

Feb. 28, 1928.

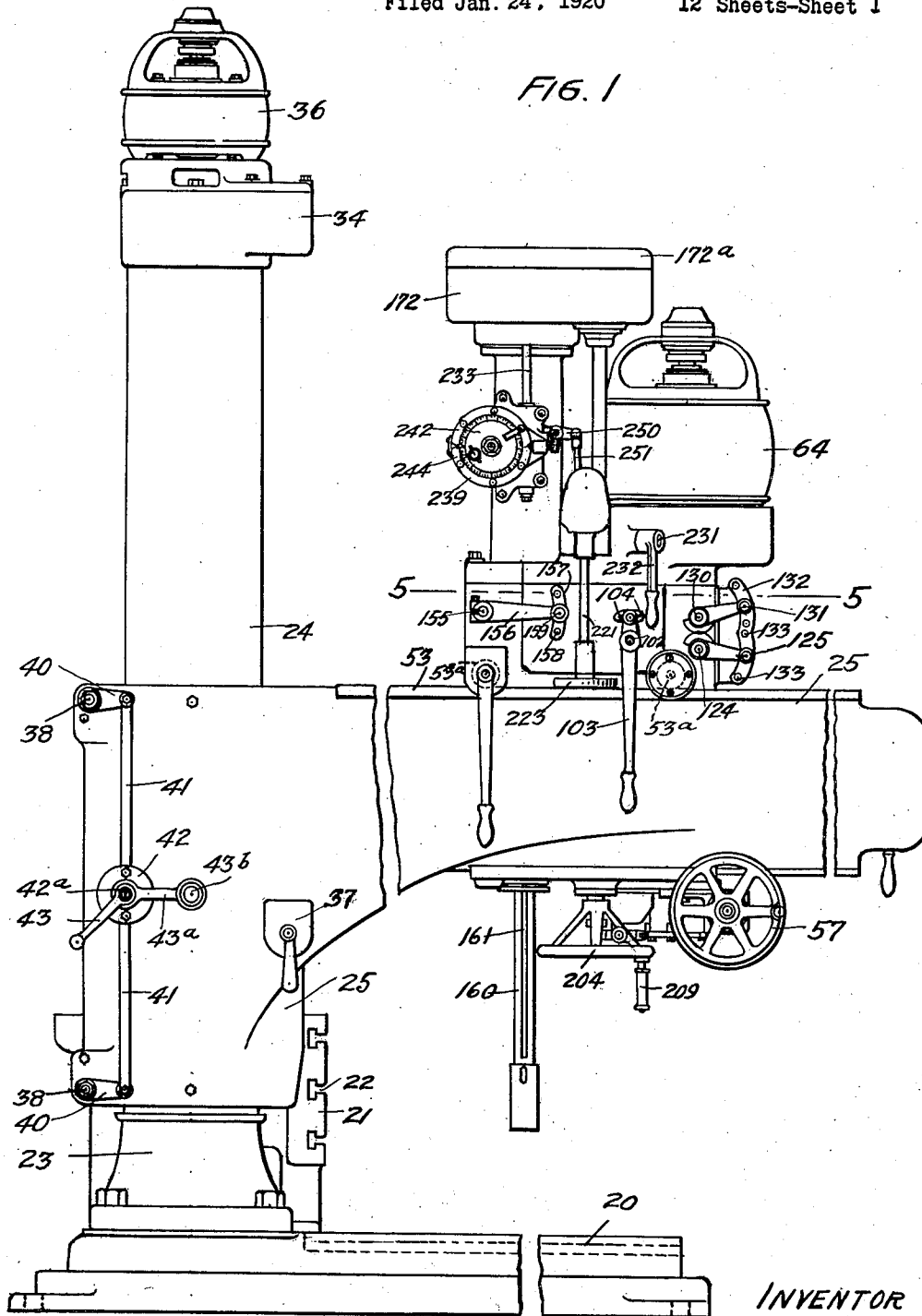
1,660,477

C. M. CONRADSON
RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 1

FIG. 1



INVENTOR
CONRAD M. CONRADSON
By *Paul H. Paul*
HIS ATTORNEYS.

Feb. 28, 1928.

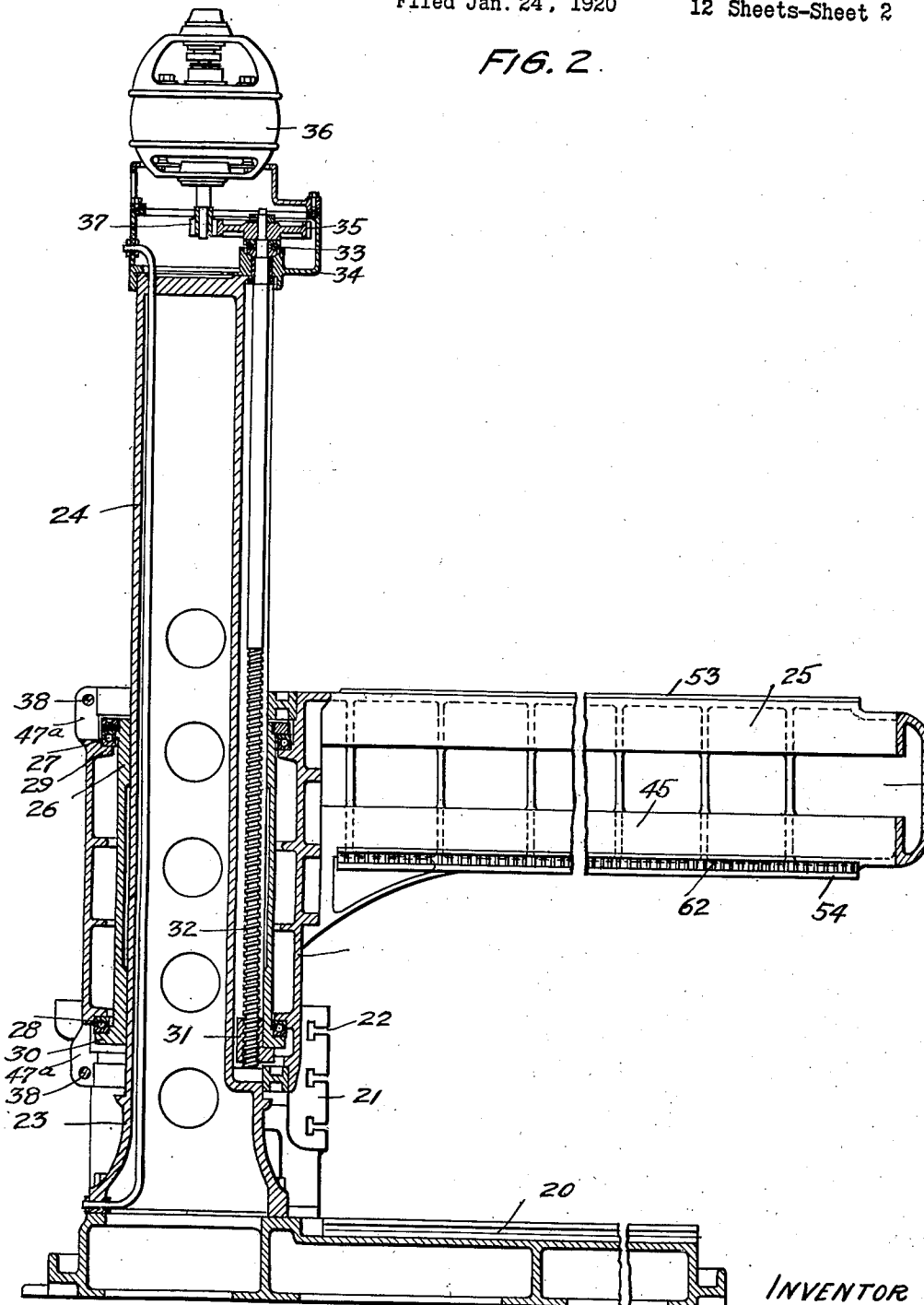
1,660,477

C. M. CONRADSON
RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 2

FIG. 2.



INVENTOR
CONRAD M. CONRADSON
By *Paul & Paul*
HIS ATTORNEYS

Feb. 28, 1928.

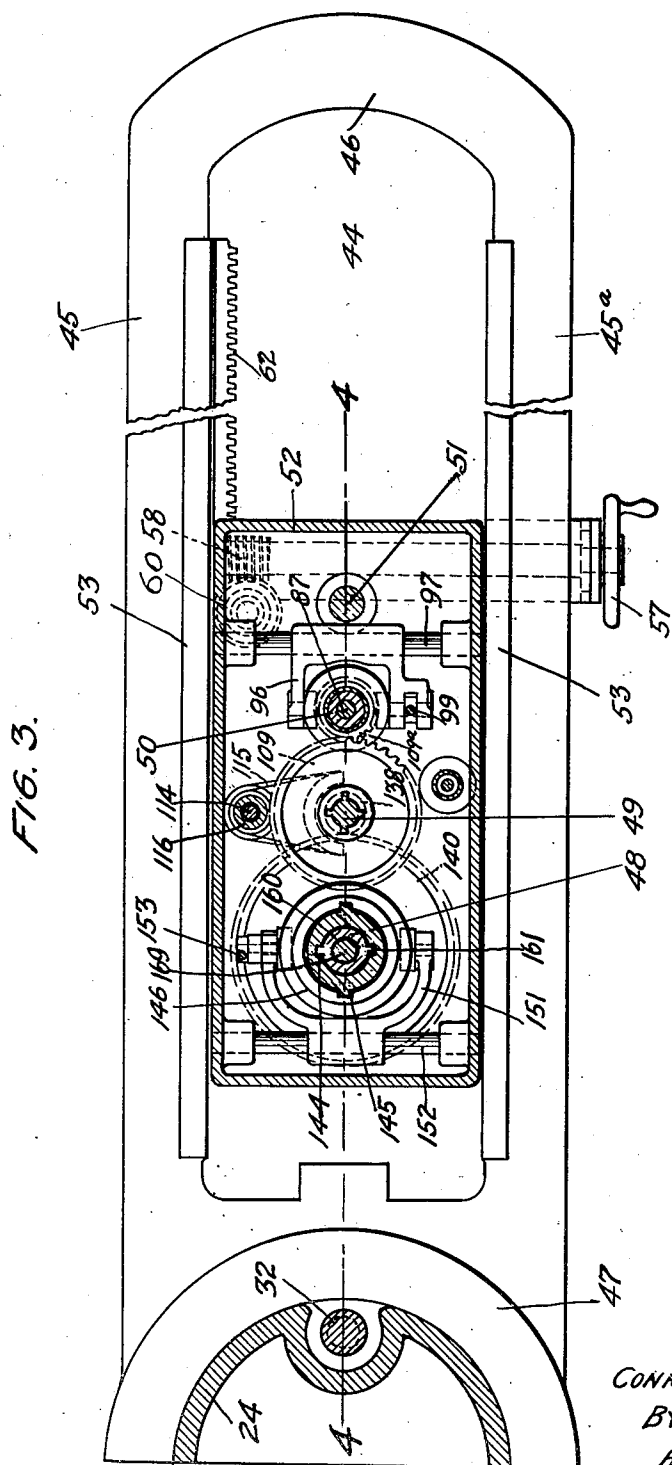
1,660,477

C. M. CONRADSON

RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 3



INVENTOR
CONRAD M. CONRADSON
BY *Paul Hand*
HIS ATTORNEYS.

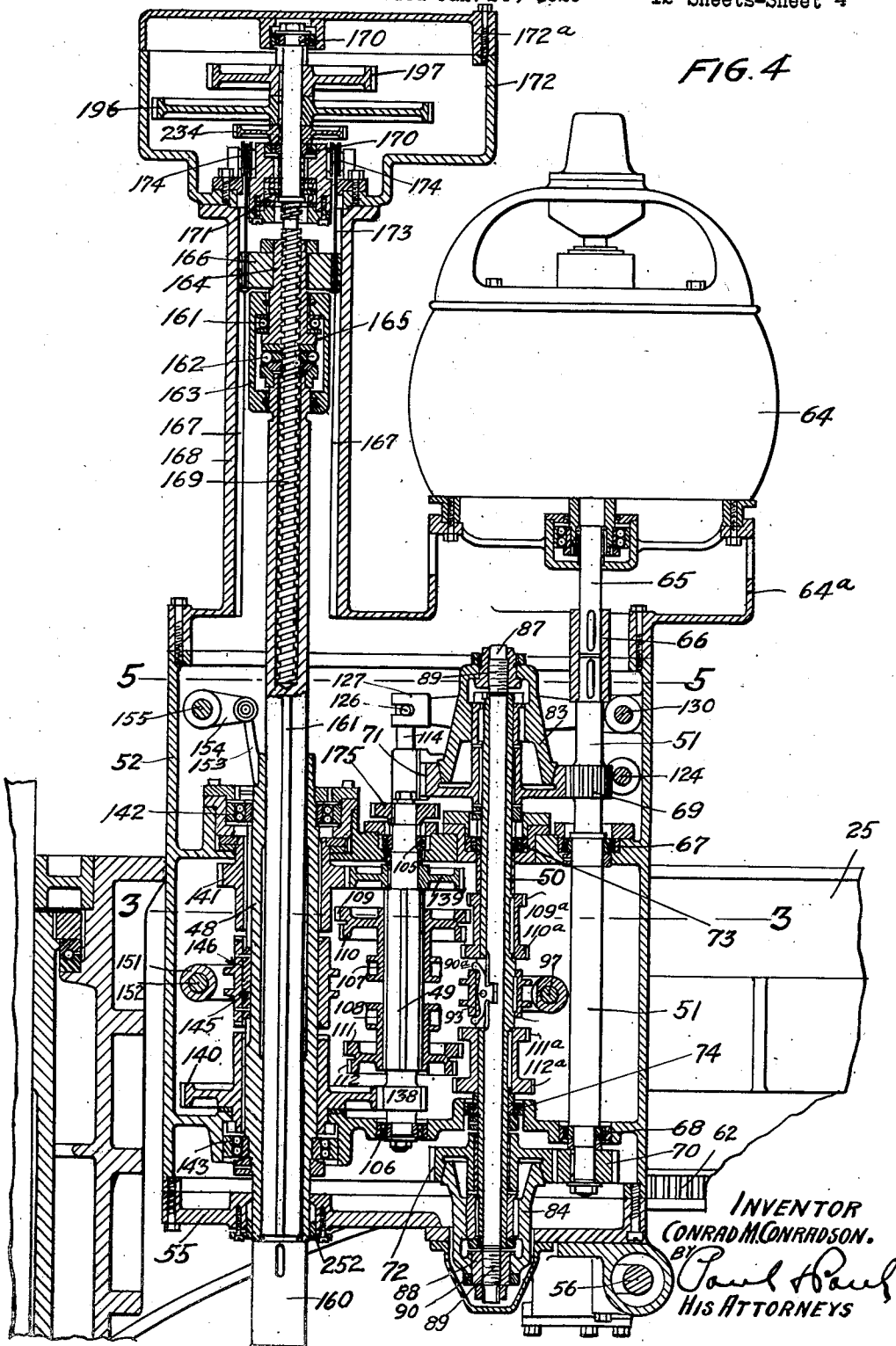
Feb. 28, 1928.

1,660,477

C. M. CONRADSON
RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 4



Feb. 28, 1928.

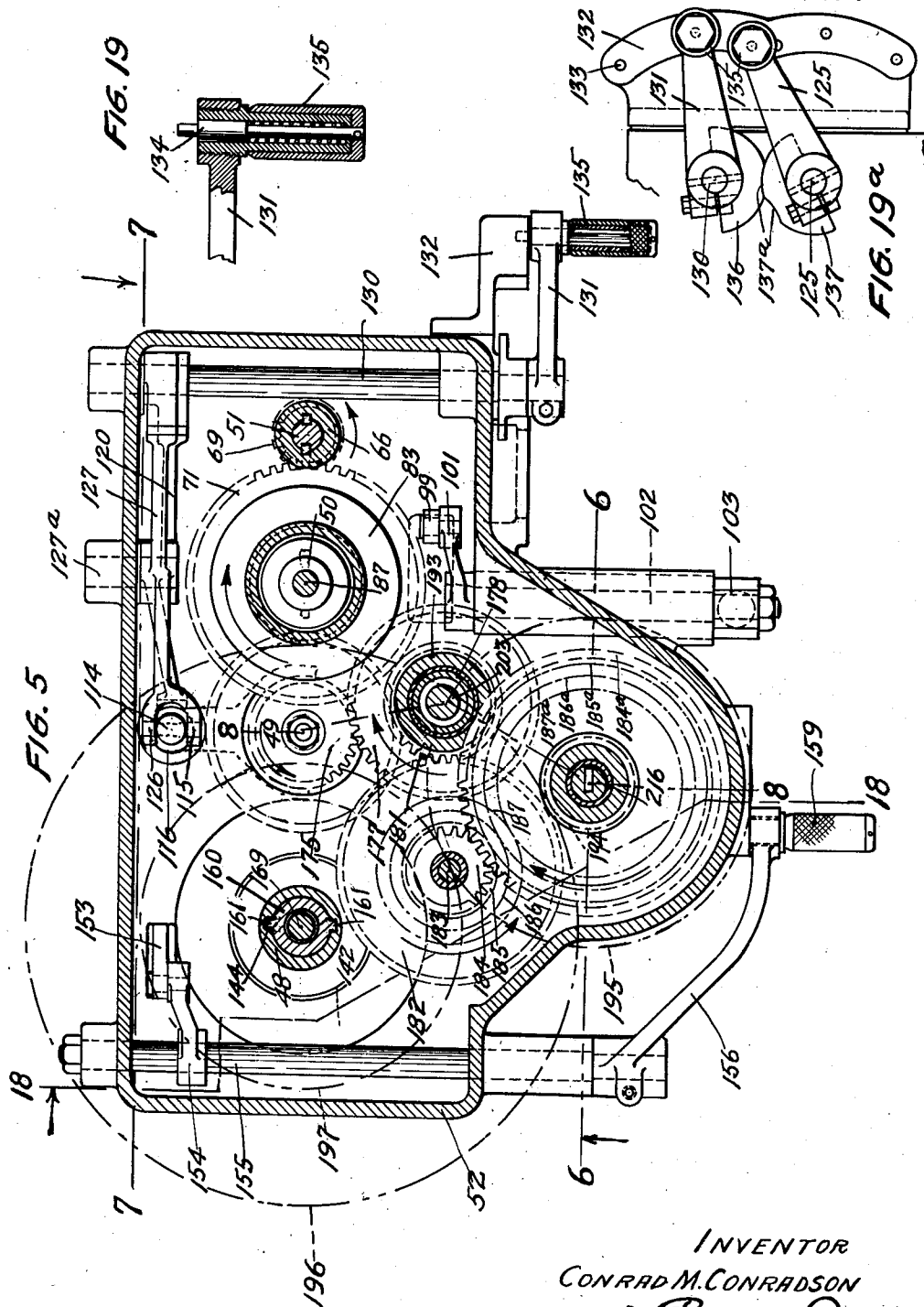
C. M. CONRADSON

1,660,477

RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 5



INVENTOR
CONRAD M. CONRADSON
BY *Paul & Paul*
HIS ATTORNEYS.

Feb. 28, 1928.

C. M. CONRADSON

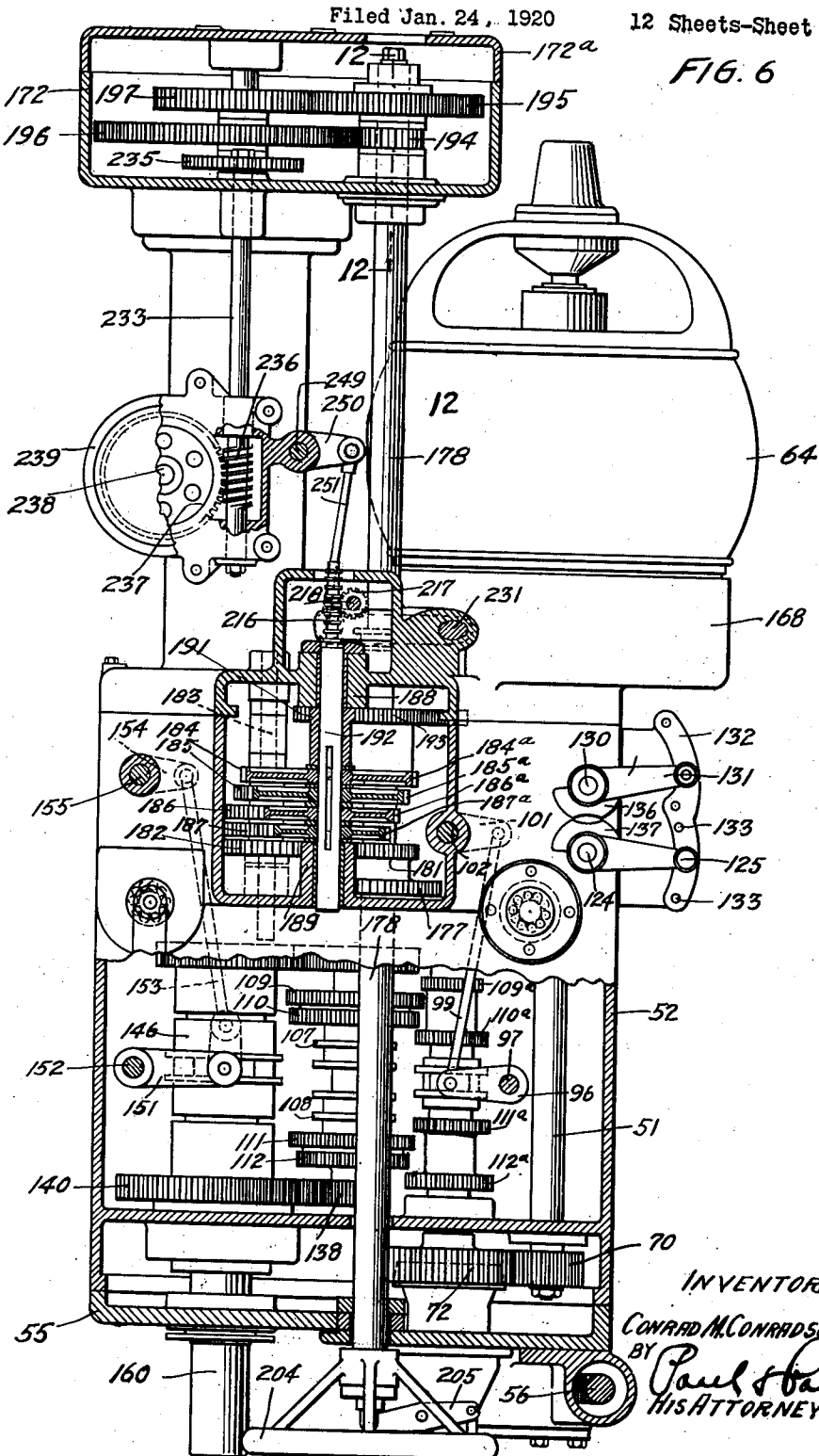
1,660,477

RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 6

FIG. 6



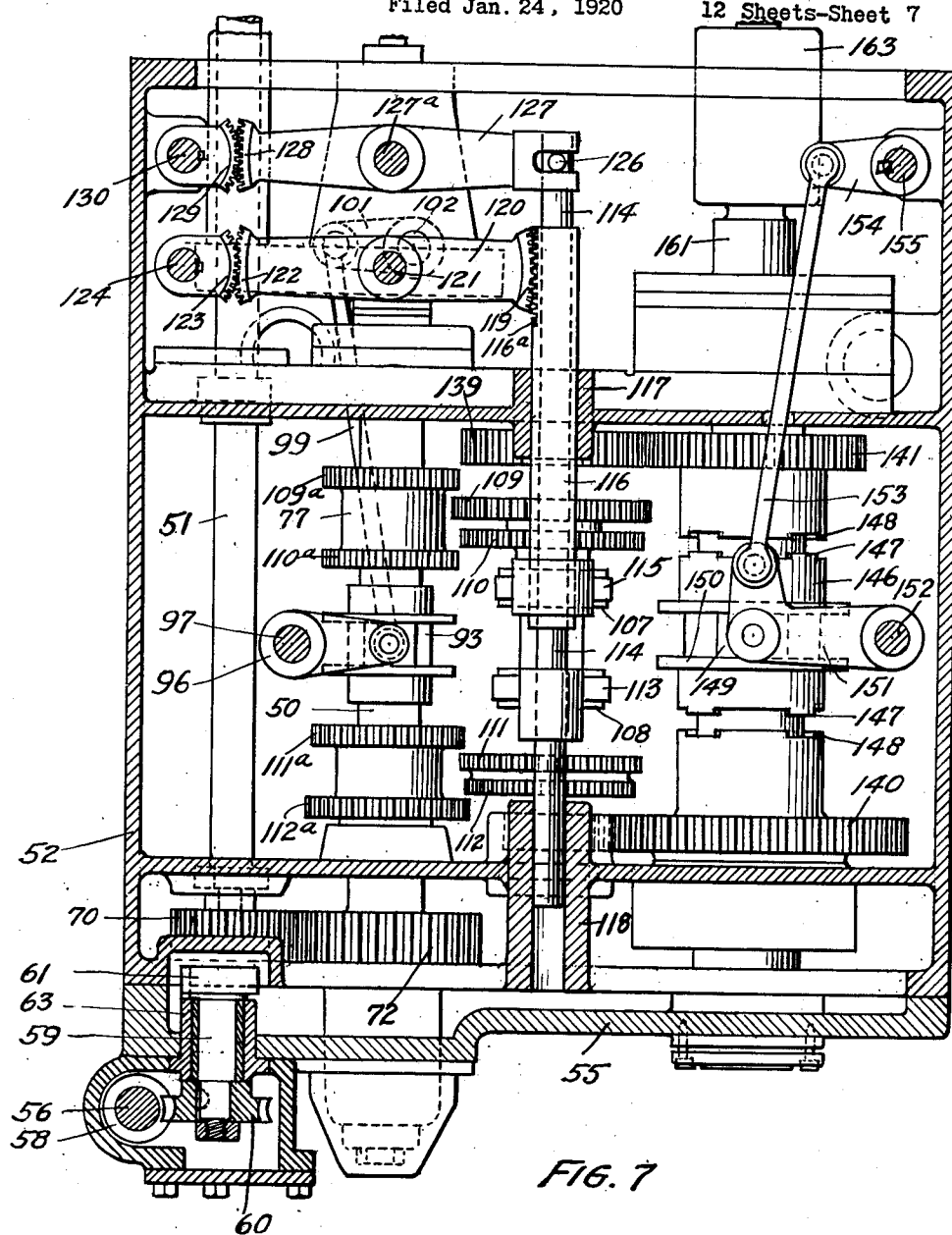
Feb. 28, 1928.

1,660,477

C. M. CONRADSON
RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 7



INVENTOR.
CONRAD M. CONRADSON
BY *Paul & Paul*
HIS ATTORNEYS.

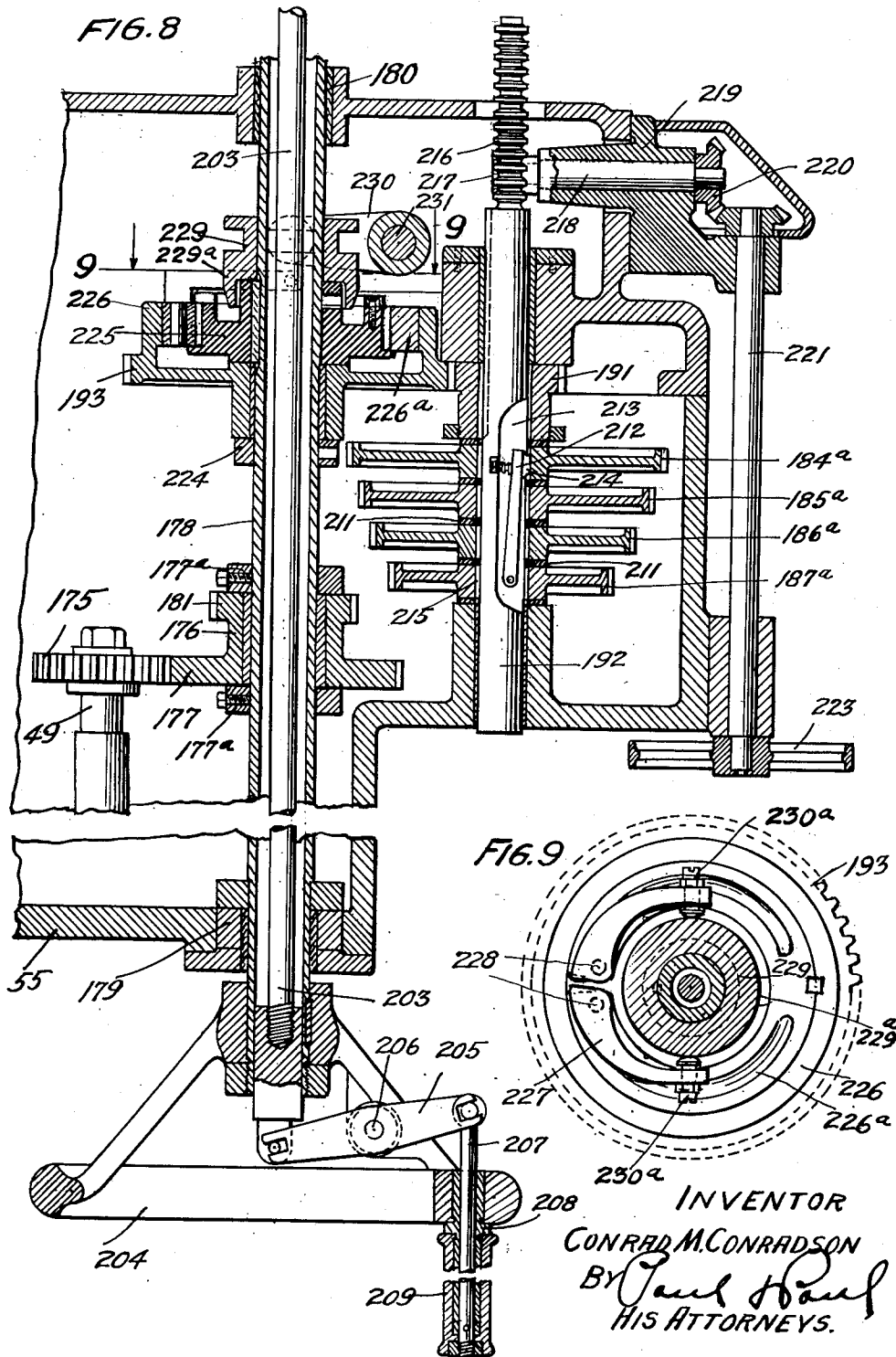
Feb. 28, 1928.

C. M. CONRADSON
RADIAL DRILLING MACHINE

1,660,477

Filed Jan. 24, 1920

12 Sheets-Sheet 8



Feb. 28, 1928.

1,660,477

C. M. CONRADSON
RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 9

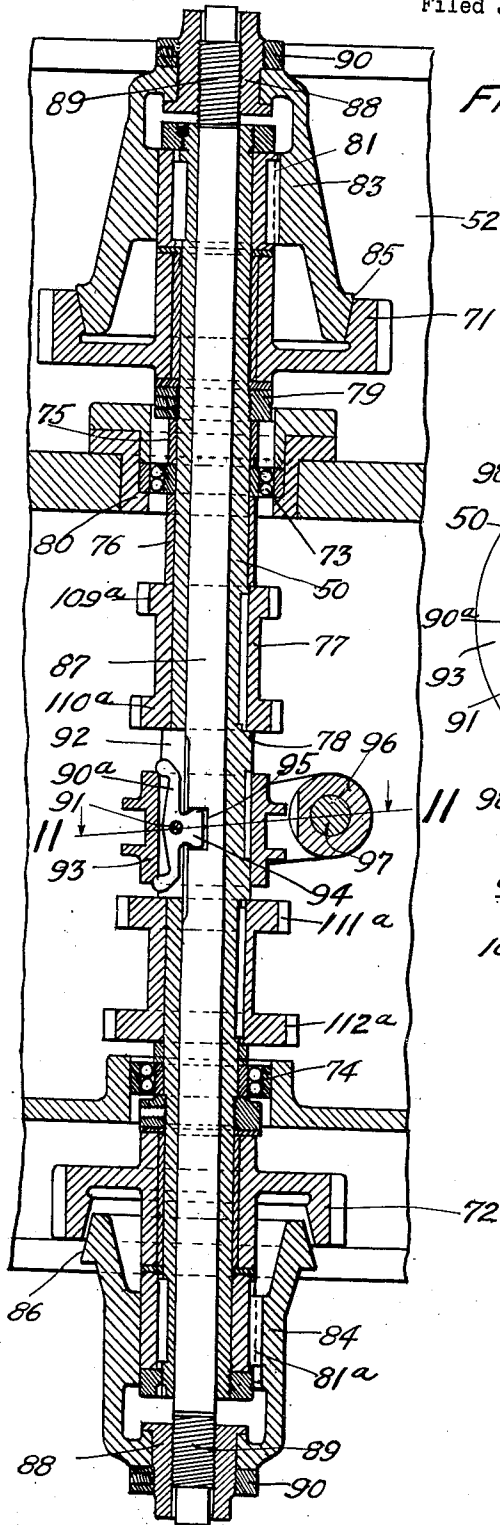


FIG. 10

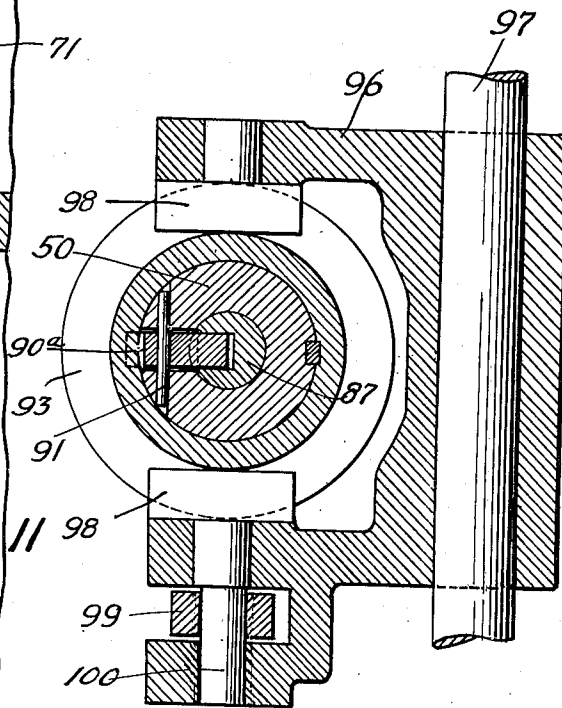


FIG. 11

INVENTOR
CONRAD M. CONRADSON
By *Paul H. Paul*
HIS ATTORNEYS.

Feb. 28, 1928.

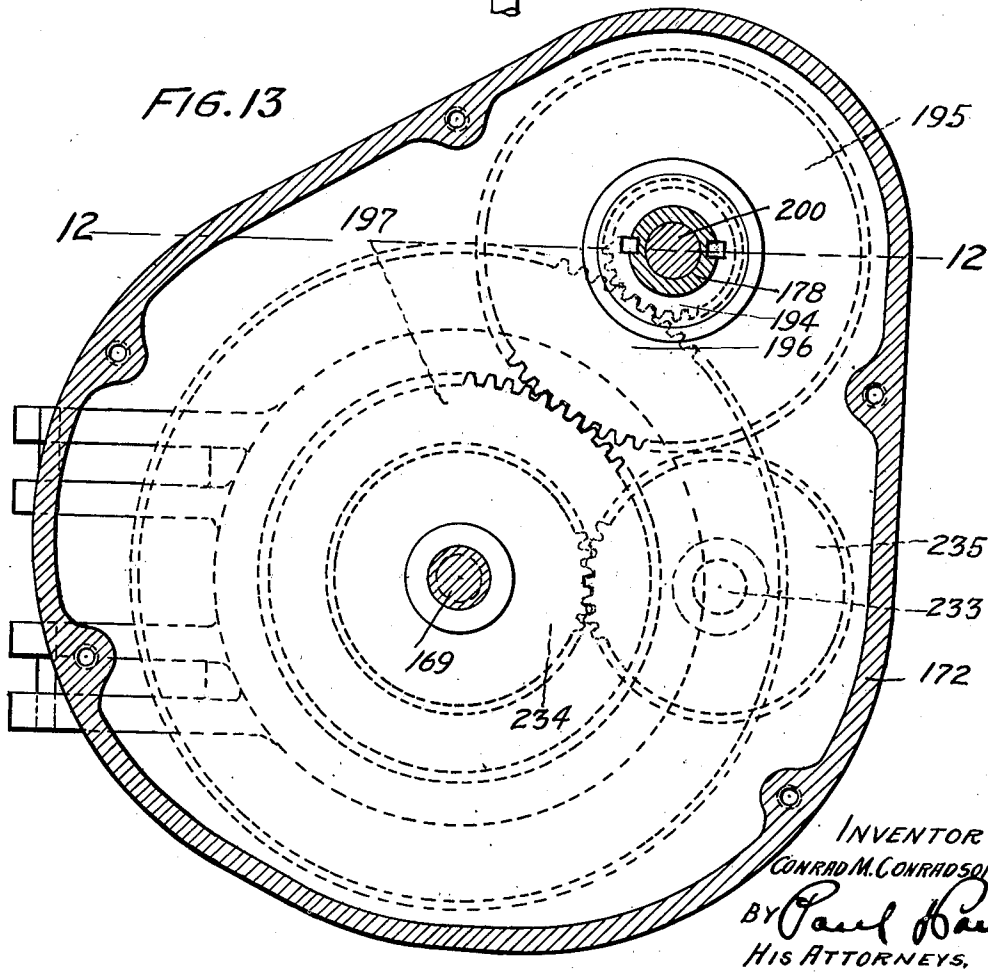
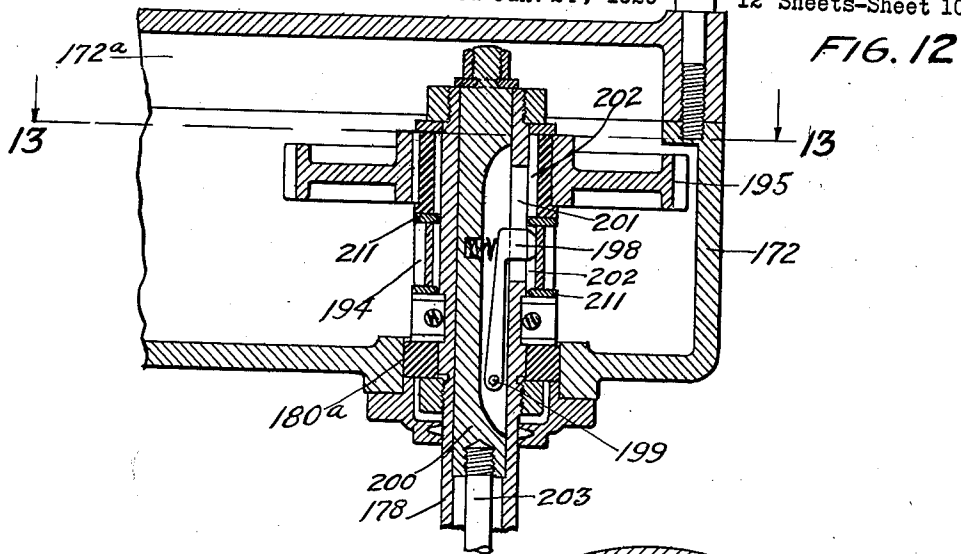
1,660,477

C. M. CONRADSON

RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 10



INVENTOR
CONRAD M. CONRADSON.
BY *Paul H. Paul*
HIS ATTORNEYS.

Feb. 28, 1928.

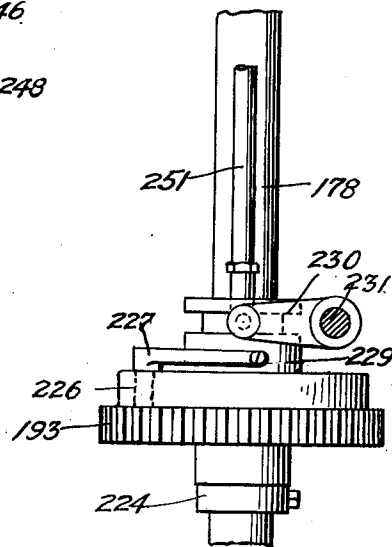
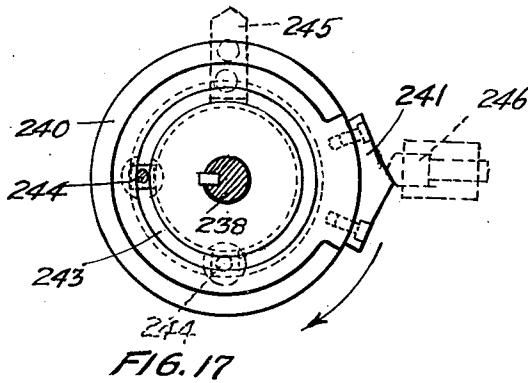
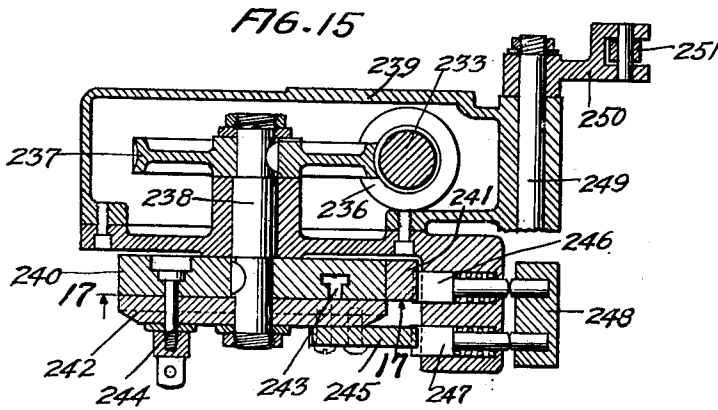
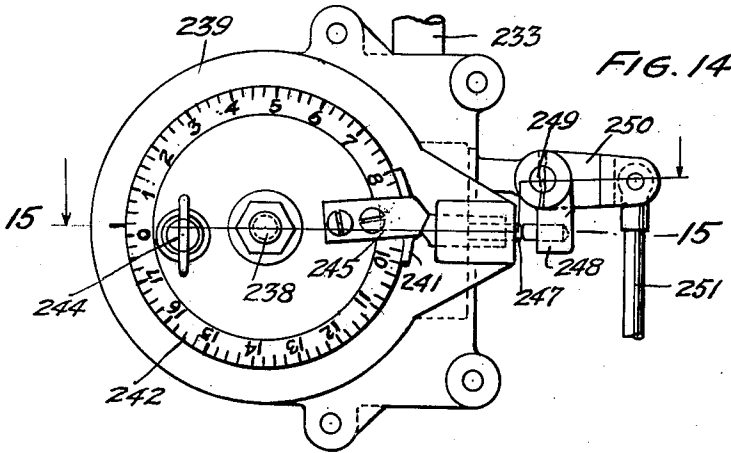
C. M. CONRADSON

1,660,477

RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 11



INVENTOR
CONRAD M. CONRADSON.
BY *Paul H. Hail*
HIS ATTORNEYS.

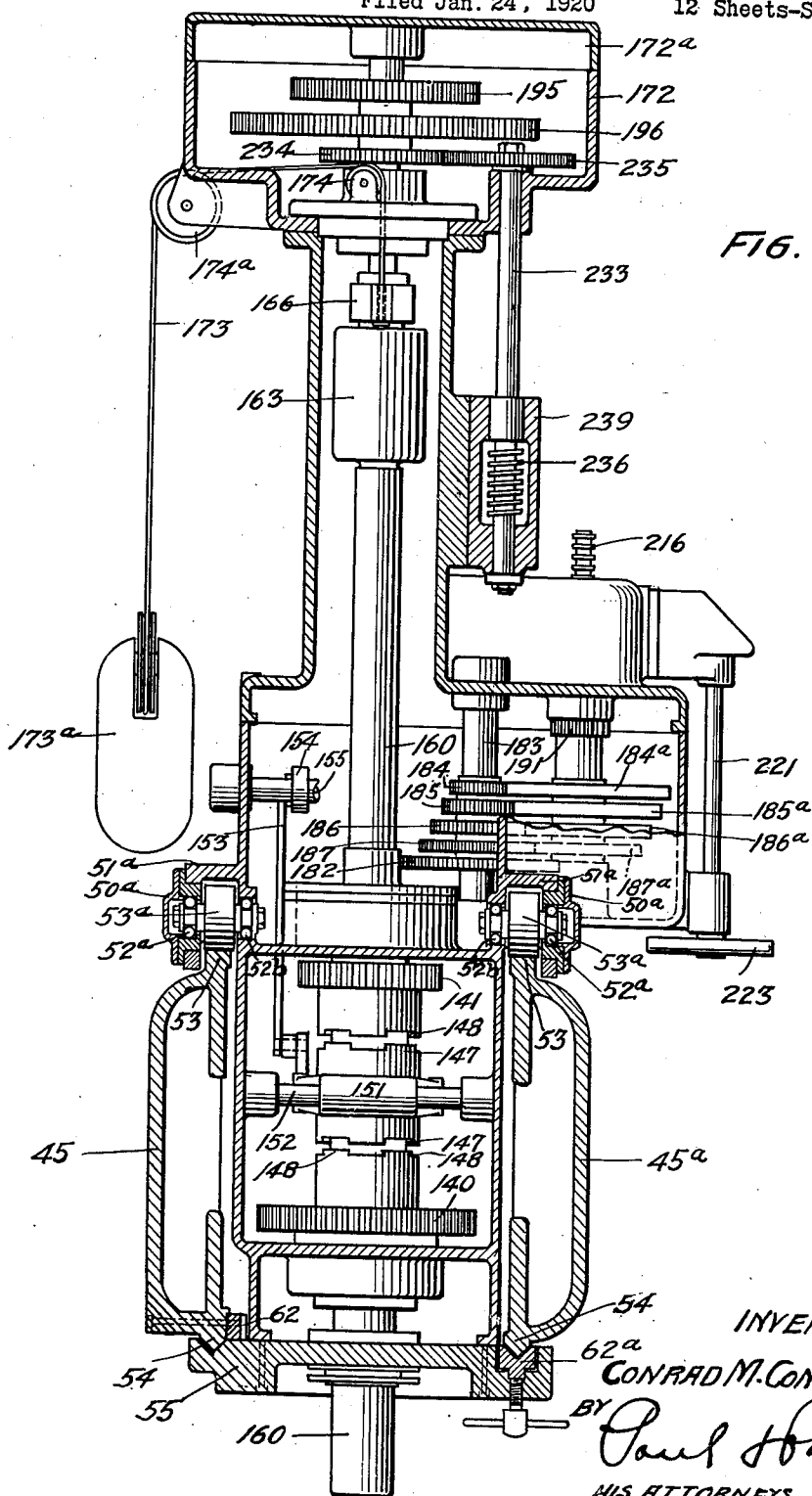
Feb. 28, 1928.

1,660,477

C. M. CONRADSON
RADIAL DRILLING MACHINE

Filed Jan. 24, 1920

12 Sheets-Sheet 12



INVENTOR.

CONRAD M. CONRADSON.

BY *Paul Paul*
HIS ATTORNEYS

UNITED STATES PATENT OFFICE.

CONRAD M. CONRADSON, OF MADISON, WISCONSIN, ASSIGNOR TO JOSEPH T. RYERSON & SON, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

RADIAL DRILLING MACHINE.

Application filed January 24, 1920. Serial No. 353,713.

The invention relates to machines for drilling, boring, tapping or other similar operations, and of the type in which the operating mechanism is carried on a swinging arm radial from and adjustably supported by a vertical column.

The general objects of the invention are to provide simplified and more efficient driving, controlling and adjusting mechanism for machines of this class, and to adapt the machine to a large variety of work and materials by providing a great number of cutting tool and feed speeds and facilities for rapid, accurate and convenient speed changes.

More particular objects are to provide a direct motor-driven, vertically adjusting mechanism for the radial arm on the supporting column independent of the tool or spindle driving gear, and a separate reversible motor for this gear mounted directly upon the gear housing and movable with the housing, thus dispensing with all reverse gearing.

A special object is to construct the radial arm in a rigid, balanced and symmetrical form, doing away with the usual twisting strain on the radial arm resulting from overhanging spindle and drive mechanism and at the same time provide ready and efficient means for lubrication and protection by enclosing the entire driving and elevating mechanism in an oil tight housing.

Other objects of the invention will appear from the following detailed description, taken in connection with the accompanying drawings:

The invention consists in the constructions and combinations, all as hereinafter described and particularly pointed out in the claims.

In the accompanying drawings forming a part of this specification:

Figure 1 is a side elevation of a radial drilling machine constructed according to my invention,

Figure 2 is a central vertical section of the supporting frame, illustrating the motor driven elevating mechanism for the radial arm and having the motor-driven drilling carriage removed from the arm,

Figure 3 is a plan view of the radial arm,

showing the drilling carriage in horizontal section on the line 3—3 of Figure 4,

Figure 4 is a central vertical longitudinal section, on the same plane as Figure 2 on the line 4—4 of Figure 3, and showing the drilling carriage in its extreme inward position on the radial arm,

Figure 5 is a horizontal section through the carriage on the line 5—5 of Figures 1 and 4,

Figure 6 is a front elevation of the carriage, partly in section, on the lines 6—6 of Figure 5 and the upper part of the casing broken away,

Figure 7 is a rear sectional vertical view on the line 7—7 of Figure 5,

Figure 8 is a transverse sectional view on the line 8—8 of Figure 5,

Figure 9 is a detail of the clutch mechanism shown in Figure 8,

Figure 10 is a vertical section on a larger scale, illustrating the operation of the friction clutch mechanism shown on a smaller scale in Figure 4,

Figure 11 is a horizontal cross section on the line 11—11 of Figure 10,

Figure 12 is a sectional view of the upper feed drive mechanism on the line 12—12 of Figures 6 and 13,

Figure 13 is a horizontal section on the line 13—13 of Figure 12,

Figure 14 is a detail view illustrating the automatic feed stop tripping mechanism,

Figure 15 is a section on the line 15—15 of Figure 14,

Figure 16 is a detail view showing the connection from the tripping mechanism to the feed operating clutch,

Figure 17 is a section on the line 17—17 of Figure 15, showing the method of adjusting the dial for the feed stop tripping mechanism,

Figure 18 is a transverse sectional view, substantially on the line 18—18 of Figure 5, showing the housing broken away in part,

Figures 19 and 19^a are details of the locking device for the speed change gears.

The supporting and adjusting mechanism.

Referring to Figures 1 and 2, 20 is the horizontal base of the machine which is constructed to properly adjust and hold the

work in conjunction with a vertical table 21 having clamping slots 22. A vertical column 23 is rigidly mounted at one end of the base 20 and upon its circular portion 24 is mounted the radial arm 25, by means of a sleeve 26, slidably fitting the column 24. The arm 25 is swingingly supported by ball bearings 27 and 28 between flanges 29 and 30 upon the sleeve 26 and a threaded nut 31 is secured to the lower end of the sleeve, through which a threaded elevating rod 32 passes (Figure 2). This rod is at its upper end provided with anti-friction radial thrust bearings 33 in a casing 34 and a gear 35 is keyed to the rod just above the bearing. A motor 36 is mounted on the casing 34 and a pinion 37 on the motor shaft meshes with the gear 35. The motor 36 is of the electric reversible type and has wire connections (not shown) with a switch unit 37 for starting, reversing and stopping the motor (see Figure 1). The radial arm 25 will either be raised or lowered on the column 23 according to the direction the motor is run and suitable clamping screws or bolts 38 are provided for clamping the arm 25 rigidly to the column in any desired position. I prefer to operate these clamping bolts simultaneously and for this purpose the clamping nuts 39 are provided with arms 40 and links 41 connect the arms 40 to a disc 42, which is fastened to a pin 42^a and operating handle 43. The pin 42^a has bearings on the end of the arm 43^a pivoted to the arm hub at 43^b. When the arm 25 is clamped the pivot pins of the links 41 are nearly on a line with the pivot of the disc 42 as shown in Figure 1 and pressure against the arms 40 tends to tighten the nuts 39 and clamp the radial arm 25 securely to the column 24. When it is desired to change the position of the arm, the handle 43 is moved upwards and both the clamping nuts 39 will thereby be released.

The arm carrying the drilling mechanism of radial drills as heretofore constructed in single solid form has necessitated the placing of the entire mechanism on one side of the arm, causing injurious twisting and unbalanced forces to be set up in the frame work of the machine. I obviate this defect by constructing the arm 25 in a double armed or box form having an opening 44 between the two members 45 and 45^a of the arm (see Figure 3) and these members are connected by an outer arch 46 and an inner hub 47 bored to fit the column 23 and split at 47^a (Figure 2) to allow for the clamping of the hub. The spindle sleeve 48 and the intermediate change gear shaft 49, clutch shaft 50 and motor shaft 51 constituting the driving members for the spindle are vertically mounted on a central radial line of the arm in a main transmission housing 52, movably supported between the arm members 45 and 45^a on the guideways 53 of the arm (Figure 3).

For the easy and rapid moving and adjusting of the transmission housing 52 upon the arm 25, I provide anti-friction rollers 53^a mounted in ball bearings 52^a and 52^b in the housing 52 and adapted to roll upon the guideways 52. The rollers are preferably four in number and are arranged in projecting brackets 51^a and covered by plates 50^a (see Figure 18). Suitable V guides 54 are arranged at the bottom of the arm members and a plate 55 is fastened to the bottom of the housing 52 and by overlapping the V guides 54 keeps the drill housing in accurate lateral and vertical position on the radial arm. Means are provided for manually moving the drill housing horizontally and radially upon the arm 23 as follows:

Referring to Figures 1, 2, 3 and 7, a shaft 56 having a hand wheel 57 and a worm 58 is journaled in the bottom plate 55 and a short upright shaft 59, having a worm wheel 60 in mesh with the worm 58 and a pinion 61 in mesh with a rack bar 62, is journaled in a bushing 63 in the bottom plate 55 of the drill housing 52. The rack bar 62 (Figure 2) is fastened to the arm member 45 and it is therefore evident that by operating the hand wheel 57 the drill housing may be moved easily and rapidly in horizontal radial directions through the medium of the worm 56, worm wheel 60, pinion 61 and rack bar 62 and that it is practically self-locking in any position. Suitable clamps 62^a (Figure 18) may, however, be provided to insure accurate unchanging location while drilling.

The spindle drive.

A second electric motor 64 of the reversible vertical type is mounted concentrically to the shaft 51 on an upper housing or cover and the shaft 51 is an extension of the motor shaft 65, the two shafts being connected together by a driving coupling 66 (see Figure 4). As the speed of this motor is constant, I provide a large number of different speeds of the spindle sleeve 48 in the transmission gearing from the motor shaft to the spindle in order to adapt the machine to a large variety of work. The number of speeds adopted are preferably sixteen and are arrived at and carried out in operation as follows:

The vertical shaft 51 being mounted in ball bearings 67 and 68, is provided with two pinions 69 and 70 of different diameters, (Figure 4). The upper smaller pinion 69 runs in constant mesh with a larger conical internal clutch gear 71, loosely mounted on the hollow clutch shaft 50 and the lower and larger pinion 70 meshes with the loosely mounted internal cone clutch gear 72 upon the same shaft 50 (see Figures 4, 10 and 11).

The shaft 50 is hollow and mounted to run in ball bearings 73 and 74 in the main housing 52 and is kept from vertical movement by the bearings 73 and 74, sleeves 75 and 76, spool gear 77 resting against shoulder 78 of the shaft 50, threaded nut 79 screwed against the sleeve 75 and flange 80 secured to the housing 52 and abutting the bearing 73 (see Figure 10). The upper end of the shaft 50 carries, slidably fastened thereto by spline keys 81, the external cone clutch member 83 for the upper internal cone clutch gear 71. In a like manner is the external conical clutch member 84 of the lower cone clutch gear 72 slidably secured to the shaft 50 by splines 81^a. The conical clutch faces 85 and 86 of the clutch members 83 and 84 converge in opposite directions and their longitudinal adjustment with respect to the internal cone clutch members 71 and 72 is such that both clutches may be out of engagement at the same time but that a slight movement in either direction from the neutral position of the external cone clutch members throws one or the other clutch in engagement. The external cone clutch members 83 and 84 are carried upon the upper and lower ends of a rod 87 passing slidably through the hollow shaft 50 and the clutch cones are properly adjusted and secured to the rod 87 by means of adjusting threaded nuts 88, screwed on to threaded portions 89 of the rod and into the clutch members 83 and 84 and secured by check nuts 90 (Figure 10). It is clear from the above that by moving the rod up or down either clutch may be thrown in engagement and the shaft too will then partake of the motion and speed of the corresponding gear. The rod 87 is caused to turn with the shaft 50 and also has vertical movement imparted to it by a dog 90^a, connected by a pin 91 to the shaft 50 (see Figures 10 and 11) and projecting through a slot in this shaft partially embraces a grooved collar 93. A tail piece 94 of the dog 90^a projects into a notch 95 in the rod 87 and when the collar 93 is moved in a vertical direction the rod 87 will partake of the movement (Figure 10). A yoke 96 is mounted upon a stationary pin 97 and has pivoted blocks 98 engaging the groove in the collar 93 (Figure 11). A link 99 is connected to a pin 100 of the yoke 96 and to an arm 101 on a rock shaft 102 (see Figures 1, 5 and 7). A handle 103 (Figure 1) is secured to the shaft 102 on the front of the machine convenient to the operator by which the cone clutches 83 and 84 may be manipulated and the drill spindle run at a speed corresponding to the speed of the clutch engaged. Notches or holes 104 are provided by means of which a latch may secure the lever in any one of one neutral and two working positions. Two different speeds may thus be imparted to the shaft 50 and from either one of these

speeds four different speeds may be transmitted to the drill spindle through the splined intermediate speed change shaft 49. This shaft is journaled in ball bearings 105 and 106 and carries two sliding flanged gear sleeves 107 and 108, each sleeve having a pair of differentiated gears attached and each of these gears 109, 110, 111 and 112 adapted to be brought in mesh with correspondingly differentiated driving gears 109^a, 110^a, 111^a, and 112^a keyed to the clutch shaft 50 (Figure 4). A special interlocking device is provided whereby only one of the sliding gears may be brought in mesh with one of the driving gears at the same time, positively locking the remaining gears out of mesh and insuring the disengagement of the working set of gears before another gear set can be put in mesh.

Referring to Figure 7, a fork 113, secured to a vertically slidable rod 114, engages the flanged gear sleeve 102 and a similar fork 115 upon a sleeve 116 engages the grooved gear sleeve 107. The sleeve 116 is slidable on the rod 114 and both are supported movably in bosses 117 and 118 of the drill housing. The sleeve 116 is provided with rack teeth 116^a in mesh with a gear segment 119 of an arm 120 pivoted to the housing at 121 and having another gear segment 122 at the opposite end in mesh with a segment 123 secured to a rock shaft 124. This shaft has bearings in and projects through the housing on the front side of the machine, where it carries an operating lever 125 (Figure 1). The sliding rod 114 has slot and pin connections 126 to an arm 127 pivoted at 127^a to the housing and having a gear segment 128 in mesh with a segment 129 fastened to a rock shaft 130 (Figure 7). This shaft is mounted above the shaft 124 and projecting through the housing is provided with an operating lever 131 (Figure 1). A bracket or double quadrant 132 is secured to the housing, with holes 133 into which spring bolts 134 arranged in the handle knobs 135 are adapted to enter to lock the operating levers 125 and 131 in neutral or working positions (Figures 5, 6 and 19). Interlocking circular segments 136 and 137 are arranged on the shafts 124 and 130 respectively, each segment having a notch 137^a cut centrally in its periphery preferably in the form of an inverted arc of a circle corresponding to the circular arc of the segments, as more clearly shown in Figure 19^a. When the levers 125 and 131 are in the central position as shown in Figure 1, either one of the levers are free to be moved in either direction on the quadrant. As soon, however, as one of the levers, as for example 125, is moved to another position, the circular periphery of the segment enters the inverted circular arc of the notch 137^a as shown in Figure 19^a and effectively prevents the lever 131 from being moved until the lever 125

has been returned to the center or neutral position. The lever 125 controls the position of the gear sleeve 107 and when raised as shown in Figure 19^a the gear 109 will be brought in mesh with the gear 109^a on the clutch shaft 50. The lever 131 likewise controls the gear sleeve 108 through the shaft 130, segment 128, arm 127, rod 114 and fork 113 and by it the gears 111 and 112 may be brought in mesh with the gears 111^a and 112^a on the clutch shaft 50 (Figure 7). When the levers 125 and 131 are in the position shown in Figure 1, the gears 109, 110, 111 and 112 are in a neutral position, as shown in full lines in Figure 4, but when any one of these gears is moved into working position, a speed of rotation will be imparted to the shaft 49 corresponding to the diameters of the gears in mesh. The shaft 49 carries a pinion 138, preferably integral with the shaft and also a larger gear 139 keyed to the shaft (Figure 4). The pinion 138 (Figures 4 and 6) is in mesh with a large gear 140 loosely mounted on the spindle drive sleeve 48 and the gear 139 meshes with an equal diameter gear 141 also loosely arranged on the spindle drive sleeve 48. This sleeve is mounted in ball bearings 142 and 143 in the drill housing and is internally provided with longitudinal grooves 144 and externally with keys or splines 145 (Figure 3). A flanged clutch sleeve 146 having suitable ways to fit the splines 145 is slidably arranged on the drive sleeve 48 and is provided with upper and lower clutch teeth or jaws 147 (see Figure 7). The hubs of the gears 140 and 141 are similarly provided with jaws 148 with which the jaws 147 are adapted to make driving connection (Figure 18). Shoes 149 fit between the flanges 150 of the clutch sleeve 146 and have pivoted connection with a forked yoke 151 mounted upon a stationary pin 152. A link 153 connects the yoke 151 to an arm 154 keyed to a rock shaft 155 having bearings in the housing and being provided outside the bearing on the front of the machine with a clutch controlling hand lever 156 (see Figures 1, 7 and 18). A quadrant plate 157 has locking holes 158 for the handle 159, the locking device being similar in construction as shown in Figure 19 and by moving the hand lever from the neutral position shown in Figure 1, for example to the lower hole in the quadrant, the clutch sleeve 146 will be brought in clutch connection with the lower gear 140 on the spindle drive sleeve 48. As this gear is driven at a slower speed than the upper gear 141, the spindle sleeve will be driven from the intermediate shaft 49 at its slowest speed. The spindle 160 to which the drill or other cutting tool is secured, passes through the drive sleeve 48 and has two splines or keys 161 slidably fitting the ways 144 of the sleeve. This construction makes a substantial effi-

cient drive from the sleeve to the working spindle and at the same time permits the spindle to be raised or lowered or fed to the work.

The spindle feed and control.

Referring to Figures 3 and 4, the spindle 160 is fitted accurately to the internal diameter of the sleeve 48 and is rigidly supported against lateral movement by said sleeve and the bearings therefor. The upper portion of the spindle is hollow and the upper end of said spindle is provided with anti-friction thrust bearings 161 and 162 within a cylindrical housing 163 securely fastened to the spindle 160 and an internally threaded feed screw nut 164 is held rigidly by a flange 165 between the bearings 161 and 162. The nut 164 is secured to a cross head 166 adapted to slide on guideways 167 in the intermediate or motor base housing 168. A feed screw 169 fitting the internal thread of the feed nut 164 passes through the cylindrical housing 163 and enters freely into the hollow portion of the spindle 160 when the spindle is raised, as shown particularly in Figure 4. The feed screw is supported and is journaled in radial ball bearings 170 and double thrust ball bearings 171 in the upper gear housing 172 having a cover 172^a. It is evident that when the feed screw 169 is revolved the spindle 160 will be raised or lowered according to the direction of rotation and that the rotating vertical thrust of the spindle is taken up primarily by the thrust bearings 161 and 162, the cylindrical housing 163 turning with the spindle 160 and that only the direct non-rotative thrust is transferred to the upper thrust bearings 171, except when the feed screw is revolved. To counterbalance the weight of the spindle I prefer to attach cables 173 to the cross head 166, running the cables over sheaves 174 and 174^a and downwards and attaching suitable weights 173^a to the lower end of the cables (Figure 18).

As related to the spindle speed eight different speeds are provided for the feed screw but sixty-four actual speeds are obtainable for the feed screw as will hereinafter be described.

Referring to Figures 4, 5, 6 and 8, a gear 175 on the change gear shaft 49 primarily transmits rotation to the feed screw through mechanism as follows:

A sleeve 176 having a gear 177 in mesh with the gear 175 is mounted to turn freely between collars 177^a upon a hollow vertical shaft 178 (Figure 8). This shaft is supported in lower bearings 179 in the bottom plate 55 of the housing and bearings 180 in the intermediate housing 168, and upper bearings 180^a in the housing 172 and the loose running sleeve 176 upon the shaft 178 is provided with a second but smaller gear

181 in mesh with a larger gear 182 fastened upon a shaft 183 (see Figures 5 and 6). A series of four gears 184, 185, 186 and 187 of different diameters are also secured to the shaft 183 and these gears are in constant mesh with a corresponding series of gears 184^a, 185^a, 186^a and 187^a, arranged to turn freely upon but capable of being attached to a vertically adjustable shaft 192 and being supported between bosses 188 and 189, washers 190 and a pinion 191. The pinion 191 is splined to the shaft 192 and meshes with a gear 193 normally driving the shaft 178 but capable of being released from the shaft by a friction clutch device, as will be hereinafter described (Figures 6 and 8).

The upper portion of the shaft 178 (see Figures 4, 6, 12 and 13) carries two independent loosely mounted gears 194 and 195 respectively in mesh with the gears 196 and 197 keyed to the feed screw 169. Either one of the gears 194 and 195 may be attached to be driven by the shaft 178 at the will of the operator by means of the spring pressed dive key 198, pivoted at 199 in a slotted plug 200, slidably fitted within the hollow shaft 178 (Figure 2). The head of the key 198 projects through a slot 201 in the wall of the shaft 178 and when in certain positions will enter a keyway 202 in the gear 194 or in the gear 195. A rod 203 is connected to the plug 200 and extends down through the shaft 178 and is loosely connected to an arm 205 that is pivoted at 206 on a hand wheel 204 (Figure 8). The arm 205 has loose connection with a short rod 207, passing through the handle bar 208 of the hand wheel and fastened to the swiveled hand grip 209. As shown in Figures 8 and 12, when the hand grip 209 is pushed upwards the plug 200 will be in its lowest position and the dive key 198 will be in engagement for slow speed with the lower small gear 194. When it is desired to drive the feed screw for a much higher speed through the upper gear 195, the hand grip 209 is pulled downwardly, raising the plug 200 so that the head of the key will enter one of the keyways 202 in the gear 195. In passing from one gear to the other, the key is temporarily thrown back by the ring or washer 211 to a neutral position to prevent engagement with two gears at the same time. As shown particularly in Figure 8, any one of the four gears 184^a, 185^a, 186^a and 187^a may be attached to the shaft 192 to drive the pinion 191 and clutch gear 193 by means of the spring tensioned dive key 212 pivoted in a keyway 213 in the shaft 192 and having a head 214 adapted to enter slotted ways 215 in any one of the gears corresponding to the adjusted vertical position of the shaft 192. A circular rack 216 is machined in the upper position of the shaft 192 and a small pinion 217 integral with a shaft 218 is in mesh with this rack

(see Figure 8). The shaft 218 has bearings 219 secured to the housing 168 and may be operated to raise and lower the shaft 192, preferably by means of a pair of bevel gears 220, a short vertical shaft 221 journaled on the front side of the housing and a handwheel 223 conveniently located for the operator. Suitable feed indexing and locking devices (not shown) are provided for the handwheel so that the dive key may be placed in driving connection with the proper change speed gear to obtain the desired feed speed for the working spindle.

It is necessary at times in the operation of the machine, as for special or experimental work or the rapid raising of the drill, or for other reasons, to be able to disconnect the power feed mechanism and operate the feed screw by hand. For this purpose (see Figures 8 and 9) the driving gear 193 for the handwheel shaft 178 is mounted loosely upon the shaft between a collar 224 and a driving disc 225 keyed to the shaft and the gear 193 is provided with a clutch rim or flange 226. A split expansible clutch ring 226^a is arranged between the disc 225 and the rim 226 which may be expanded to clutch the rim 226 or be released therefrom by means of cam arms 227, pivoted to the ring 226^a and capable of expanding the ring when being separated by the conical sleeve 229 (Figure 8). This sleeve is slidably supported upon the shaft 178 and may be raised or lowered to clutch or release the gear 193 by means of the yoke arm 230 secured to a rock shaft 231, said shaft projecting through the housing and having an operating handle 232 on the front side of the machine in convenient reach of the operator. (See Figures 1 and 6.) When the clutch is released, the feed screw may be operated in either direction by turning the handwheel 204 and at relatively fast or slow speed by shifting the upper feed driving gears 194 and 195 by means of the hand grip 209, as heretofore described.

For the rapid, safe and efficient operation of the machine, an adjustable automatic stop device accurately controlling the down movement of the drill spindle is provided as follows: Referring to Figures 1, 6 and 13 to 17, this device consists of a vertically mounted worm shaft 233, driven from the feed screw shaft 169 by gears 234 and 235 (Figure 13) and having a worm 236 in mesh with a worm wheel 237 upon a short shaft 238 (Figure 6). This shaft has bearings in the cover of an oil tight casing 239 and is provided outside the casing with a disc 240 having a cam 241. A dial plate 242, having index marks as shown in Figure 14 is adjustably secured to the disc 240 by means of a circular T-slot 243 and clamping bolt 244. A beveled cam plate 245 is a part of the dial plate 242 and spring bolts 246 and 247, operated respec-

tively by the cams 241 and 245, are arranged in a projecting part of the casing cover and are adapted to rock an arm 248 and shaft 249 when pushed out by the cams 241 and 245. The shaft 249 has an arm 250 with link connection 251 with the yoke arm 230 controlling the clutch of the feed driving gear 193 and when in the operation of the feed screw the worm wheel 237 has rotated far enough to cause one of the cams 241 or 245 to push out one of the spring bolts 246 or 247, the shaft 249 will be rocked to cause the arm 250 to release the clutch ring 225 from the feed gear 193. In practice when the worm wheel shaft has turned substantially one revolution, the drill spindle has descended its maximum distance and when the dial is adjusted, as shown in Figure 14 and the shaft has completed a revolution, as shown, the drill is at its lowest position and a slight further movement will throw out the clutch and stop the feed. When, however, the dial is adjusted as indicated in dotted lines in Figure 17, the clutch will be released when the spindle has descended one-fourth of its maximum travel. After the clutch has been released and the feed stopped, the drill may be raised by the hand wheel 204 to its highest position, when the cam 246 will be in the initial position shown in Figure 17, the conical sleeve meanwhile holding the clutch released by means of the straight portion 229^a engaging the adjusting screw 230^a until the clutch is again put in operation by means of the hand lever 232.

As the various drive and transmission parts within the housing 52 are run in a bath of oil to prevent leakage past the drill spindle sleeve, I provide a stuffing box 252 at the lower end of the sleeve 48 in the bottom plate 55.

I claim as my invention:

1. In a machine of the class described, a radial arm having a longitudinal opening therein, a head mounted on said arm within said opening for back and forth movement therein, a drive shaft mounted in said head, a tool spindle mounted in said head, a clutch shaft mounted in said head and having a clutch connection with said drive shaft, a variable speed transmission shaft mounted in said head and having a driving connection with said clutch shaft, said drive shaft, said spindle, said clutch shaft and said transmission shaft being in alignment in the longitudinal center of said head to distribute the load evenly thereon, and a motor mounted on said head and operatively connected with said drive shaft.

2. In a machine of the class described, a radial arm, a head mounted for longitudinal movement thereon, a drive shaft mounted in said head, a clutch shaft having variable speed driving connections with said drive

shaft, a change gear shaft having variable speed driving connections with said clutch shaft, a spindle also mounted in said head and having driving connections with said clutch shaft, said drive shaft, said spindle, said clutch shaft and said transmission shaft being in alignment in the longitudinal center of said head to distribute the load evenly thereon.

3. In a machine of the class described, a radial arm, a head mounted for longitudinal movement thereon, a spindle mounted in said head, a forward and reverse motor mounted on said head, a drive shaft mounted in said head and coupled to said motor, and variable speed driving connections between said drive shaft and said spindle, said shaft and driving connections having their axes intersecting the longitudinal center of said arm.

4. In a radial drill, an arm, a head mounted for longitudinal movement thereon, a drive shaft mounted in said head to intersect the longitudinal axis of said arm, a motor mounted on said drive shaft and having its weight through the position of said drive shaft evenly distributed on said head and arm, a spindle also mounted to intersect the longitudinal axis of said arm, and change speed driving connections between said drive shaft and said spindle.

5. In a machine of the class described, a radial arm composed of parallel side members having a space between them, a head journaled on said side members to move back and forth within said space, an upright shaft mounted in said head, an upright spindle journaled in said head, a clutch shaft and a transmission shaft also journaled in said head, said drive shaft, said spindle, and said clutch and transmission shafts being in vertical alignment and substantially equidistant from said members, whereby the load will be evenly distributed on said members, said drive shaft having operative connections through said clutch and transmission shafts with said spindle, and a motor having a driving connection with said drive shaft.

6. A radial drill comprising a base, an upright column thereon, a radial arm supported by said column, a head mounted for longitudinal movement on said arm, a drive shaft mounted in said head, a clutch shaft having change speed driving connections at its opposite ends with said drive shaft, a spindle having change speed connections with said clutch shaft through said driving connections, and a reversing motor mounted on said head and operatively connected with said drive shaft.

7. In a machine of the class described, a radial arm, a head mounted thereon, a motor carried by said head, a drive shaft coupled to said motor, a hollow clutch shaft having change speed clutch connections at opposite

ends thereof, a rod in said hollow shaft for operating said clutch connections, and a spindle having a change speed driving mechanism between it and said clutch connections.

8. The combination, with a head, of a drive shaft mounted therein, a reversing motor coupled to said drive shaft, a hollow clutch shaft also mounted in said head and having change speed clutch members at its opposite ends, a rod mounted in said hollow shaft for operating said clutch members, to set and release them alternately, and a spindle operatively connected with said clutch members.

9. In a machine of the class described, a radial arm, a head mounted for movement back and forth on said arm, a primary drive shaft journaled in said head, a motor connected therewith, a clutch shaft having variable speed driving connections with said drive shaft, a change gear shaft mounted to engage the gears of said clutch shaft, means for shifting said change gears to lock one set of gears against axial movement while the others are shifted, and a spindle having a driving connection with said change gear shaft.

10. In a machine of the class described, a radial arm, a head mounted for movement thereon, a drive shaft mounted in said head, a motor mounted on said head and having its armature shaft coupled with said drive shaft, a clutch shaft having variable speed driving connections with said drive shaft, a change gear shaft, and sliding gears thereon, levers for shifting said change gears and provided with means for locking one set of gears against axial movement when the others are in working position, and a spindle having driving connections with said change gear shaft.

11. A radial drill comprising a base, an upright column thereon having a vertical recess in its walls, a screw fitting within said recess, a sleeve mounted for vertical movement on said column and operatively connected with the lower end of said screw, a radial arm having a hub journaled at its upper and lower ends on said sleeve for rotary movement thereon or vertical movement therewith, and means for clamping said arm on said column and locking it against rotary movement.

12. A radial drill comprising a base, an upright column thereon having a vertical recess in its walls, a sleeve mounted for vertical movement on said column, a screw fitting within said recess and operatively connected with said sleeve for raising or lowering it, a housing mounted on the top of said column, a motor supported by said housing above said column and having a driving connection with said screw, a radial arm having a hub journaled on said sleeve for rotary movement thereon, and vertical move-

ment with said sleeve, and means for clamping said arm on said column.

13. In a machine of the class described, a radial arm having a longitudinal opening therein, a head journaled on said arm in said opening, a drive shaft mounted in said head, a motor connected with said drive shaft and concentric therewith, a clutch shaft having driving connections with said drive shaft and mounted in said head, a spindle mounted in said head, a transmission shaft having driving connection with said clutch shaft and with said spindle, said drive, clutch, and transmission shafts, and said spindle being all in alignment, and substantially equidistant from the bearings of said head on each side of said arm, whereby the load of said motor and the strain of said shafts and spindle will be evenly distributed on the bearings for said head.

14. In a machine of the class described, a radial arm composed of parallel side members having space between them, a head mounted to move back and forth in said space, and having anti-friction bearings on the upper surfaces of said members and V guide bearings on the under surfaces of said members, a motor mounted on said head, a spindle carried by said head to intersect the longitudinal axis thereof, and variable speed driving connections between said motor and said spindle.

15. In a machine of the class described, a radial arm composed of parallel side members having a space between them, a head mounted to move back and forth in said space and having anti-friction bearings on the upper surfaces of said members, a plate provided on the underside of said head and lapping the under surfaces of said members, and having V guides thereon, a motor mounted on said head, a spindle carried by said head to intersect the longitudinal axis thereof, and variable speed driving connections between said motor and said spindle.

16. In a machine of the class described, a radial arm composed of parallel side members having a space between them, a head mounted to move back and forth in said space, a worm journaled in said head and having an operating hand wheel, a shaft having a worm wheel in mesh with said worm, a pinion on said shaft, a rack bar mounted on one of said arm members and meshing with said pinion, a motor mounted on said head, a spindle carried by said head to intersect the longitudinal axis thereof, and variable speed driving connections between said motor and said spindle.

17. In a machine of the class described, a radial arm comprising narrow comparatively deep side members and a bridge connecting their outer ends, a transmission housing movably supported between said members, a drive shaft centrally mounted in said hous-

ing, a tool spindle also mounted in said housing, a clutch and variable speed transmission shafts mounted in said housing between said drive shaft and said spindle, and
 5 said shafts intersecting the longitudinal axis of said housing and said arm.

18. In a machine of the class described, a radial arm having a longitudinal opening therein, a transmission housing fitting within said opening and having bearings in the
 10 side members of said arm, a worm, a rack bar for adjusting said transmission housing back and forth in said radial arm, a drive shaft mounted in said housing, a tool spindle
 15 a clutch and variable speed transmission shafts also mounted in said housing, said shafts intersecting the longitudinal axis of said housing and said arm.

19. A radial drill comprising an upright
 20 column, a radial arm mounted thereon, a head mounted for longitudinal movement on said arm, a drive shaft journaled in said head, a clutch shaft mounted in said head in parallel relation with said drive shaft and
 25 having at its opposite ends change speed clutch connections with said drive shaft.

20. In a radial drill, an arm, a head having bearings on said arm for longitudinal

movement, an upright drive shaft journaled in said head, a spindle journaled in said
 30 head and having change speed driving connections with said drive shaft, a motor mounted on said head for operating said drive shaft, said motor, said drive shaft and
 35 said spindle being centrally mounted with respect to the longitudinal axis of said arm for distributing the load evenly on the bearings of said head on said arm.

21. In a radial drill, an arm, a head having bearings thereon for longitudinal
 40 movement, an upright drive shaft journaled in said head, a clutch shaft journaled in said head and having driving connections with said drive shaft, a spindle having
 45 change speed driving connections with said clutch shaft, a motor mounted on said head for operating said drive shaft, said motor, said drive shaft and said clutch shaft being
 50 centrally mounted with respect to the longitudinal axis of said arm for distributing the load and the application of power evenly thereon.

In witness whereof, I have hereunto set my hand this 20th day of January, 1920.

CONRAD M. CONRADSON.