mounted on the wings of the bed in line with certain of the work-holders when the turret is in any one of its indexed positions. Four work-holders are shown, these being arranged at right angles to each other. Three tools are aligned respectively with three of the work-holders, the fourth workholder being at a loading station in front of the machine. The invention, however, is not limited to these particular numbers of work-holders or tools. For the support of the work-holders, the turret 22 is provided with a series of radially extending arms 23. Within each arm 23 is fixed a hollow sleeve 30. A shaft 31 extends through this sleeve and is mounted therein on suitable ball bearings for rotation on a horizontal axis. Mounted on the outer end portion of the shaft 31 is a suitable chuck 32 which is adapted to hold a piece of work W.

In the embodiment illustrated in the drawings the work is shown as a cylindrical collar or bushing to be finished on its interior surface. Suitable clamps 33 may be employed to hold the work solidly in position in the chuck 32. The inner end of the shaft 31 projects into the interior of the turret 22. Suitable mechanism is provided for rotating the chuck 32. For this purpose a common drive may be employed, or the chucks may be independently driven. As shown in Figures 2 and 3, for example, the several chucks may be driven by a single motor. For this type of drive, a miter gear wheel 35 is loosely mounted on the inner end portion of each shaft 31. Fixed to a face of the gear wheel 35 is a ring 36 having a conical friction surface 37 on its rim. This surface is engageable by a complemental friction surface of a clutch member 40 which is splined to a reduced end portion 41 of the shaft 31. The inner end of the shaft is drilled axially to hold a suitable spring 42 which normally presses the friction face of the clutch member 40 into driving engagement with the friction face 37 of the ring 36. Thus the gear wheel 35 is usually connected to the shaft 31 through the clutch member 40. The gear wheels 35 of the several shafts 31 are all in mesh with a horizontal gear wheel 45, this gear being mounted on a vertical quill 46 on which is also mounted a suitable pulley 47. This pulley is preferably rotated constantly during the operation of the entire apparatus, a suitable driving means such as an electric motor 50 being operatively connected with the pulley 47 as by one or more belts 51. The quill 46 rotates about a fixed shaft or post 52, this post being anchored at its lower end in the bed 20. The turret 22 has a downwardly extending tubular projection 53 which surrounds the quill 46 and is separated therefrom by suitable ball bearings so that the quill and turret are both freely rotatable with respect to each other. It is desirable that the rotation of each chuck shaft 31 be stopped when the arm 23 containing it reaches work-loading position in which the arm and shaft extend forwardly of the apparatus. To this end a suitable cam lug 60 is mounted on the fixed vertical shaft 52.

When the turret 22 revolves so as to move one of the arms 23 from the last operating station to the loading station, the clutch member 40 corresponding to this arm 23 moves into engagement with the fixed cam lug 60. This causes the clutch member 40 to move radially outward against pressure of its spring 42, disengaging its friction face from the frictional surface 37 of the ring 36. Thus the constantly turned gear wheel 35 is disconnected from its shaft 31 as long as the corresponding arm 23 remains in the loading position. As soon as this arm is swung by indexing movement of the turret 22 from the loading position to the first operating position, the clutch member 40 moves out of engagement with the cam lug 60 and thereupon connects the corresponding gear wheel 35 and shaft 31 for rotation of the latter.

Mechanism for indexing the turret 22 is illustrated in Figures 3 and 6. For this purpose a suitable motor 65 is connected through gears 66 and 67 to a shaft 68. Mounted on this shaft is a pinion 70 which meshes with a pinion 71 loosely mounted on a shaft 72. Mounted on the shaft 72 is one member 73 of a clutch, the other member 74 being formed on or rotatable with the pinion 71. An end portion of the shaft 72 projects through the hub of the pinion 71 and carries a spring 75 which tends to hold the clutch member 73 in engagement with the clutch member 74. The opposite end of the shaft 72 rests against a suitable end bearing 80 which, as shown, may be carried by a sliding carriage 81, the latter being slidable in the direction of the axis of the shaft 72 to permit the clutch member 73 to move clear of the clutch member 74. A stiff spring 82 is provided to press the shaft 72 axially to a position in which the clutch members 73 and 74 are engaged so that the shaft may be driven. Mounted on the shaft 72 for rotation therewith is a suitable worm 83 which meshes with a worm gear 84, the latter being fixed on a vertical shaft 85. As shown in Figure 3, the shaft 85 carries a pinion 90 fixed at the upper end thereof, this pinion meshing with a ring gear 91 secured to the turret 22. Thus rotation of the gear wheel 84 results in indexing movement of the turret 22. Stops for limiting the indexing movement of the turret are provided in the form of stop pins 95, one of these pins being mounted on the under side of each of the arms 23, as shown in Figures 2 and 3. A stop rod 96 is vertically slidable in the bed 20 and is arranged so that its upper end portion is normally in the path of movement of the stop pin 95 when the turret is rotated on its axis. Indexing movement of the turret, as illustrated in Figure 2, is in a counterclockwise direction, hence the gear wheel 84 is driven in a clockwise direction by rotation of the worm 83. Indexing movement of the turret brings one of the stop pins 95 into engagement with the upper end of the stop rod 96 which is in its path of motion. This prevents further rotation of the turret or of the gear wheel 84. The worm 83, however, continues to rotate with the shaft 72 and is compelled to travel axially, or tangent to the stationary gear wheel 84. As a result the shaft 72 is also moved axially until the clutch element 73 is moved out of engagement with the clutch element 74, this axial movement of the shaft being against the pressure of the springs 82 and 75. Thus the shaft 72 disconnects itself from the pinion 71, the spring 82 thereupon acting to hold the turret firmly in its indexed position with one of the stop pins 95 against the upper end portion of the stop rod 96.

Means for moving the stop rod 96 into and out of operative position are illustrated in Figures 3 and 6. A spring 100 is provided to react against a collar 101 mounted on the stop rod, in a direction to press the rod downwardly out of operative position. Fixed to the rod 96 is a second collar 102, the under face of which is engaged by a pair of arms 105 mounted on a cross shaft 106 which is rockably mounted in suitable bearings 107 and carries a crank arm 110. A thrust rod 111 bears at one end against the crank arm 110, the opposite end of the thrust rod 111 riding on the edge of a cam 112. This cam has a recess 113. The cam disk 112 may be mounted on a shaft 114 with a gear wheel 115 which is driven by a worm 116 mounted on the shaft 68. When the end of the rod 111 rides into the recess 113 of the cam 112, the rod is moved toward the left by the spring 100 acting through the shaft 106 and the crank arm 110, releasing the stop rod 96. When the end of the rod 111 rides out of the recess 113, the rod is pushed toward the right, raising the stop rod 96 into operative position against the pressure of the spring 100. When the turret is stationary, one of the stop pins 95 is strongly pressed against the stop rod 96 by the spring 82, so that the rod 96 may be frictionally held in locking position even when released from below. It is desirable to relieve this pressure to permit the stop rod to move clear of the pin with which it is engaged. To this end a vertical shaft 120 is provided with an eccentric member 121 bearing against an end of the worm 83. If the shaft 120 is rocked in a counterclockwise direction, the eccentric member 121 will press against the worm 83 and this will result in an axial movement of the shaft 72 toward the end bearing 80. Such axial movement of the shaft will result in a counterclockwise movement of the gear wheel 84 and hence in a clockwise movement of the turret 22 sufficient to relieve the pressure between the stop rod 96 and the stop pin 95 in contact therewith. Rocking movement of the shaft 120 may be obtained by means of a lever arm 122 mounted thereon. A pin 123 is mounted near the end of this arm and is engageable by a pin 124 mounted on the cam member 112. The position of the pin 124 is so related to the recess 113 that the pin 124 comes into engagement with the pin 123 so as to rock the arm 122 and relieve the pressure of the stop rod 96 against a pin 95 just after the rod 111 rides into the recess 113 of the cam member 112 to release the rod 96. Thus when the pin 124 clears the pin 123, releasing the arm 122 and hence the shaft 72, the latter moves axially under the influence of the spring 82 so as to connect the clutch members 73 and 74 for the resumption of rotation of the shaft 72. This causes indexing movement of the turret until the next succeeding pin 95 is stopped by engagement with the upper end of the stop rod 96 which has meanwhile been raised as the rod 111 rides out of the recess 113. This brings into alignment with the tools three of the arms 23 which carry the several pieces of work, the fourth arm 23 being at the loading station.

For the grinding away of portions of the work, the tools must be suitably fed against the surfaces to be ground. According to the present invention, such feeding movement is obtained by relative movement between the work and the tool in a substantially vertical direction, that is,

in the general direction of the axis of rotation of the turret. This relative feeding movement can be obtained in various ways such as that illustrated on the drawings. As shown, on each of the wings 21 of the bed 20 is mounted a substantial bracket 125 which projects upwardly and outwardly from the top of the wing. A fixed horizontal shaft 126 is mounted at its mid-portion on said bracket. A tool carriage 127 is rockably and slidably mounted on said shaft, the end portions of the shaft bearing in the carriage at one side thereof. The carriage projects from the shaft across and above the top of the wing 21, the side of the carriage remote from the shaft 126 being supported by a roller 128. Mounted on the carriage 127 approximately above the shaft 126 is a motor 130 connected by any suitable means such as a belt 131 to a shaft 132 which is journalled horizontally in the carriage 127 to point toward the axis of rotation of the turret 22. An idle pulley 133 may be employed to keep the belt clear of portions of the carriage. On the shaft 132 is mounted a grinding tool 135 which is positioned to move into and out of operative position with relation to a piece of work W, and also back and forth across the face of the work, when the carriage 127 slides along the shaft 126. The tool shaft 132 is preferably parallel to the carriage rock shaft 126, the axes of these shafts being substantially spaced apart and approximately in the same horizontal plane.

A lateral relative feeding motion between the tool and the work is required when the tool is in operative position to press the tool against the surface of the work to be ground. In the illustrated embodiment of the invention, this feeding motion is effected by a slight rocking movement of the carriage 127 about the shaft 126. Since the tool axis is horizontally spaced from the rocking axis of the carriage, the feeding movement of the tool is upward or downward, that is, in the general direction of the axis of rotation of the turret. This results in a direction of tool feed which is approximately perpendicular to the movement of the work when the turret is indexed. Hence, a slight error in the indexing results in a much smaller error in the grinding.

The carriage is rocked by raising or lowering the roller 128. For this purpose the roller may be mounted in the upper end portion of a vertical slide member 140, the lower end being in threaded engagement with the internally threaded hub of a bevel gear wheel 141. This gear wheel meshes with another wheel 142 mounted on a shaft 143. On this shaft is also mounted a handwheel 146 which may be manipulated to rock the carriage 127. For automatic control of the tool feed, a collar 150 may be frictionally mounted on the shaft 143 to rock therewith, the collar 150 having an arm 151 extending therefrom and provided at its outer end with a cam follower 152 adapted to ride on the edge of a cam 153. This cam is preferably of a spiral shape so that as the cam is revolved about the axis of a shaft 155 on which it is mounted, the cam follower 152 is swung away from the axis of the shaft 155, thus rocking the collar 150 and shaft 143. This in turn rocks the carriage 127 and moves the tool 135 against the surface of the work if the tool is in operative position relative to the work. This tool feeding mechanism includes means for adjusting the feed automatically to compensate for where surface portions of the tool are removed when the tool is dressed or trued by a suitable truing tool.

Truing points 160 are provided for the tools 135. As shown in Figure 5, each truing point may be carried by an arm 161 pivotally mounted on the bed by a tapered spring-pressed bearing 162. The truing point 160 is so mounted as to swing in a circle tangent to the periphery of the tool 135 at its uppermost point, this being the point at which the tool engages the work. This requires that the axis about which the truing point swings is in the vertical plane containing the axis of rotation of the tool. Thus the pivot 162 must be either directly above or directly below the axis of the tool 135. On the drawings it is shown as directly below. The arm 161 may be suitably shaped to clear the tool when the truing point is in operative position. A solenoid 163 may be provided for each arm 161 and connected thereto as by a link 164, the solenoid being adapted to be energized to swing the arm 161 and point 160 into position for truing the tool 135. This operative position of the point may be definitely established by a limit stop device such as an arm 165 rockable with the arm 161 to engage a fixed member such as the bed, or a wear-piece mounted thereon, when the point 160 is in correct operative position. A spring 166 may be arranged to pull the arm 161 to inoperative position when the solenoid is deenergized. The solenoids 163 for the several arms 161 may be simultaneously controlled by a single switch or, as shown, each solenoid may be connected with a separate control switch 167. Each switch is provided with an operating arm 168 adapted to be engaged by a cam element 169 on the carriage 127 to open the switch 167 when the carriage advances toward the work so that during the grinding operation, the solenoid is deenergized and the spring 166 holds the arm 161 and point 160 out of the way.

For the traversing movements of the tools across the surface of the work hydraulic apparatus may be provided as illustrated particularly in Figures 3 and 4. As shown in Figure 3, a collar 170 is loosely fitted on the tubular extension 53 of the turret 22. Projecting radially from this collar 170 are four arms 171. Three of these arms are connected to links 172 for the reciprocation of the carriages 127, the fourth arm 173 being connected through a piston rod 175 to a power piston reciprocable by a suitable fluid such as oil under pressure in a cylinder 180. Each arm 172 is pivotally connected at its outer end to an intermediate point 185 of an upright lever 186. Each lever 186 is rockably mounted at its lower end 187 on the bed so that reciprocation of the arm 172 attached to the lever 186 swings the upper end of the lever toward and away from the turret. At the upper end of each lever 186 may be mounted a roller 189 riding in a groove or equivalent recess in the carriage 127. Rocking of the lever 186 on its pivot 187 thus causes the carriage 127 to slide on the shaft 126 to move the tool 135 into and out of operative position.

Mechanism for operating and controlling the piston in the cylinder 180 is fully illustrated and described in the application of Bryant Serial No. 640,846, filed November 2, 1932. Such mechanism includes valve means in a valve chest 190, and an oil reservoir 181 containing a pump 182 which may be connected to the shaft 68 as by a pulley-and-belt connection 183. The valve means in the chest 190 is directly controlled by a valve

stem 206 which projects therefrom and is axially movable by an arm 250 carried by the piston rod 175 to reverse the direction of motion of the piston. The piston may move through a short stroke to reciprocate the tool on the surface of the work, or through a long stroke to retract the tool from the work for indexing the turret and truing the tool. The stroke of the piston is controlled by a solenoid 260 which, when energized, limits the stroke of the piston to traversing the tools over the work. When the solenoid 260 is deenergized, the piston is permitted a longer stroke to retract the tools from the work, as described in the said application of Bryant. For the automatic control of the solenoid a suitable cam disk 265 may be provided, as shown in Figures 7 and 8. A switch 266 having an operating arm 267 is mounted adjacent to the cam disk 265 so that a cam follow 268, carried by the arm 267, is in engagement with the edge of the disk 265. This edge has a portion offset inwardly as at 270. When the cam follower 268 reaches the off-set portion 270 of the cam edge, the arm 267 rocks opening the switch 266 and deenergizing the solenoid 260 to permit withdrawal of the tools from the work.

The motor 65, in addition to driving the indexing shaft 86 and the indexing cam 112, may also be employed to drive the solenoid control cam 265 and the feed cam 153. To this end the shaft 68 may be provided with a worm 300 meshing with the gear wheel 301 mounted on the shaft 302. This shaft may be mounted in bearings near the ends of opposite wings 21 of the bed frame. The shaft 302 is operatively connected as by bevelled gears 305 and 306 in each of these wings to shafts 307. In the wing 21 of the bed frame into which the shaft 68 extends, a cross shaft 311 may be driven through a worm 312 on the shaft 68 and a gear wheel 313 on the shaft 311 meshing therewith. Each of the shafts 307 and 311 is operatively connected with a corresponding shaft 155 as by a suitable train of gear wheels 315, 316, and 317. Each shaft 155 carries a corresponding feed cam 153, as hereinbefore described. On one of the shafts 155 may be mounted the solenoid control cam 265. As a result of this arrangement, the motor 65 is employed for the simultaneous driving of these various cams.

In order to synchronize the movements of the various cams with the indexing of the turret, the worm 83 is preferably of such a kind as to drive the gear wheel 84 and shaft 85 at about six times the speed of rotation of the indexing cam 112, the solenoid control cam 265, or the feed cam 153. As a result, the indexing movement of the turret to shift the chucks from one operating station to the next takes place during a period equivalent to about one sixth of a revolution of the other cams. This speed ratio may, of course, be altered as desired by selection of suitable gearing for the drive of the several cams.

For some purposes it may be desirable to drive the work-holders at different speeds for the successive grinding operations. For example, it might be advantageous in some cases to rotate the work-holder at a comparatively slow rate during the rough grinding operation by #1 tool, and more rapid rates of rotation of the work during the finishing operations of #2 and #3 tools. Such various speeds at the several operating stations may be obtained in various ways such as by the use of separate driving motors for the several work-holders, as shown in Figures 9–11. As therein shown, a gear wheel 330 may be mounted on the inner end portion of each shaft 31. Each gear wheel 330 meshes with a worm 331 on a shaft 332 driven directly by a motor 335. There is thus a separate motor 335 for each work-holder, these motors being suitably mounted within the turret 22. The speed of the motors is individually controlled according to the station of the work-holder, any suitable means being employed for this purpose. As shown, the turret 22 is adapted to revolve about a central stationary shaft 336, preferably hollow, on which is mounted a commutator member 337 of insulation. Sets of contact elements 340 are carried by the member 337 in positions for contact with sets of brushes 341, carried by the motors 335, when the corresponding work-holders are in positions for operative relation with the tools 135. Thus, in the embodiment illustrated, there are three sets of contact elements 340 for the three work-holders adjacent to the tools, the brushes of the fourth motor having no circuit connections at such time so that the motor is idle and the work in the work-holder can be readily changed. Wires 342 may extend from the several contact elements 340 through the hollow shaft 336 to respective control boxes 350 conveniently located on or near the machine. The setting of these control boxes determines the speed of rotation of each work-holder when it moves into position for a grinding operation.

In the operation of the apparatus as a whole, the turret is indexed while the tools are retracted from their operative position and are being moved slowly past their respective truing tools. The indexing movement of the turret is stopped when one of the stop pins 95 engages the upper end of the stop rod 96. As hereinbefore described, this causes the worm 83 to act as a nut on the gear wheel 84 so as to move the shaft 72 axially to disconnect the clutch member 73 from the clutch member 74 as indicated in Figure 6. The spring 82, presented against the end of the shaft 72 through the bearing 80, holds the turret firmly in its indexed position. The hydraulic mechanism is so regulated by previous adjustment that the piston moves the tools 135 into the corresponding pieces of work shortly after the turret has reached its indexed position. When the piston rod reaches its extreme tool-advancing position the solenoid 260 is energized to limit the stroke of the tools to a movement back and forth within the work. At the same time the constant revolution of the shafts 155 brings the feed cams 153 into engagement with the cam followers 152, resulting in a lateral feeding movement of the tools against the surface of the work which is to be ground. During the grinding operation, the index cam 112 is constantly rotated, the deenergizing of the solenoid 260 being timed to permit the retraction of the tools from the work before the recess 113 in the index cam 112 reaches the end of the rod 111. Thus, the tools are all clear of the work when the rod 111 is permitted to move into the recess 113, releasing the stop rod 96. Immediately after this, the squared pin 124 on the cam disk 112 engages a pin 123 in the end of the arm 122 and rocks the arm 122 sufficiently to relieve the pressure of the spring 82, acting through a stop pin 95 on the stop rod 96. Thus the retraction of the stop rod 96 under the influence of gravity and the spring 100 is permitted so that the turret is then free to be revolved. The pin 123 thereupon rides clear of the pin 124, permitting the arm 122 to swing back and the shaft 72 to move axially so as to reengage the clutch mem-

bers 73, 74. The shaft 72 is thereupon driven through the gear wheels 70 and 71, this resulting in indexing movement of the turret to the next position. Since the time required for the grinding step is considerable, ample time is available during the grinding step for an operator to remove the finished piece of work in the chuck at the work changing station, and to secure in the chuck a fresh piece of work to be ground. This cycle may be repeated indefinitely.

It is evident that various changes and modifications may be made in the specific embodiment of the invention herein shown and described, without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. In a machine of the class described having a bed, a turret rotatable on said bed about a vertical axis, and a plurality of radially projecting work-holders on said turret, a plurality of tool carriages mounted on said bed, each said tool carriage being rockable on a horizontal axis, means associated with each tool for rotating the tool on an axis parallel to the rocking axis of the carriage, means for advancing each tool along its own axis toward the turret, and means for automatically rocking each carriage while the tool is in position for engagement with the work to impart lateral feeding movement to each said tool.

2. In a turret grinding machine, a flat turret, a work-holder carried by said turret and arranged transversely with respect to the turret axis, a tool rotatable on an axis aligned with said holder, driving means for said tool, a carriage supporting said tool and driving means, means rockably supporting said carriage, means for rocking said carriage on an axis transverse to the turret axis, whereby lateral feeding movement is imparted to said tool, and means for reciprocating said carriage and tool toward and from said turret.

3. A machine of the class described comprising a rotatable turret, a plurality of work-holders carried by said turret and rotatable on axes transverse to the turret axis, a tool into operating relation with which said work-holders may be successively positioned by indexing of said turret, and power means for producing relative feed motion between said tool and the holder in operating relation therewith in the general direction of the axis of rotation of said turret.

4. A machine of the class described comprising a rotatable turret, a plurality of work-holders carried by said turret, a tool into operating relation with which said work-holders may be successively positioned by indexing of said turret, means for traversing said tool relatively to the work on which it is operating in a direction transverse to the turret axis, and power means for producing a predetermined relative feed motion between said tool and work in the general direction of the axis of rotation of the turret.

5. A machine of the class described comprising a rotatable turret, a tool rotatable on an axis transverse to the axis of rotation of the turret, a plurality of work-holders movable successively into operative relation with said tool by indexing of said turret, means for traversing said tool in the direction of its axis, and power driven cam means for producing a predetermined feeding motion between the tool and work in the general direction of the axis of rotation of the turret.

6. A machine of the class described comprising a rotatable turret, a plurality of work-holders arranged radially in said turret, a tool rotatable on an axis substantially perpendicular to the axis of rotation of said turret, means for indexing said turret to positions in which the work-holders are brought successively into operative relation with said tool, means for traversing said tool in the direction of its axis, means for producing a predetermined feeding movement between said tool and work in the general direction of the axis of rotation of the turret, and common driving means for the indexing and feeding means.

7. A machine of the class described comprising a rotatable turret, a rotatable tool, a carriage for said tool rockable on an axis parallel to the tool axis to impart feeding movement to the tool, the tool rotation axis and carriage rocking axis being in a plane substantially perpendicular to the axis of rotation of the turret, and a plurality of work-holders on said turret movable successively into operative relation with said tool by indexing of the turret.

8. A machine of the class described comprising a rotatable turret, a rotatable tool, a carriage for said tool rockable on an axis parallel to the tool axis to impart feeding movement to the tool, the tool rotation axis and carriage rocking axis being in a plane substantially perpendicular to the axis of rotation of the turret, a plurality of work-holders on said turret movable successively into operative relation with said tool by indexing movement of the turret, and means for traversing said tool in a direction transverse to the axis of rotation of the turret.

9. A machine of the class described comprising a rotatable turret, a plurality of rotatable tools, a plurality of work-holders carried by said turret and movable into operative relation with successive tools by indexing of said turret, and power driven cam means for simultaneously feeding said tools transversely of their respective axes of rotation and in a direction substantially parallel to the axis of rotation of said turret.

10. A machine of the class described comprising a rotatable turret, a plurality of tools, a plurality of work-holders carried by said turret and movable into operative relation with successive tools by indexing of said turret, means for simultaneously traversing said tools relatively to adjacent work-holders, and power means for automatically and simultaneously feeding said tools at independent predetermined rates in the general direction of the axis of rotation of said turret.

11. A machine of the class described comprising a turret rotatable about a vertical axis, a plurality of work-holders carried by said turret and arranged radially therein, a plurality of tools arranged around said turret to be simultaneously in operative relation with different ones of said work-holders, said tools being rotatable on axes transverse to the turret axis, means for indexing said turret to shift said work-holders from one tool to the next, means for simultaneously traversing said tools along their respective axes, and means for feeding said tools in the general direction of the axis of rotation of the turret.

12. A machine of the class described comprising a bed, a turret rotatable on said bed, work-holders carried by said turret, a plurality of tools arranged for simultaneous operative relation with certain of said work-holders, means for indexing said turret to shift said work-holders from tool to tool, a carriage for each said tool rockable on an axis transverse to the axis of the turret to impart feeding movement to the tool, said carriages being slidable along their rocking axes to impart traversing movement to the tools toward and from the axis of said turret,

and means engaging said carriages at points adjacent to their respective working axes to impart sliding movement to said carriages simultaneously.

13. In a machine of the class described, a rotatable grinding tool, means for imparting lateral feeding movement to said tool, and a truing device for said tool comprising an arm having a truing element thereon movable to and from a position in contact with the tool at a point in the path of feeding motion of the center of the tool, said arm being pivotally mounted at a point beyond the opposite side of the tool and in line with said point of contact and the center of the tool, whereby the peripheral contour of the tool is internally tangent to the circular path described by the truing element in moving to and from operative position.

14. In a machine for internal grinding, a grinding tool rotatable on a horizontal axis, means for imparting upward feeding movement to said tool, and a truing device for said tool comprising an arm having a truing element thereon movable into and out of contact with said tool at its uppermost point, said arm being pivotally mounted at a point directly below the center of said tool, whereby the path of movement of said truing element is tangent to the peripheral contour of the tool.

15. In a turret grinding machine, a work-holder carried by said turret, a tool rotatable on an axis aligned with said work-holder, a carriage for said tool movable toward and from said work-holder, a bed on which said carriage is slidably mounted, an arm pivotally mounted on said bed, a truing device carried by said arm and movable thereby into and out of operative position for truing said tool, means including a solenoid for rocking said arm to move the truing device into and out of operative position, and means for automatically controlling said solenoid, said control means including a switch and means actuated by movement of said carriage toward the work-holder to operate the switch for the withdrawal of said truing device from operative position, said last named means being actuable by movement of the carriage away from the work to operate the switch for the movement of the truing device into operative position.

16. In a turret grinding machine, a turret revoluble on a vertical axis, a plurality of work-holders radially arranged on said turret, a plurality of tools rotatable on axes aligned respectively with certain of said work-holders, carriages for said tools movable to reciprocate said tools along their respective axes, and means for simultaneously reciprocating said carriages, said last named means including a rockable member coaxial with said turret, means for rocking said member, upright lever arms pivotally mounted at their lower ends and connected to respective carriages at their upper ends, and connecting rods extending between said members and intermediate points of said lever arms.

17. A machine of the class described comprising a rotatable turret, a plurality of work-holders carried by said turret and movable thereby into successive operating stations, tools at the several operating stations arranged to be in operative relation to the work-holders in succession, and means for automatically rotating the work-holders at the several stations at different predetermined speeds.

18. A machine of the class described comprising a rotatable turret, a plurality of tools, a plurality of rotatable work-holders carried by said turret and movable into operative relation with successive tools by indexing of said turret, means for feeding said tools in the general direction of the axis of rotation of said turret, and means for automatically rotating said work-holders at different predetermined speeds, the speed of rotation of each work-holder at any time being determined by the operating station which it occupies at the time.

19. A machine of the class described comprising a rotatable turret, a plurality of tools arranged about said turret and each rotatable on an axis transverse to the axis of rotation of the turret, a plurality of work-holders movable successively into operative relation with said tools by indexing movement of said turret, means for traversing each said tool in the direction of its axis, and means for automatically rotating the work-holders at different speeds predetermined for operation with the several individual tools.

20. A machine of the class described comprising a rotatable turret, a plurality of tools arranged about said turret and each rotatable on an axis transverse to the axis of rotation of the turret, a plurality of work-holders movable successively into operative relation with successive tools by indexing movement of said turret, means for traversing each said tool in the direction of its axis, and power means for automatically and independently feeding each said tool in the general direction of the axis of rotation of the turret.

21. In a turret grinding machine, a work holder carried in said turret, a tool rotatable on an axis aligned with said work-holder, a carriage for said tool movable toward and from said work-holder, a bed on which said carriage is slidably mounted, a truing device rockably mounted on said bed, a solenoid actuable to rock said device into and out of operative position, and control means responsive to certain movements of said carriage for controlling the energization of the solenoid.

22. In a grinding machine, a work-holder, a tool rotatable on an axis alined with said work-holder, a carriage for said tool movable toward and from said work-holder, a bed on which said carriage is slidably mounted, an arm pivotally mounted on said bed, a truing device carried by said arm and movable thereby into and out of operative position for truing said tool, a solenoid actuable to move said arm into and out of operative position, and control means responsive to movement of said tool away from the work to energize said solenoid to move the truing device into operative position, said control means being responsive to movement of the tool toward the work to deenerergize said solenoid.

23. A machine of the class described, comprising a plurality of tools, a plurality of rotatable work-holders movable in turn into operative relation with successive tools, and means for automatically rotating each work-holder at different speeds according to the particular tool with which it is in operative relation.

24. A machine of the class described, comprising a plurality of work-holders movable in turn into operative relation with successive tools, means for simultanenously moving all said work-holders from their operating stations to the next succeeding stations, means for automatically rotating each work-holder at different speeds according to the successive operating stations occupied thereby.

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