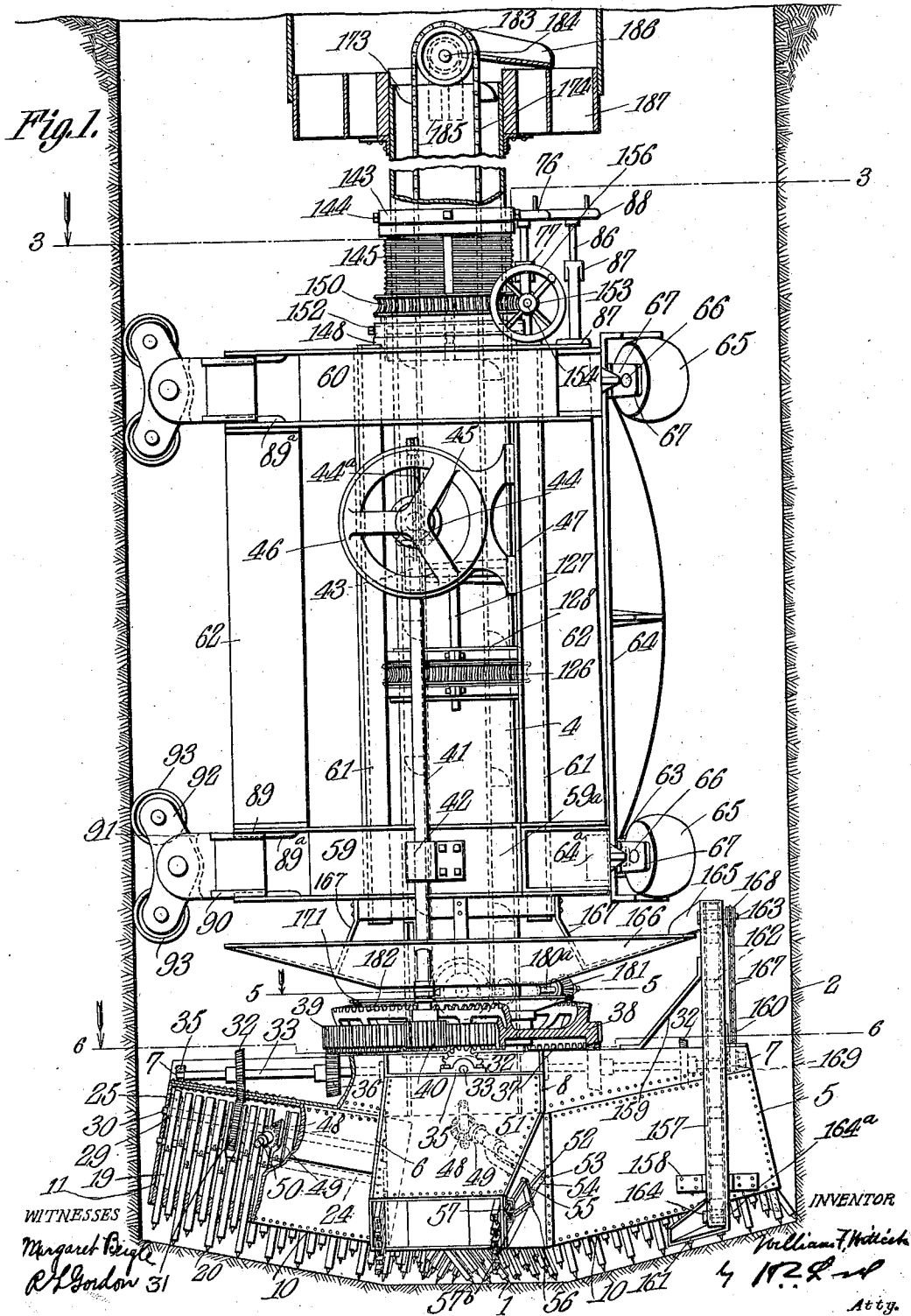


W. F. WITTICH.
SHAFT BORING AND TUNNELING MACHINE.
APPLICATION FILED DEC. 11, 1909.

1,179,342.

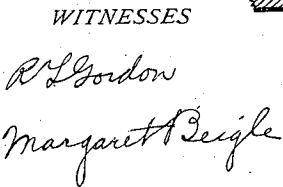
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Fig. 2.



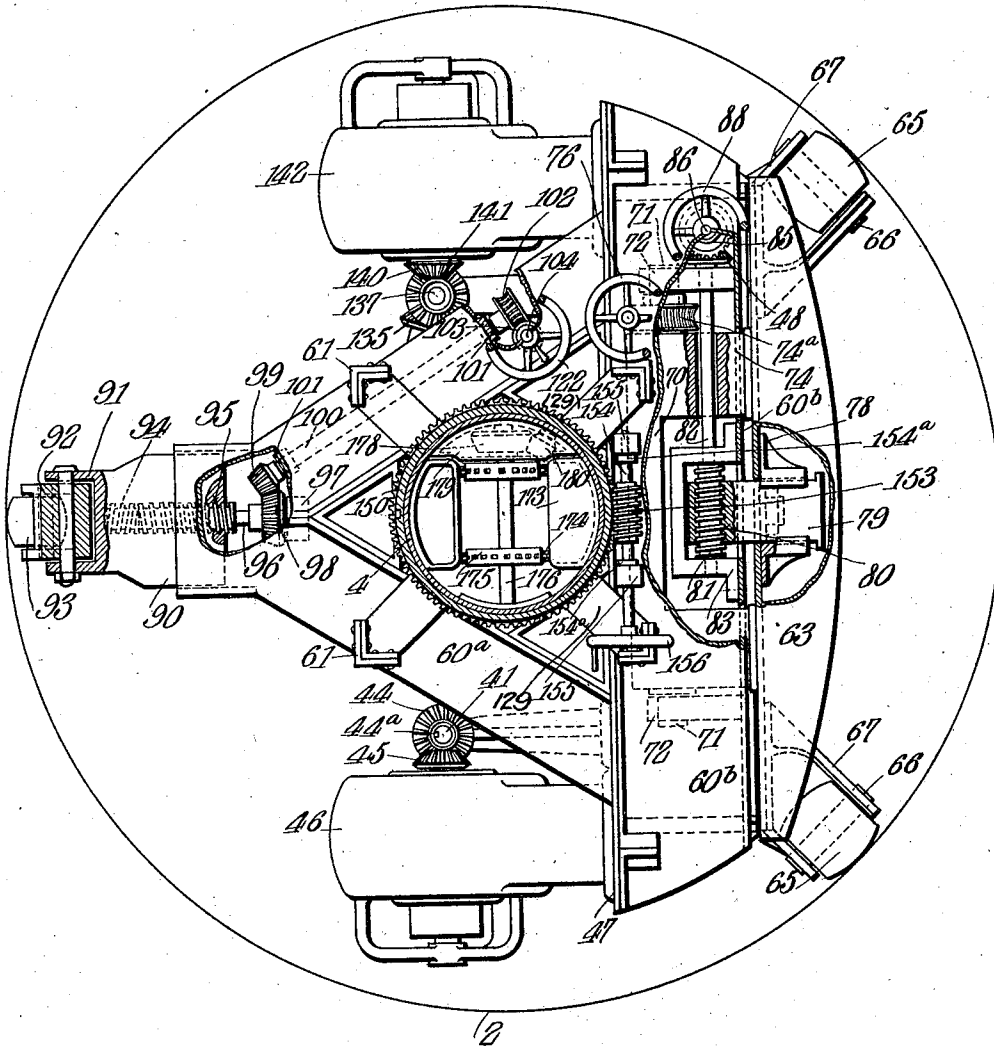
INVENTOR
William F. Wittich
by H. C. Lind.
Attorney

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Fig. 3.



WITNESSES

R. L. Gordon

Margaret Beyle

INVENTOR

William F. Wittich

by N. C. Lord

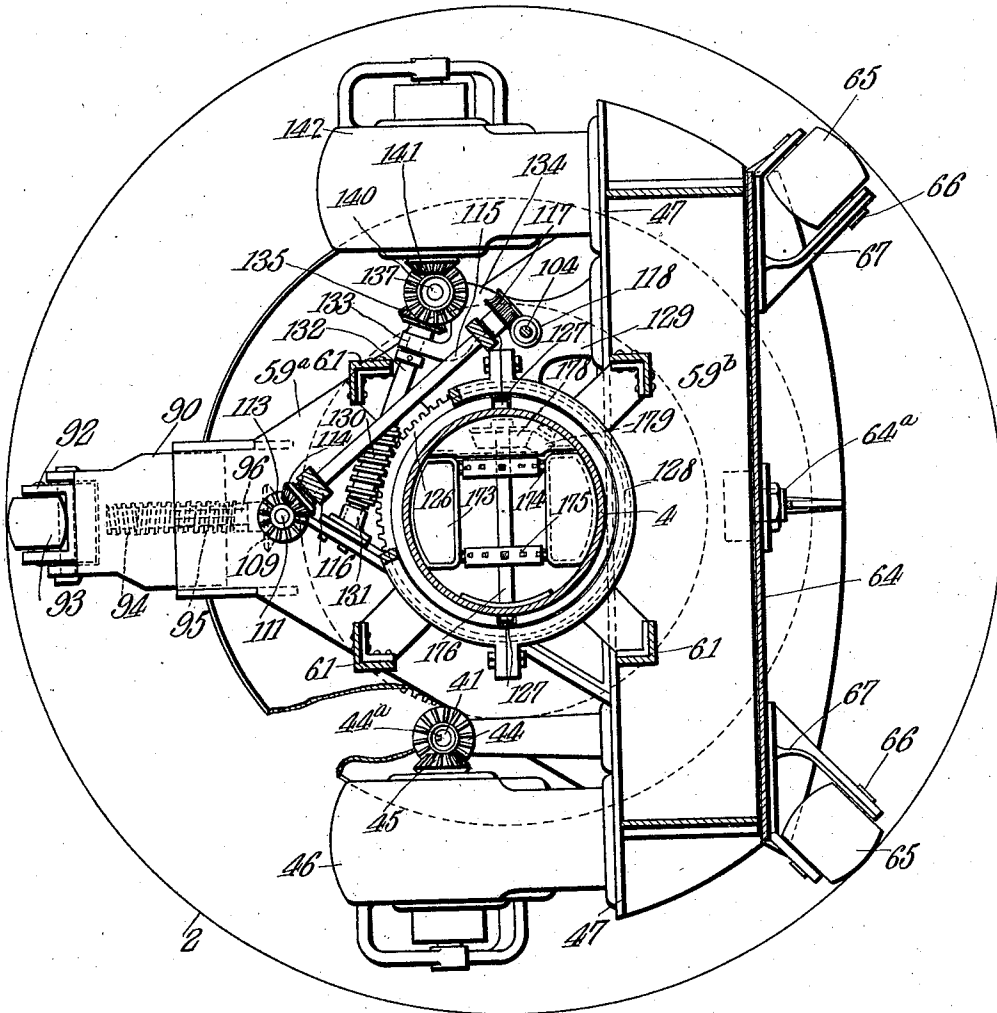
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Fig. 4.



WITNESSES

R. Gordon

Margaret Beigle

INVENTOR

William F Wittich

by H. Z. Lord

Attorney

W. F. WITTICH.
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Fig. 5.

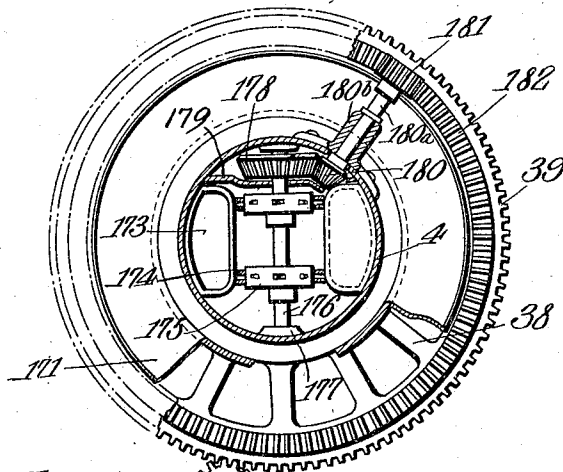


Fig. 11.

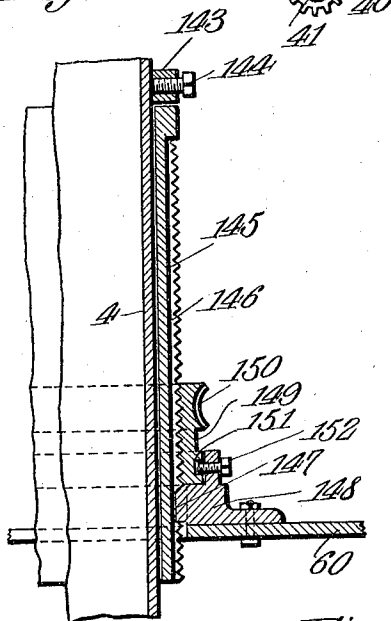


Fig. 10.

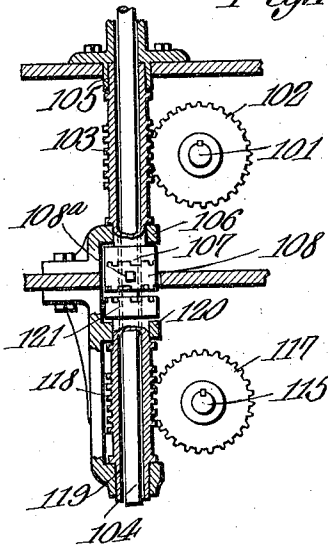
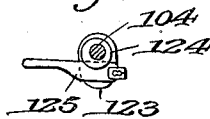


Fig. 10^a.



INVENTOR

William F. Wittich

Attorney

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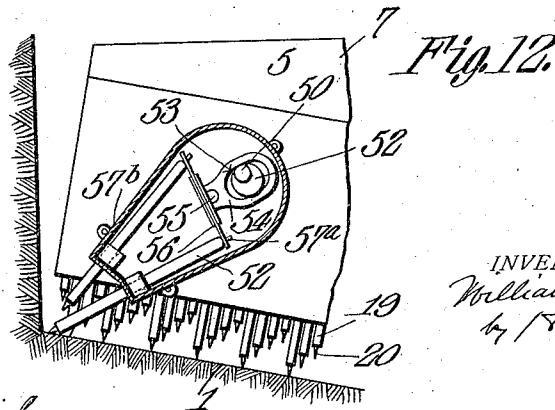
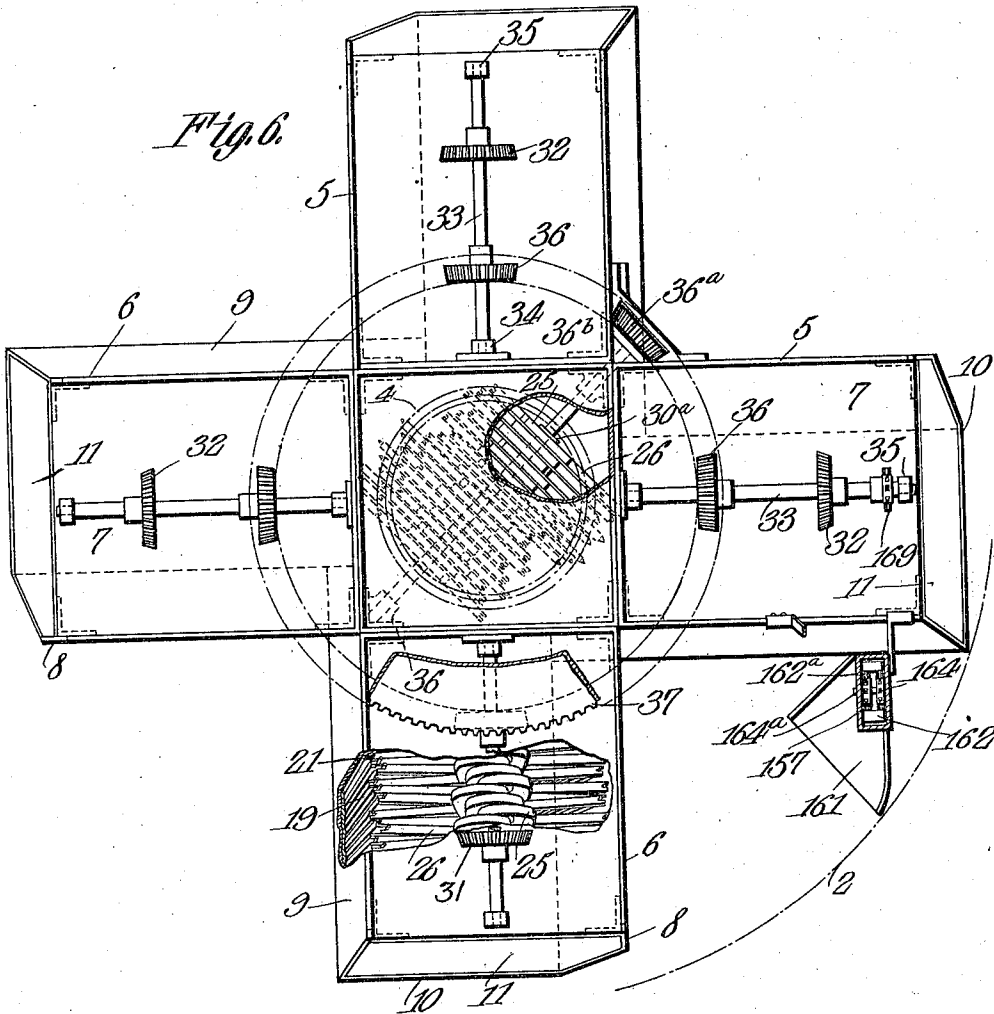
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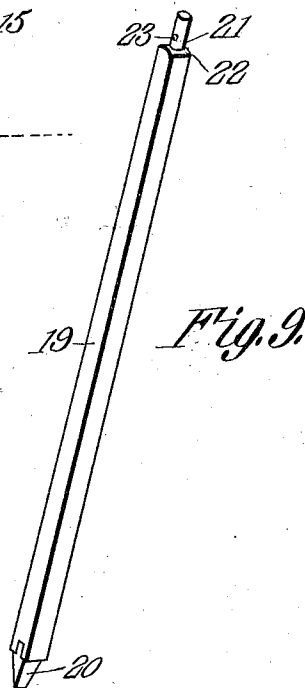
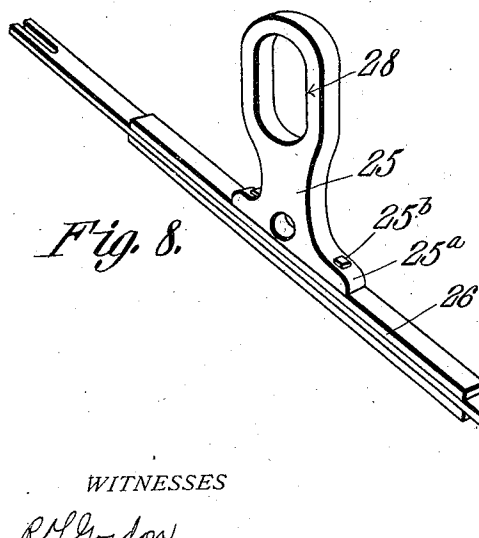
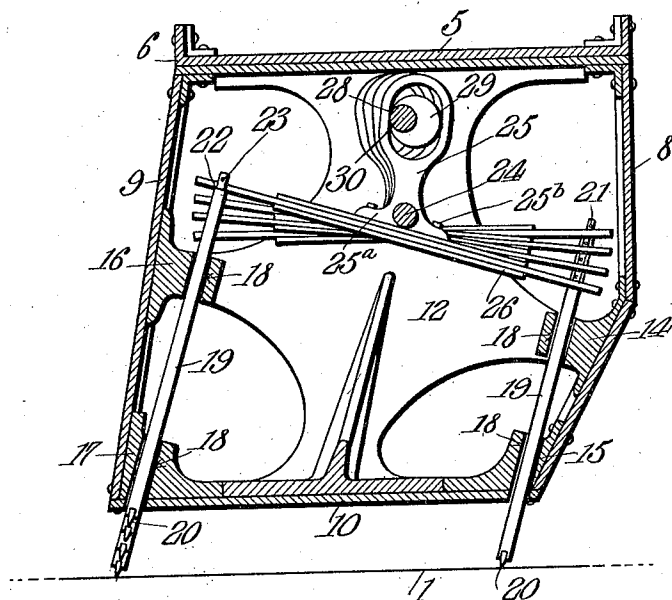
R. L. Gordon

Margaret Beigle

INVENTOR
William F. Wittich
by R. L. Gordon
Attorney

1,179,342.

Fig. 7.



WITNESSES

R L Gordon

Margaret Beigle

INVENTOR
William F. Withich
by R. L. L. and
Attorney

UNITED STATES PATENT OFFICE.

WILLIAM F. WITTICH, OF ERIE, PENNSYLVANIA.

SHAFT BORING AND TUNNELING MACHINE.

1,179,342.

Specification of Letters Patent.

Patented Apr. 11, 1916.

Application filed December 11, 1909. Serial No. 532,534.

To all whom it may concern:

Be it known that I, WILLIAM F. WITTICH, a citizen of the United States, residing at Erie, in the county of Erie and State of Pennsylvania, have invented new and useful Improvements in Shaft Boring and Tunneling Machines, of which the following is a specification.

This invention relates to shaft boring or tunneling machines, and consists in certain improvements in the construction thereof, as will be hereinafter fully described and pointed out in the claims.

In the accompanying drawings the machine is shown as forming a shaft but it is obvious that in most of its aspects at least, it is clearly adapted for tunnel boring.

With machines having a plurality of tools which are carried by a rotating head, and reciprocating so as to operate upon the face of the bore, difficulty has been encountered in properly operating the tools, especially where the tools are driven from a single unit of power, as distinguished from individual motors for each tool. The most convenient method of imparting reciprocating motion to the tools is to utilize a crank, and where this is done it will be observed that the extremities of the throw are the slowest parts of the movement imparted to the tool. This, of course, is just the reverse of what it ought to be to get the best results. Furthermore, where the tool is so reciprocated and unyieldingly driven with the full throw of the crank, it sometimes happens that undue strain is placed upon some particular part of the tools, and their driving means. In the present construction, I have obviated most of these difficulties. In a general way, I have accomplished this by oscillating a bell crank, and forming one of the arms of the bell crank with a spring. In this structure, the spring takes up the speed of the bell crank where the crank imparts to it its highest speed, and the inertia of the tool with the yielding of the spring permits the tool to deliver its blow at nearly its maximum velocity. It also makes the tool deliver its full blow and yet yield if unusual obstacles are encountered. It also cushions the yielding part against shock.

The invention is illustrated in the accompanying drawings as follows:

Figure 1 shows a side elevation of the machine; Fig. 2 a similar view taken from

the opposite side of the machine, and without the head; Fig. 3 a section on the line 3—3 in Fig. 1; Fig. 4 a section on the line 4—4 in Fig. 2; Fig. 5 a section on the line 5—5 in Fig. 1; Fig. 6 a section on the line 6—6 in Fig. 1; Fig. 7 a cross section of one of the arms of the head; Fig. 8 a perspective view of one of the oscillating levers or bell cranks; Fig. 9 a perspective view of one of the tools; Fig. 10 an enlarged view of the actuating mechanism for the clamps; Fig. 10^a is an enlarged view showing a detail of the latch mechanism forming part of the actuating mechanism for the clamps; Fig. 11, an enlarged section of a fragment of the head feeding mechanism; Fig. 12 a side view of one of the arms, showing the radial corner cutting tools; Fig. 13 a central section through the frame; Fig. 14, a cross section of the axial adjusting mechanism of the frame.

1 marks the face of the bore; 2 the side walls. The head is provided with the hub 3. The hub is secured to a hollow shaft 4; the arms 5 are attached to the hub 3, the arms 5 being U-shaped, (see Fig. 7) the edges 6 stiffening the arms in an axial direction, and the bottom 7 being slightly inclined and stiffening the arms circumferentially. A box is secured to the bottom of the arms 5, in which the tools, and actuating mechanism for the tools, is mounted. This box is made up of sides 8 and 9 and the bottom 10. It is closed at the end with a plate 11, and intermediate of its ends has a brace or web 12 (see Fig. 7). Guides 14 and 15 are arranged lengthwise of the arm on the side 8, and guides 16 and 17 on the side 9. These guides have the guide openings 18 preferably arranged at an incline so as to give the tools 19 a slight slant to the working face, the tools projecting forward slightly in the direction of the rotation of the head. The tools are provided with the usual points 20, and are provided at their upper ends with the reduced extension 21, the extension forming the shoulder 22 at the top of the tool. The tools also have the pins 23 slightly above the shoulder 22. A shaft 24 extends from the hub to the outer plate of the arm, and carries the rock levers 25. The lower end of the rock lever has the arms 25^a to which the leaf spring 26 is secured by means of the bolts 25^b. (See Fig. 8). The spring 26 has the central leaf provided with the slots 27 at its ends. The

slot 27 straddles the projection 21, the ends of the spring extending between the shoulder 22 and the pins 23. This forms a connection between the tool and the spring, allowing the slight movement between the spring and the tool necessary to compensate for the difference in direction of the movement of the end of the spring which is circular and the straight movement of the tool.

A crank shaft 30 is journaled on the hub, and outer plate, and the web 12. It has a series of eccentrics or cranks 29, each eccentric or crank operating a rock lever 25. Their throw is arranged successively so that the load of the crank shaft is divided. Each rock arm 25 has the slot 28 in which the eccentric 29 operates. The operation of this part of the mechanism is very simple. The crank shaft is rotated, thus imparting an oscillating movement to the bell crank formed by the lever 25 and the spring 26. The oscillation of this bell crank gives oscillating movement to the end of the spring and thus drives the tool. It will be observed that the maximum velocity of the lever 25 is reached at the center of its stroke. It starts slowly, reaches its maximum velocity at its center, and then gradually decreases in velocity until the extreme of its stroke is reached. As before stated it is desirable that the tool deliver its blow at its maximum velocity. In the present construction, the spring is sufficiently yielding, and the tools sufficiently heavy so that as the lever 25 is reversed in its direction of movement through the action of the eccentric and starts on its forward stroke, the spring yields, allowing the tool to lag. As the tool, under the influence of the spring, picks up the velocity of the lever, it reaches its maximum velocity about the time, or slightly after the time, the lever reaches its maximum velocity. As the lever slows up, the spring yields under the momentum of the tool, and permits the tool to advance and deliver its blow prior to the time the lever reaches the extreme of its movement. In this way, a quick, snappy blow is delivered, and at the same time the operating parts are cushioned against the blow, so that the machine is relieved from the jar of the blow.

The driving mechanism for the crank shaft is as follows: Arranged on each crank shaft is a gear 31. This meshes a gear 32 extending through the bottom 7 of the box. The gear 32 is fixed on the shaft 33, and the shaft 33 is mounted in the bearings 34 and 35 on the bottom 7. A gear 36 is also fixed on the shaft 33, and meshes the gear 37 arranged on the wheel 38. The wheel 38 is journaled on the shaft 4, and on the outer periphery of this wheel is a gear 39. A pinion 40 is in mesh with this gear 39. The pinion 40 is fixed on the shaft 41. The shaft

41 is journaled in the bearings 42 and 43, carried by the main frame. It has a pinion 44 which is connected with the shaft 41 by means of a spline and groove mechanism 44^a. A gear 44 meshes gear 45 on the motor 46. Motor 46 is mounted on the plate 47 carried by the main frame.

It is difficult, with the arms extending radially, to carry the operating mechanism to the center of the bore, and if this is not done, there will of course remain a core of material upon which the tools do not operate. To obviate this difficulty, I have set a line of tools at an angle to the arms at the center. These tools are driven by the crank shaft 30^a, the tools being exactly similar to those in the arms having the springs 26, levers 25, and cutter tools, etc., to complete the mechanism. These levers are mounted on the rock shaft similar to shaft 24, (not shown). The crank shaft 30^a is mounted in the bearings 36^b, and has a gear 36^a arranged in the space at the angle of the arms, and arranged to mesh the gear 37, so that these tools at the center are driven in the same manner as the tools in the arms.

One of the difficult features of operating a machine of this type is the proper cutting at the extreme outer edge of the face, or, in other words, the corner between the side walls and the working face. Where tools are used, even if they are somewhat inclined, the outer tools are apt to wedge, and inasmuch as the material at the corner is supported by the side wall, there is difficulty in loosening the material. I prefer, therefore, to provide tools having a radial movement of action to take care of this corner. A gear 48 is fixed on the crank shaft, and meshes a gear 49. The gear 49 is fixed on the shaft 50, extending through the side of the box forming the arm, suitable bearings 51 being provided for the shaft. (See Fig. 1). A crank 52 is fixed on the outer end of this shaft, and operates in the slot 53 of the lever 54. The lever 54 is mounted on the stud 55, extending from the box, and carries the spring 56, which is similar to spring 26. Tools 57 are formed similarly to tools 19, and have the same means of connection 57^a with the spring. (See Fig. 12.) These tools extend through the guides 57^b secured to the box, and the tools operate at a slant to the face, but in a substantially radial direction, so as to cut the corner between the face and the side walls of the bore.

The frame is made up of two triangular heads or ends 59 and 60. These are formed of channel iron, and are made up of the sides of the triangle 59^a and 60^a and the bases 59^b and 60^b. Extending between these triangular ends of the frame are the angle irons 61, and the top and bottom plates 62. This frame is supplemented by an auxiliary

frame made up of the cross pieces 63, and connecting longitudinally the pieces 64. This is connected at its front end with the main frame by means of the king bolt 64^a.

5 It is connected with the main frame at the rear end of an adjusting mechanism herein-after described. This supplemental frame is provided with the wheels 65 which are journaled on the axles 66, carried by the brackets 67. These wheels allow the ready forward movement of the frame.

Means for adjusting the main frame on the supplemental frame so as to change the axial direction of the head is as follows:
 15 The cross piece 60^b is open at the bottom, and telescopes an upwardly projecting part 63^b on the supplemental frame. (See Figs. 3 and 13.) A yoke 70 has the trunnions 71 at its ends which are journaled in the bearings 72 secured in the pieces 60^b. Eccentrics 74 are carried by the yoke 70, and operate upon the cross pieces 63 at the upper end of the machine. It will readily be observed that by oscillating these eccentrics, the main
 20 frame may be separated or moved away from or permitted to move toward the supplemental frame. A worm gear 74^a is fixed on one of the trunnions 71. A worm 75 is mounted on a shaft 75^a and operates the worm gear 74^a. A hand wheel 76 is fixed on the shaft 75^a for operating the worm, and a bearing 77 mounted on the frame is provided for the shaft 75^b. A bearing plate 78 (see Figs. 13 and 14) is arranged at the center of the cross piece 63, and in it, the extension piece 79 is swiveled. This extension is also free to move axially in the bearing to permit of the adjustment of the main frame to and from the supplemental frame. A
 30 screw 81 operates in the nut 80. The screw 81 is mounted on the shaft 82 and the shaft 82 is journaled in the yoke 83 which is secured to the piece 60^b. The shaft 82 is also locked against axial movement in the yoke, the ends of the screw 81 engaging the ends of the yoke for this purpose, so that as the screw is rotated the main frame is shifted transversely on the supplemental frame, thus changing the axial direction of the head laterally to the supplemental frame. A
 40 gear 84 is fixed on the shaft 82 and meshes a gear 85. A gear 85 is fixed on the shaft 86. The shaft 86 is journaled in the bearings 87, extending from the main frame, and the hand wheel 88 is fixed on the shaft 86 by means of which the screw 81 may be operated to adjust the main frame, laterally upon the supplemental frame.

60 A cylindrical pocket 89 is arranged in the angle between the sides 59^a—59^a. Clamping heads 90 are telescopically arranged in these pockets, the splines 89^a preventing the turning of the heads in the pockets. The head has a slot 91 in which the arm 92 is pivoted, the arm being provided with the wheels 93

at each end. The head has the screw thread 94 in which the screw 95 operates. The screw is mounted on the shaft 96 which has the bearing 97 on the frame. The screw at the upper end of the frame is provided with
 70 a gear 98. A gear 99 meshes this gear, the gear 99 being fixed on the shaft 100 journaled in the bearings 101 on the frame. A worm gear 102 is fixed on the shaft 100. A worm 103 meshes the worm gear 102. The
 75 worm 103 is actuated through a shaft 104 (see Fig. 10.) The worm is mounted in the bearings 106, and is in the form of a sleeve through which the shaft 104 extends. The worm has the detent clutch member 107
 80 fixed on it. A detent clutch member 108 is fixed on the shaft 104 by means of the set screw 108^a. By moving the shaft 104 endwise, the clutch members 107 and 108 may be thrown into and out of engagement, and
 85 when thrown into engagement, the worm 103 may be actuated, and by the train of mechanism hereinbefore described, the clamp at the upper end of the frame set.

The shaft 96 on the screw at the lower
 90 end of the frame has the gear 109. (See Fig. 2.) A gear 110 meshes the gear 109. The gear 110 is fixed on the shaft 111; the shaft 111 is mounted in the bearings 112, arranged on the frame. A gear 113 is fixed on
 95 the shaft 111. A gear 114 meshes the gear 113. The gear 114 is fixed on the shaft 115. The shaft 115 is carried in the bearings 116 extending from the frame. A worm 117 is fixed on the shaft 115, and meshes a worm
 100 118. The worm 118 is mounted in the bearings 119 and 120, extending from the frame. This worm is in the form of a sleeve through which the shaft 104 extends. It has the detent clutch member 121. The clutch member
 105 108 is adapted to be brought into engagement with this clutch member by moving the shaft 104 endwise. With this mechanism, it is possible, therefore, to set either clamp with the shaft 104 by simply moving the
 110 shaft endwise. The shaft 104 is provided with a hand wheel 122 (see Figs. 1 and 3) by which it may be operated. The shaft extends through the bearing 123. It has a collar 124 (see Figs. 2 and 10^a.) A latch 125
 115 is mounted on the bearing 123 and adapted to be carried under the collar 124. As shown in Fig. 10^a, the latch is indicated as being under the collar 124. It will be readily seen that by swinging the latch 125 out-
 120 wardly from under the collar 124, the shaft 104 may be depressed thus shifting engagement of the detent collar 108. When the latch is thrown out the shaft will be dropped so as to bring the clutch member 108 into
 125 engagement with the clutch member 121 (see Fig. 10.)

It will be observed that in adjusting the frame, the main frame is adjusted on the supplemental frame so as to give the head
 130

the proper axial direction, and the clamps are then set, locking the frame with the walls of the bore.

The means for driving the main shaft, and thus rotating the head are as follows: A worm gear 126 is mounted on the shaft 4 and fixed against rotation with respect to the spline 127, but is free to rotate with the shaft. It is carried between the rings 128. These rings are carried by the posts 129 on the frame, so as to maintain them in fixed position as the shaft 4 is moved forward, the spline and groove mechanism permitting the worm to slide on the shaft 4, but yet drive the shaft. The worm 130 meshes the worm gear 126. It is carried by the shaft 132 and the shaft is mounted in the bearing 131 on one of the cross pieces 61, and the bearing 133 on the extension 134. A gear 135 is fixed on the shaft 132 and meshes a gear 136. The gear 136 is fixed on the shaft 137. Shaft 137 is carried in the bearings 138, arranged on the post 139, extending from the plate 62. A gear 140 is fixed on the shaft 137 and meshes a gear 141 on the driving shaft of the motor 142. The motor 142 is mounted on the plate 47. It will be observed therefore that the tools and head may be driven independently so that their speeds may be so controlled as to give greatest efficiency. With some materials the tools should be actuated with greater velocity with relation to the head than with others.

Means for feeding forward the head is as follows: A collar 143 is fixed on the shaft. As shown this is accomplished by set screw 144. (See Fig. 11.) A screw threaded sleeve 145 is arranged on the shaft. It has a longitudinal groove 146 in which the spline 147 projects. The spline projects from a bearing 148 fixed on the frame head 60. A nut 149 is journaled in the bearing and is provided with a worm gear 150. The nut is provided with an annular groove 151 into which the screw 152 projects, thus locking it against longitudinal or axial movement. A worm 153 meshes the worm gear. The worm is fixed on the shaft 154. (See Fig. 3.) The shaft 154 is carried by the bearings 155 and is locked against axial movement therein by the collars 154^a. A hand wheel 156 is provided for operating the shaft. By this means, the shaft may be fed forward as the work on the face progresses. After the limit of the feed is reached, the frame is loosened and fed forward. The feeding device is so operated to allow the frame to be lowered.

An elevator 157 is mounted on one of the arms of the head by means of the brackets 158, 159 and 160. A scraper 161 is arranged at the bottom which picks up the material from the face of the bore and accumulates it in position to be taken up by the cups 162 of

the conveyer. The cups are mounted on the chain 162^a (see Fig. 6.) This chain passes over the wheel 164 at the bottom of the conveyer and a similar wheel at the top. Wheel 164 is mounted on the shaft 164^a, and the wheel at the top (not shown) is mounted on the shaft 163. A shaft is arranged at the top of the conveyer to carry the stuff to the top of the hopper 166. A chain 167 extends from the wheel 168 on the shaft 163 to a wheel 169 on one of the shafts 33. The hopper 166 is suspended from the frame by means of the brackets 167. It empties into a supplemental hopper 171, this hopper being mounted on the gear 38. The shaft 4 has the openings 172, connecting with the hopper 171. An elevator is arranged within the shaft 4. This elevator has the cups 173 mounted on the chain 174. The chain runs on the sprockets 175 at the bottom. This sprocket is mounted on the shaft 176. The shaft 176 is mounted in the bearings 177 arranged at the bottom of the shaft 4. A gear 178 is arranged at one end of the shaft and is protected by a housing 179 extending from the shaft. A gear 180 meshes the gear 178. This gear is mounted on the shaft 180^a. The shaft 180^a is arranged in a bearing 180^b extending from the shaft 4. A gear 181 is fixed on the shaft 180^a, and meshes a gear 182 on the top of the wheel 38. The elevator is thus driven from the same source of power that drives the tools. The chain 174 passes over the wheel 183 at the top of the shaft. The wheel 183 is mounted on the shaft 184 and this is carried by bearings 185 mounted on the shaft 4. The material is delivered by buckets 173 to a spout 186 and carried by the spout to the pockets 187 which are carried by shaft 4.

What I claim as new is:

1. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter carried by the head; an oscillating means actuating the cutter; mechanism operating upon said means for driving the same as the head rotates; and a spring connection between the means and the cutter.

2. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter carried by the head; an oscillating means for actuating the cutter; mechanism operating upon said means for driving the same as the head rotates; a spring arm secured to the oscillating means and forming a connection between the means and the cutter.

3. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter carried by the head; a crank mechanism for actuating the cutter; devices operating upon said mechanism for driving the same as the head rotates; and a spring connection between the mechanism and the cutter.

4. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter

carried by the head; a crank mechanism for actuating the cutter; devices operating upon said mechanism for driving the same as the head rotates; and a flat spring actuated by the crank mechanism, and conveying the movement of the crank mechanism to the cutter.

5. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter carried by the head; a crank mechanism for actuating the cutter; devices operating upon said mechanism for driving the same as the head rotates; and a flat spring acting upon the cutter from the crank mechanism in the form of an oscillating arm for connecting the movement of the mechanism to the cutter.

6. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter carried by the head; a crank mechanism; devices operating upon said mechanism for driving the same as the head rotates; a rock lever carried by the crank mechanism; a spring attached to the lever and forming a rock arm and arranged to communicate the movement of the lever to the cutter.

7. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter carried by the head; a crank mechanism for actuating the cutter; devices operating upon said mechanism to drive the same as the head rotates; a rock arm having a slot in which the crank operates; and a connection between the rock arm and the cutter.

8. In a shaft boring or tunneling machine, the combination of a head; two cutters arranged to operate alternately; an oscillating means for actuating said cutters alternately; and mechanism operating upon said means as the said head rotates for driving said means.

9. In a shaft boring or tunneling machine, the combination of a rotating head; a tool slidably mounted in the head having a reduced end, forming a shoulder; a spring lever engaging the shoulder on the reduced end; and means for actuating the spring lever.

10. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter mounted in the head; a bell crank for actuating the cutter, one arm of the bell crank being connected with the cutter; means operating upon the opposite arm of the bell crank for actuating the bell crank.

11. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter mounted in the head; a bell crank for actuating the cutter, one arm of the bell crank being connected with the cutter; and the opposite arm of the bell crank being slotted; a crank operating in the slot for actuating the bell crank; and means for actuating the crank.

12. In a shaft boring or tunneling machine,

the combination of a rotating head; two cutters mounted on the head; a cutter actuating lever connected with the cutters, and intermediately pivoted; an arm extending from said lever; and means operating upon said arm for actuating the lever.

13. In a shaft boring or tunneling machine, the combination of a head; means for rotating the head; a cutter mounted in the head; a bell crank for actuating the cutter, one arm being connected with the cutter; and mechanism independent of said means for rotating the head and connected with the opposite arm of the bell crank for actuating the cutter.

14. In a shaft boring or tunneling machine, the combination of a head; means for rotating the head; a cutter mounted in the head; mechanism for actuating the cutter comprising a spring for yieldingly actuating the cutter; and devices for actuating said spring, said devices being independent of the said means for rotating the head.

15. In a shaft boring or tunneling machine, the combination of a head; means for rotating the head; two cutters mounted in the head; a lever intermediately pivoted for actuating the cutters; and mechanism independent of said means for rotating the head for actuating said lever.

16. In a shaft boring or tunneling machine the combination of a head; means for rotating the head; two cutters mounted in the head; a lever in the form of a spring intermediately pivoted for actuating said cutters; and mechanism operating upon the spring and independent of said means for rotating the head for actuating said lever.

17. In a shaft boring or tunneling machine the combination of a rotating head; two cutters, one having an axial direction of thrust; a bell crank for actuating each cutter, each bell crank having one arm connected with the cutter; means operating upon the opposite arm of each bell crank for actuating the bell cranks.

18. In a shaft boring or tunneling machine, the combination of a rotating head; two cutters carried by the head, one having a radial thrust, and the other an axial thrust; bell cranks for actuating said cutters, one arm of each bell crank being in the form of a spring and connected with one of the cutters; and means operating upon the opposite arms of the bell cranks for actuating the bell cranks.

19. In a shaft boring or tunneling machine the combination of a rotating head; two cutters carried by the head arranged for axial thrust, and one cutter arranged for radial thrust; a rock lever for actuating the two cutters having an axial thrust; a lever for actuating the cutter having a radial thrust; and means for actuating said levers.

20. In a shaft boring or tunneling machine the combination of a rotating head; two cutters mounted on the head, and arranged to have an axial thrust, and two cutters mounted on the head, and arranged to have a radial thrust; levers in the form of springs intermediately pivoted for actuating said cutters; and means for actuating said levers.
21. In a shaft boring or tunneling machine the combination of a rotating head; a cutter carried by the head and arranged for an axial thrust; a lever pivotally mounted for actuating said cutter; and means for actuating said lever.
22. In a shaft boring or tunneling machine the combination of a rotating head; a cutter carrier by the head and arranged to have an axial thrust; a lever in the form of a spring for actuating said cutter; and means for actuating said lever.
23. In a shaft boring or tunneling machine the combination of a rotating head; two cutters mounted in the head, and arranged for axial thrust; a lever intermediately pivoted for actuating said cutter; and means for actuating said lever.
24. In a shaft boring or tunneling machine the combination of a rotating head; two cutters mounted in the head, and arranged for axial thrust; a lever in the form of a spring intermediately pivoted for actuating said cutters; and means for actuating said lever.
25. In a shaft boring or tunneling machine, the combination of a rotating head; a cutter carried by the head and arranged for a radial thrust; a lever pivotally mounted for actuating said cutter; and means for actuating said lever.
26. In a shaft boring or tunneling machine the combination of a rotating head; a cutter carried by the head and arranged to have a radial thrust; a lever in the form of a spring for actuating the said cutter; and means for actuating said lever.
27. In a shaft boring or tunneling machine the combination of a rotating head; two cutters mounted in the head, and arranged for axial thrust; a lever intermediately pivoted for actuating said cutter; and means for actuating said lever.
28. In a shaft boring or tunneling machine the combination of a rotating head; a cutter mounted on the head, and arranged for axial thrust; a cutter mounted on the head and arranged for radial thrust; levers for actuating said cutters; means for actuating said levers, the means for actuating the lever operating the radially operating cutter being driven from the means operating the lever actuating the axially operating cutter.
29. In a shaft boring or tunneling machine, the combination of a rotating head, having a radially extending arm; a rock shaft mounted in the arm; a crank shaft mounted in the arm and having the same general direction as the rock shaft; means for actuating the crank shaft; a cutter mounted in the head; a bell crank for actuating the cutter mounted on the rock shaft and arranged to be actuated by the crank shaft.
30. In a shaft boring or tunneling machine, the combination of a rotating head, having a radially extending arm; a rock shaft mounted in the arm; a crank shaft mounted in the arm and having the same general direction as the rock shaft; a cutter mounted in the head; a bell crank for actuating the cutter mounted on the rock shaft and arranged to be actuated by the crank shaft; means for actuating the head; and means for actuating the crank shaft independently of the means for actuating the head.
31. In a shaft boring or tunneling machine, the combination of a rotating head having a radial arm; a drive shaft mounted on the arm; a crank shaft mounted on the arm; means for conveying the motion of the drive shaft to the crank shaft; means for driving the crank shaft; a rock shaft; a reciprocating tool mounted in the head; a lever mounted on the rock shaft for actuating the cutter, said lever being actuated by the crank shaft.
32. In a shaft boring or tunneling machine the combination of a rotating head having a radial arm; a box on the arm; tool guides in the box; tools in the guides; bell cranks for actuating the tools housed by the box; and means for actuating the bell cranks.
33. In a shaft boring or tunneling machine the combination of a rotating head having a radial arm; a box on the arm; reciprocating tools mounted in the box; a crank shaft arranged in the box; means for driving the crank shaft; a rock shaft arranged in the box; and a lever pivotally mounted on the rock shaft for actuating said tools, said lever being actuated by the crank shaft.
34. In a shaft boring or tunneling machine the combination of a rotating head having a radial arm; a box mounted on the arm; a rock shaft in the box; two tools arranged in the box, one on each side of the rock shaft; a lever pivotally mounted on the rock shaft for actuating the tools; a crank shaft on the box for actuating the lever; and means for driving the crank shaft.
35. In a shaft boring or tunneling machine the combination of a rotating head having a radial arm; a box on the arm; a rock shaft mounted in the arm; tools slidably mounted in the box at each side of the shaft; a lever mounted on the shaft for actuating the tool; a crank shaft for actuating the tool;

tuating the lever; and means for driving the crank shaft.

36. In a shaft boring or tunneling machine the combination of a rotating head 5 having a radial arm; a tool arranged for axial thrust mounted on the arm; a rock shaft; a lever mounted on the rock shaft for actuating the tool; a crank shaft for actuating the lever; a tool mounted on the 10 arm, and arranged for radial thrust; means actuated by the crank shaft for actuating said radial tool; and devices for driving the crank shaft.

37. In a shaft boring or tunneling machine the combination of a rotating head; 15 a rock shaft radially mounted on the head; a series of cutters at each side of the rock shaft; levers pivotally mounted on the rock shaft, each lever having its ends connected 20 to cutters at each side of the rock shaft; and means for actuating the lever.

38. In a shaft boring or tunneling machine, the combination of a rotating head; 25 a rock shaft radially mounted in the head; a series of cutters at one side of the rock shaft; a series of bell cranks mounted on the rock shaft, one arm of each bell crank being connected to a cutter, and the other 30 arm being slotted; a crank shaft extending through the slots, and having its cranks arranged to operate in the slots to actuate the levers; and means for actuating the crank shaft.

39. In a shaft boring or tunneling machine the combination of a rotating head; 35 a rock shaft radially mounted in the head; a series of bell cranks at each side of the shaft; a series of levers mounted on the shaft, the opposite ends of each lever being 40 connected to cutters at the opposite sides of the shaft; and means for actuating the levers.

40. In a shaft boring or tunneling machine the combination of a rotating head; 45 a rock shaft radially mounted in the head; a series of bell cranks at each side of the shaft; a series of levers mounted on the shaft, the opposite ends of each lever being 50 connected to cutters at the opposite sides of the shaft; and means for actuating the levers, said levers being in the form of a spring.

41. In a shaft boring or tunneling machine the combination of a rotating head; a 55 rock shaft radially mounted in the head; a series of bell cranks at each side of the shaft; a series of levers mounted on the shaft, the opposite ends of each lever being

connected to cutters at the opposite sides of the shaft for actuating the cutters, said 60 levers being in the form of springs; slotted bell crank arms extending from said levers; a crank shaft extending through said arms having its cranks arranged to operate in 65 the slots to actuate the levers; and means for driving said crank shaft.

42. In a shaft boring or tunneling machine, the combination of a rotating head; a 70 rock shaft radially mounted in the head; a crank shaft arranged parallel to the rock shaft; a gear mounted concentrically with the head; a gear connection between said gear and the crank shaft; levers mounted 75 on the rock shaft and actuated by the crank shaft; and cutters actuated by the levers.

43. In a shaft boring or tunneling machine, the combination of a rotating head 80 having radial arms; a series of cutters mounted in the arms; rock shafts radially mounted in the arms; rock levers mounted 85 on the shafts for actuating the cutters; means for actuating the rock levers; a series of cutters arranged at the center of the head, the line of the series of the cutters at the center being at an angle to the line of the 90 series of cutters in the arms; a rock shaft arranged to cross the center at an angle to the rock shafts in the arms; rock levers mounted on said shafts at the center to actuate the said series of cutters; and means 95 for actuating the rock levers at the center of the head.

44. In a shaft boring or tunneling machine the combination of a rotating head 100 having radial arms extending therefrom; a series of cutters in said arms; a gear mounted concentrically with the head; means for actuating said cutters in said arms; and a connection between the gear and the concentrically mounted gear; and means for 105 actuating said cutters; a central line of cutters mounted at the center of the head but in a line at an angle to the line of cutters in the arms; a gear connection arranged in the angle between the arms for actuating 110 said centrally located cutters, said gear connection being driven by the gear mounted concentrically on the head.

In testimony whereof I have hereunto set my hand in the presence of two subscribing 110 witnesses.

WILLIAM F. WITTICH.

Witnesses:

H. C. LORD,
MARGARET M. BEIGLE.