

Nov. 6, 1923.

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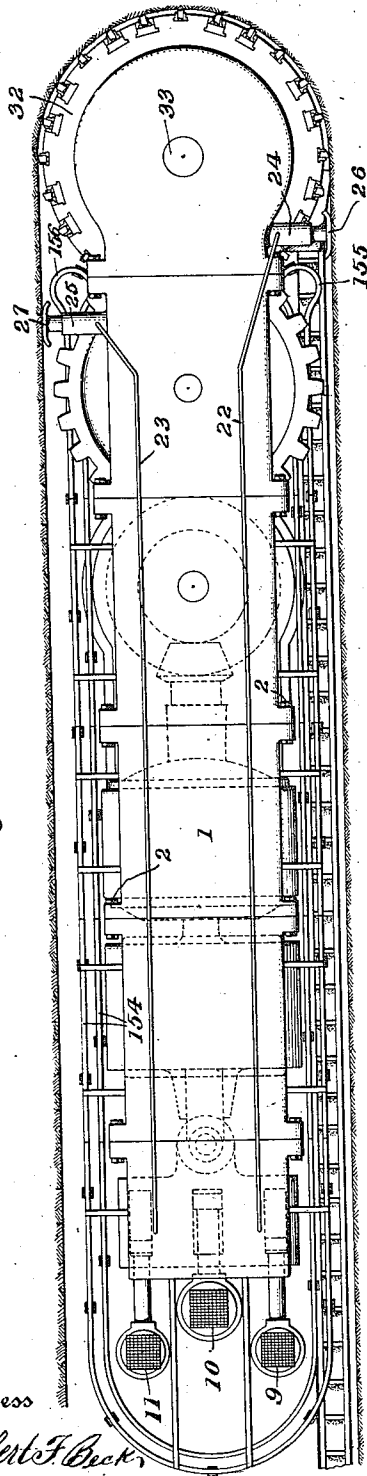
E. C. MORGAN

TUNNELING MACHINE

Filed Oct. 6, 1917

17 Sheets-Sheet 1.

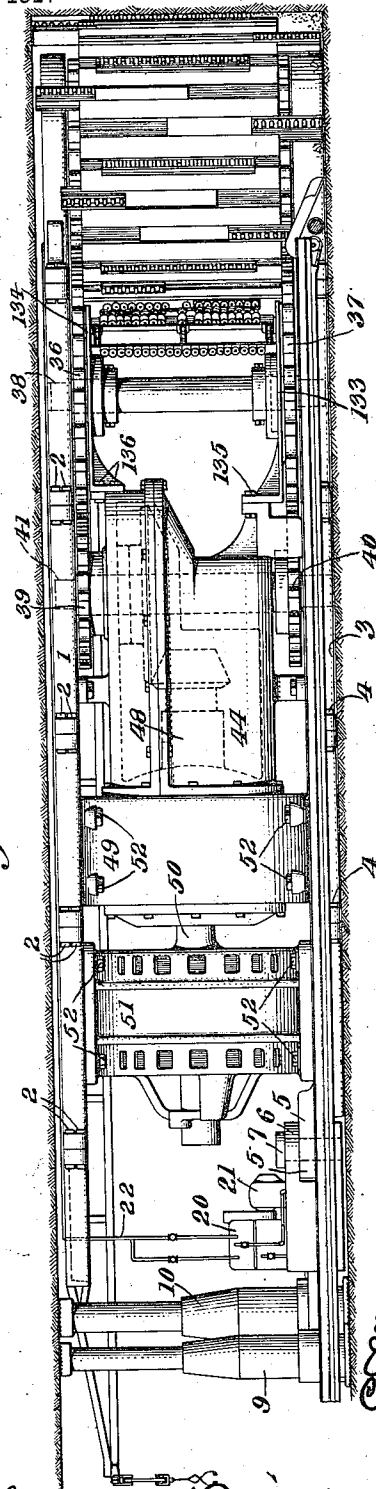
Fig. 1.



Witness

Robert F. Beck,

Fig. 2.



By

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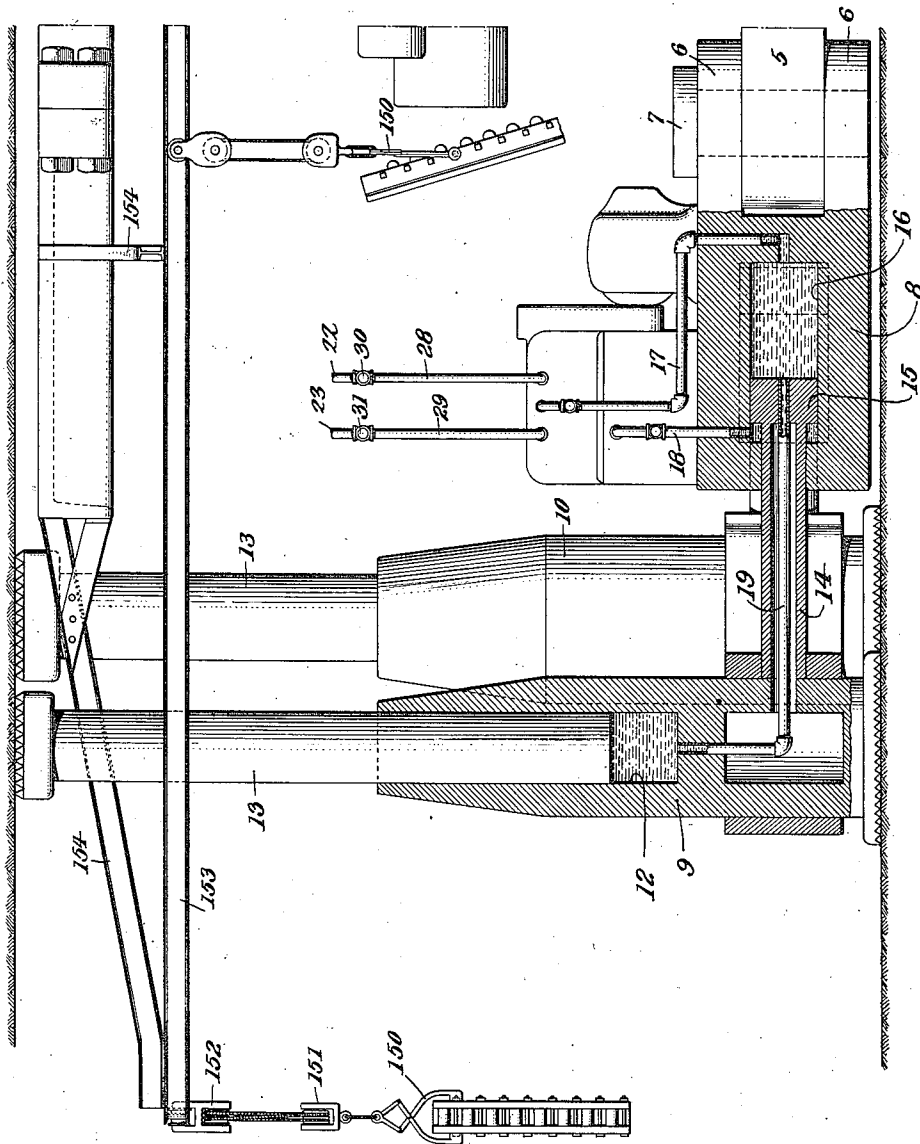
Nov. 6, 1923.

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Witness

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Fig. 3.

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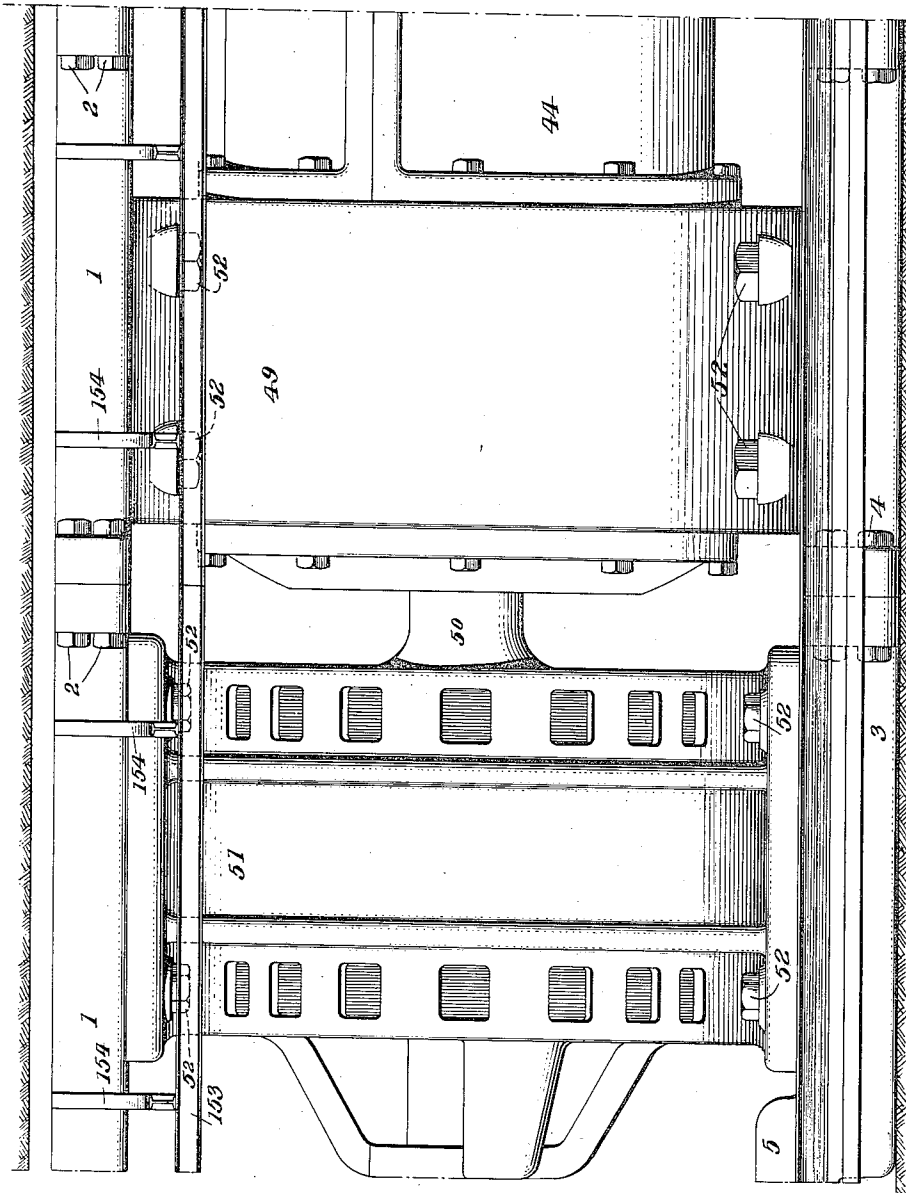
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Witness

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Fig. 4.

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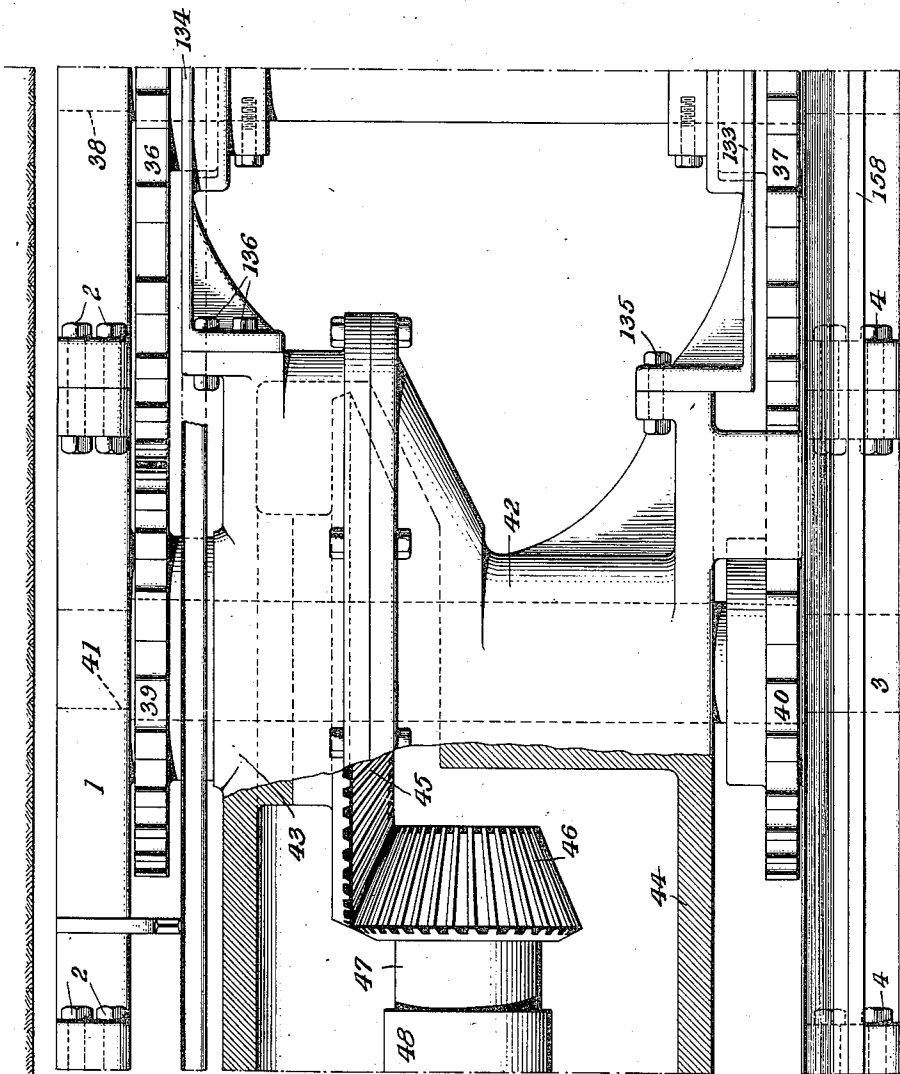


Fig. 5.

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11

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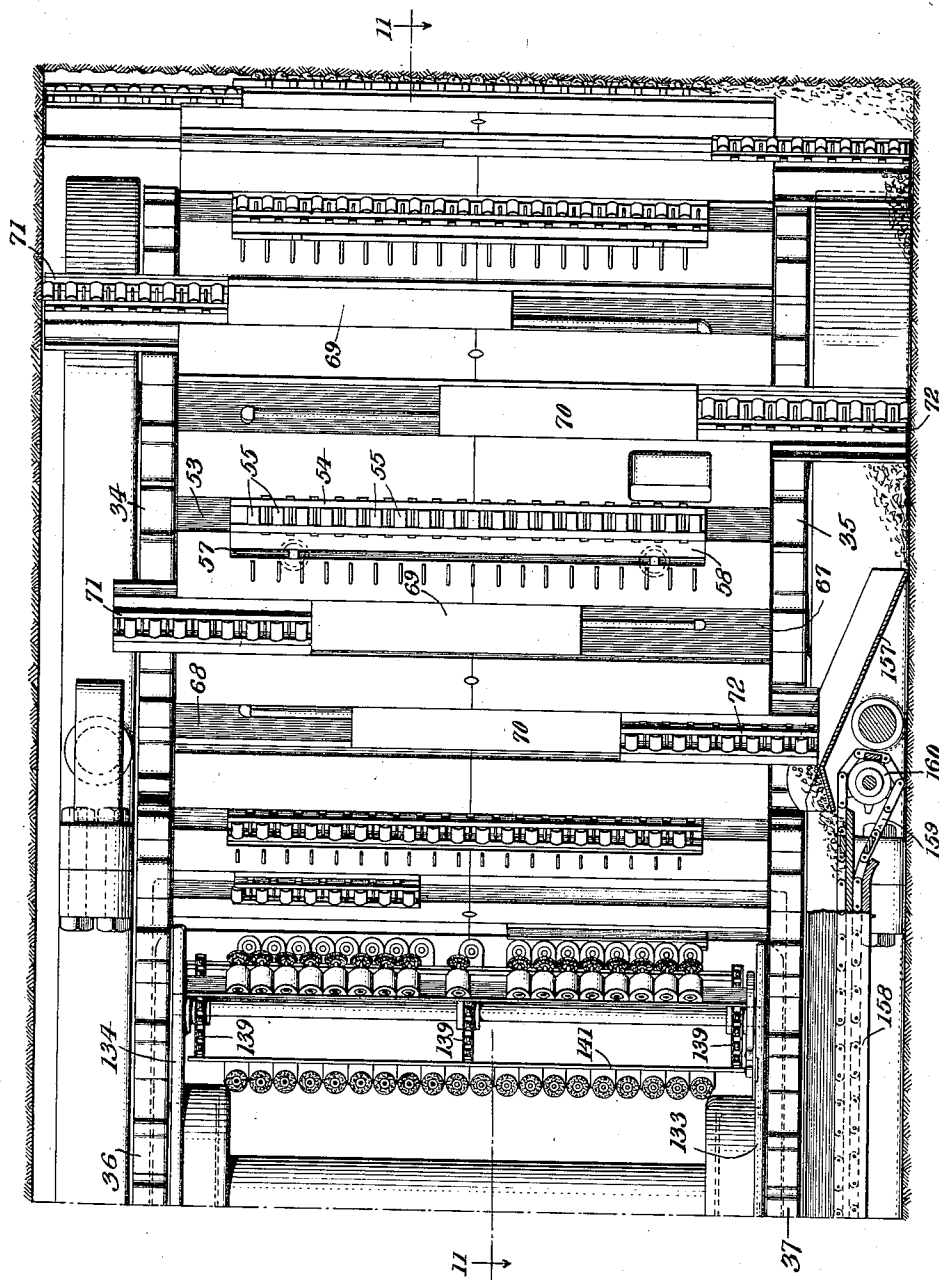


Fig. 6.

Witness

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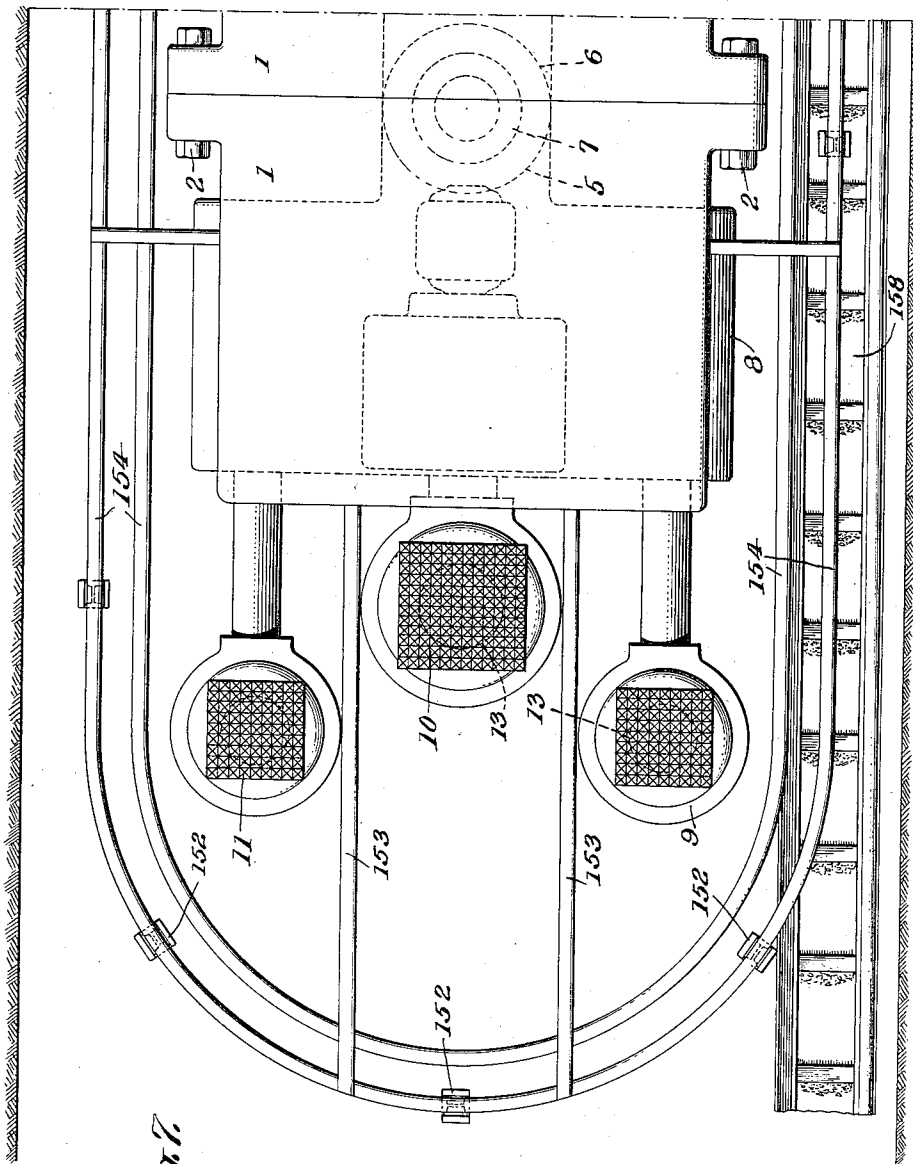


Fig. 7.

Witness

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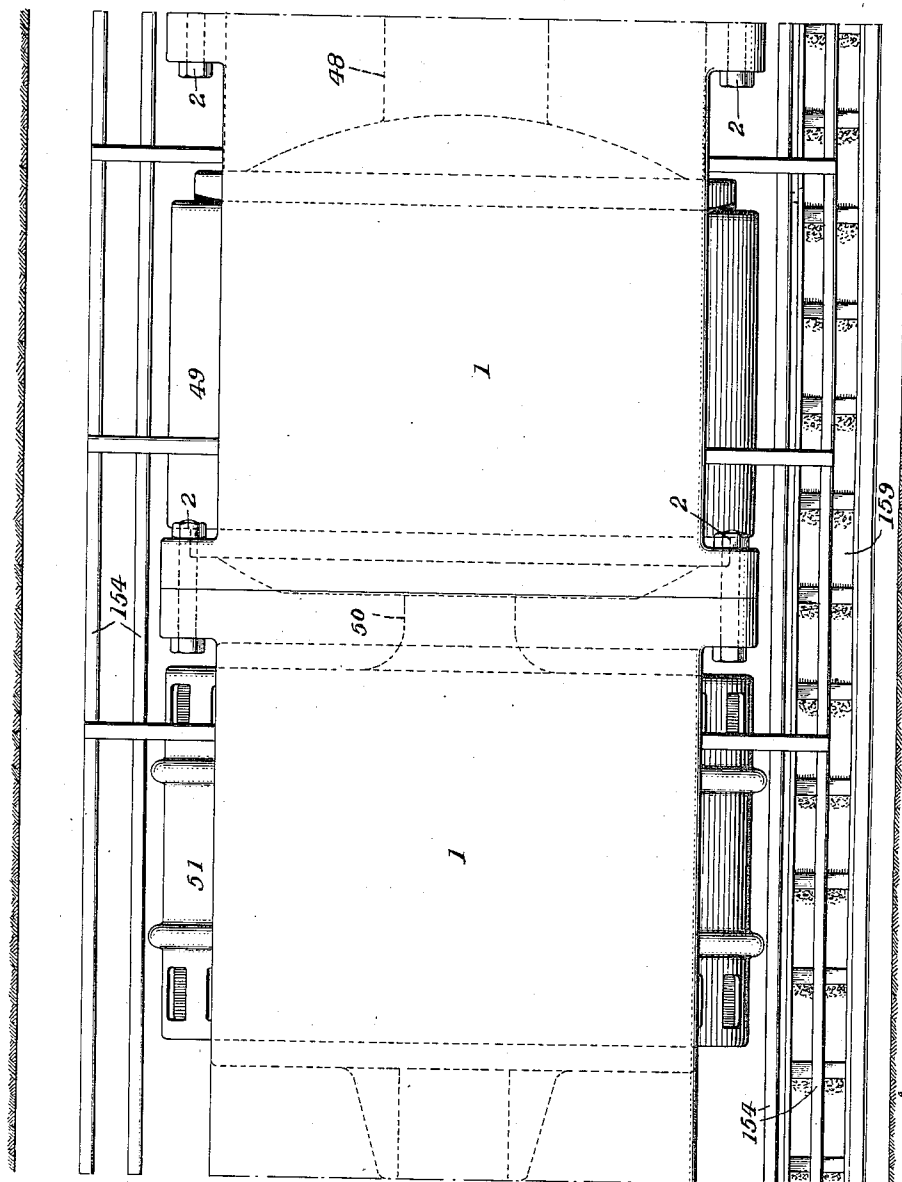
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Witness

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Fig. 8.

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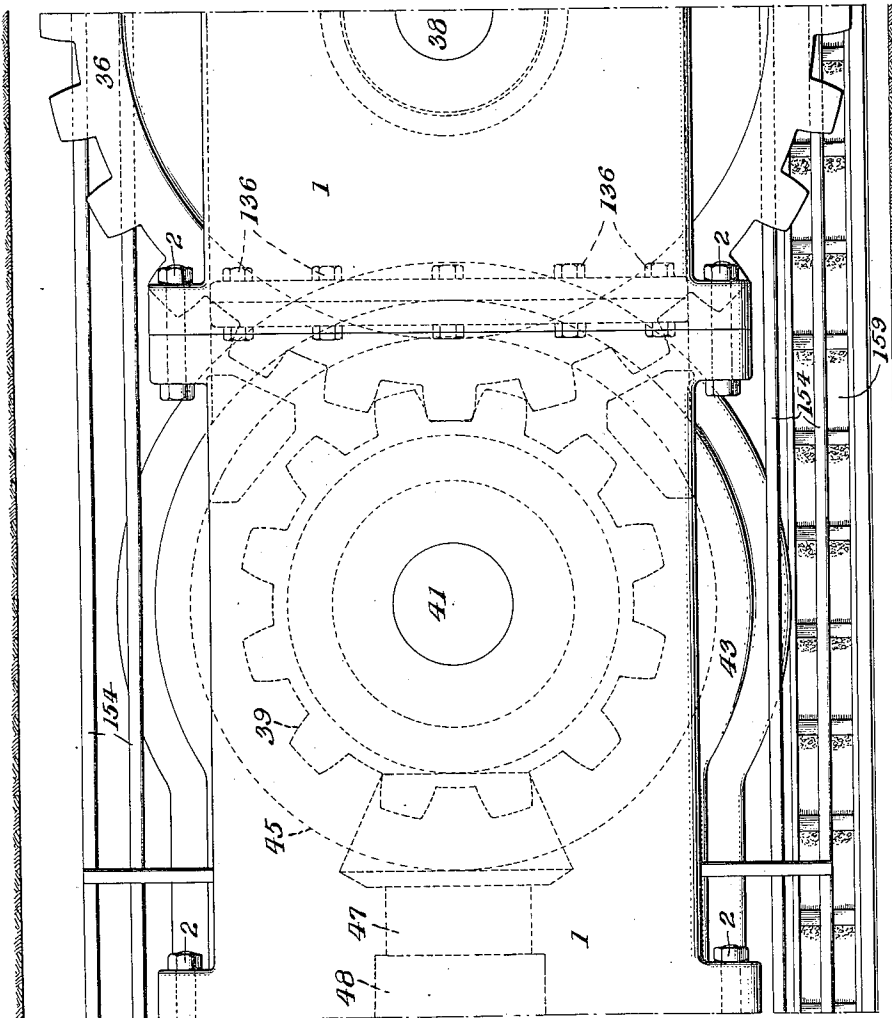


Fig. 9.

Witness

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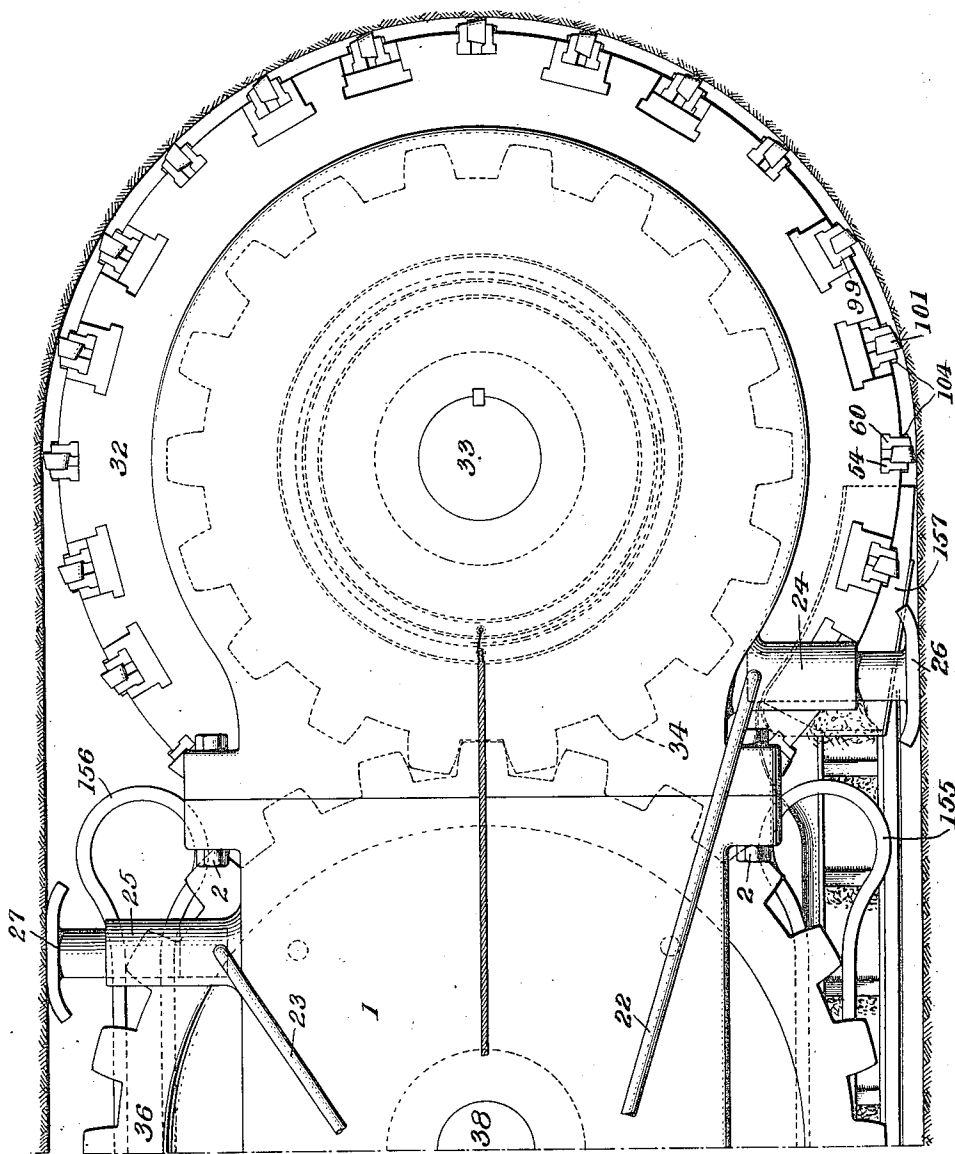


Fig. 10

Witness

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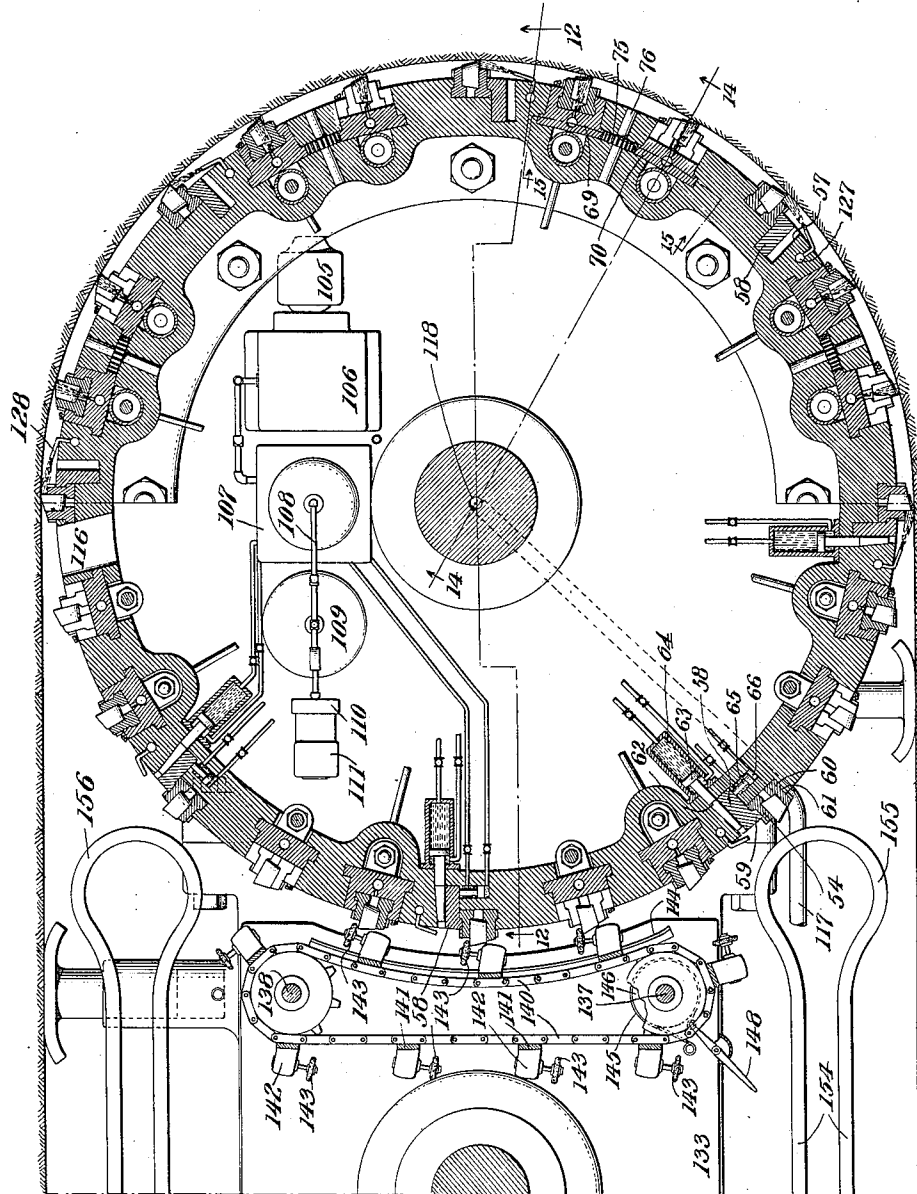


Fig. 11.

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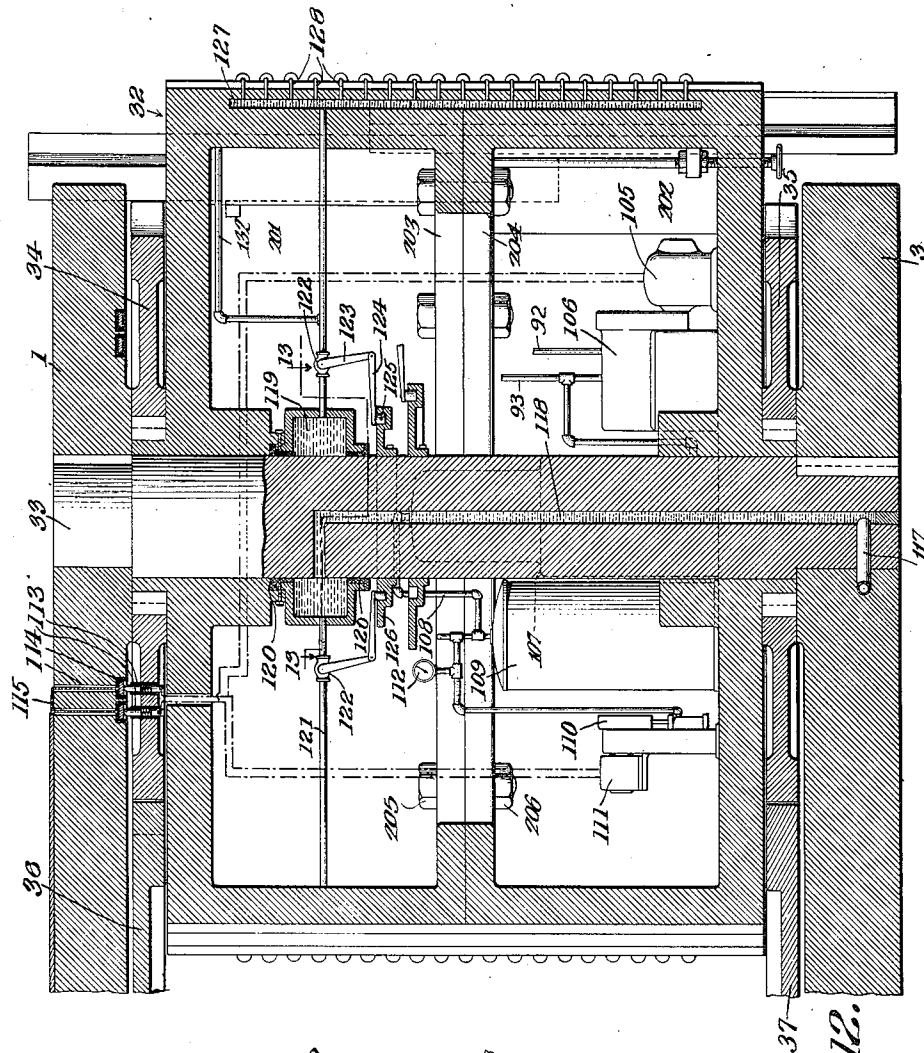


Fig. 12.

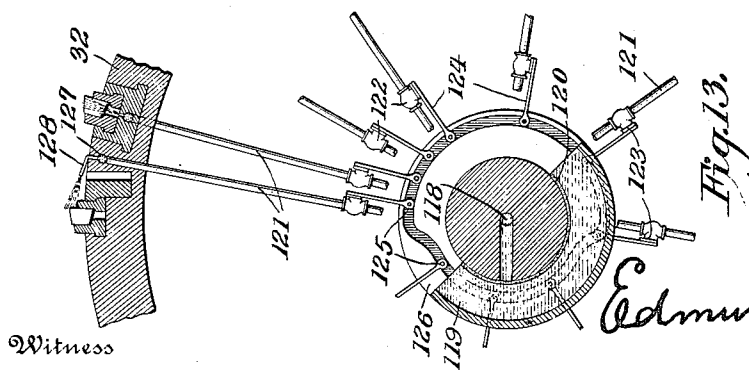


Fig. 13.

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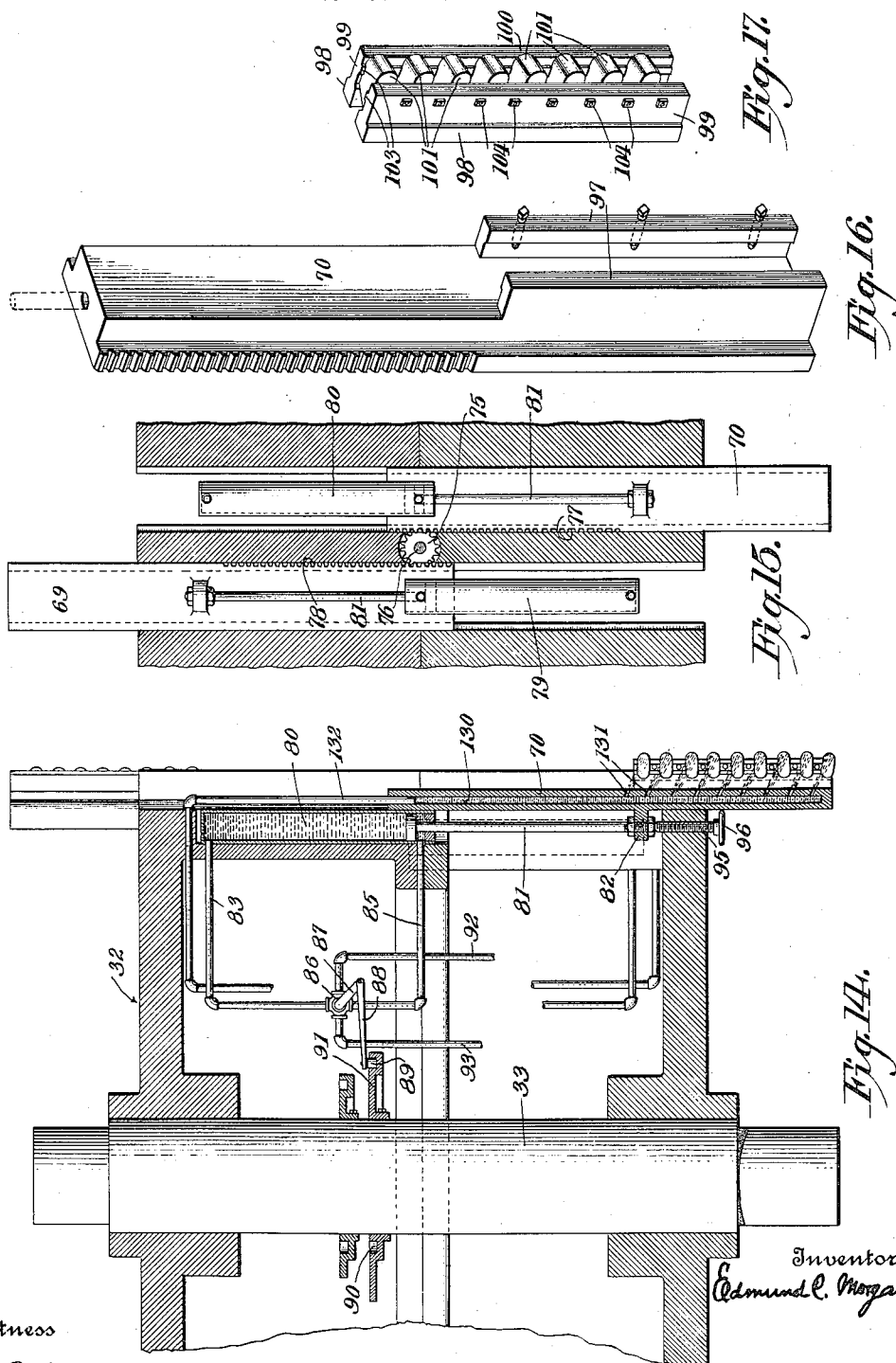
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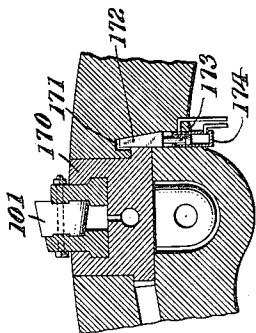


Fig. 21.

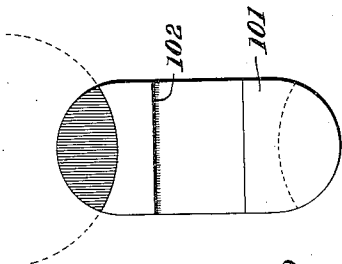


Fig. 20.

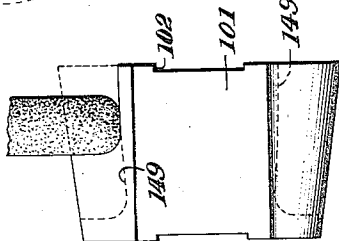


Fig. 19.

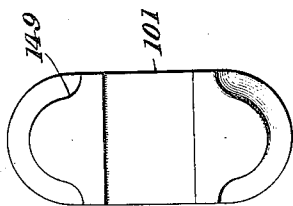


Fig. 18.

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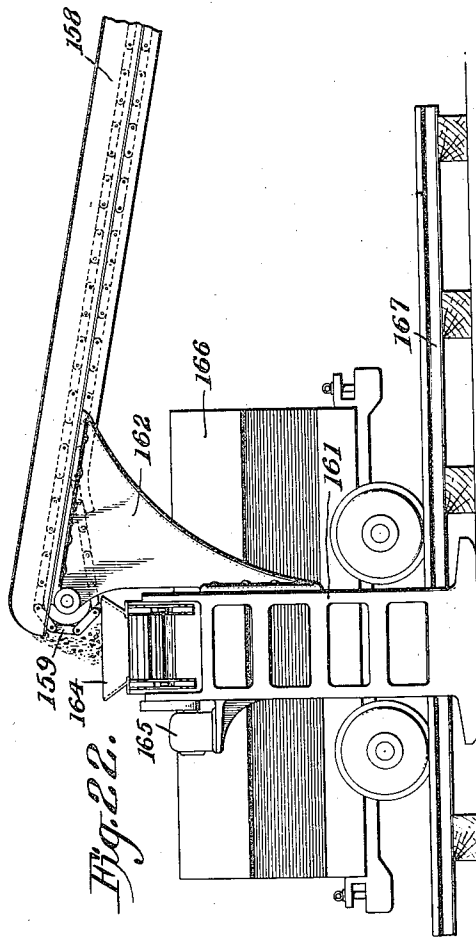


Fig. 22.

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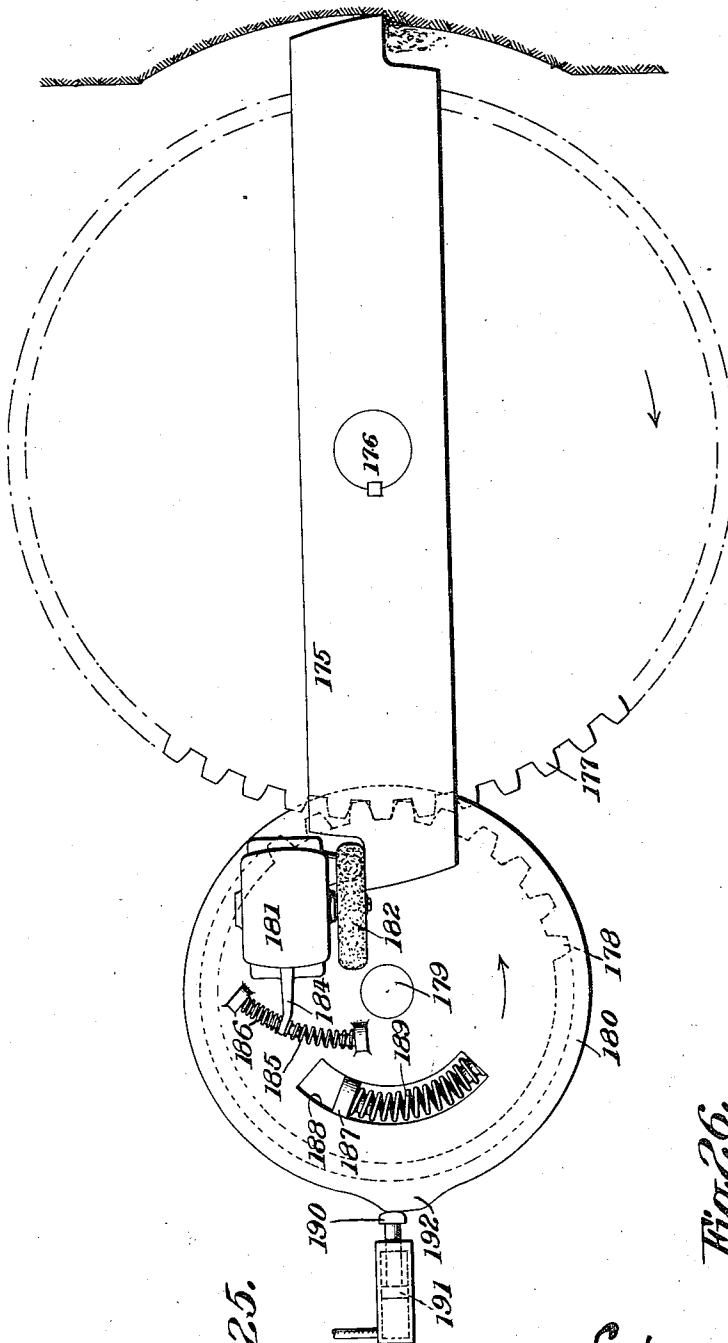
E. C. MORGAN

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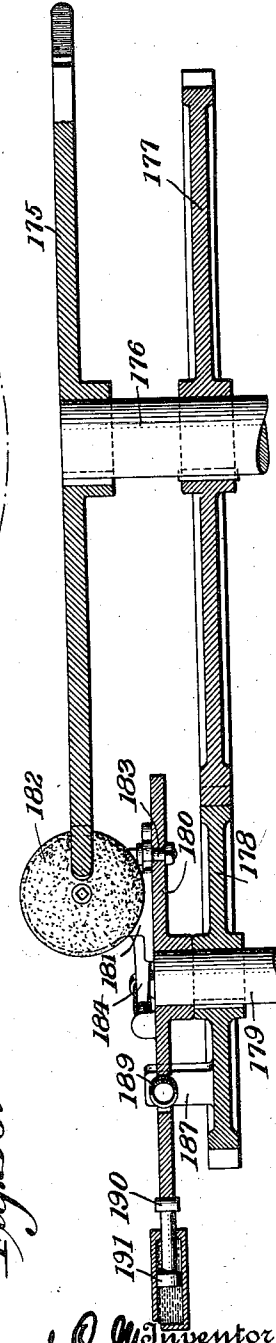
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TUNNELING MACHINE

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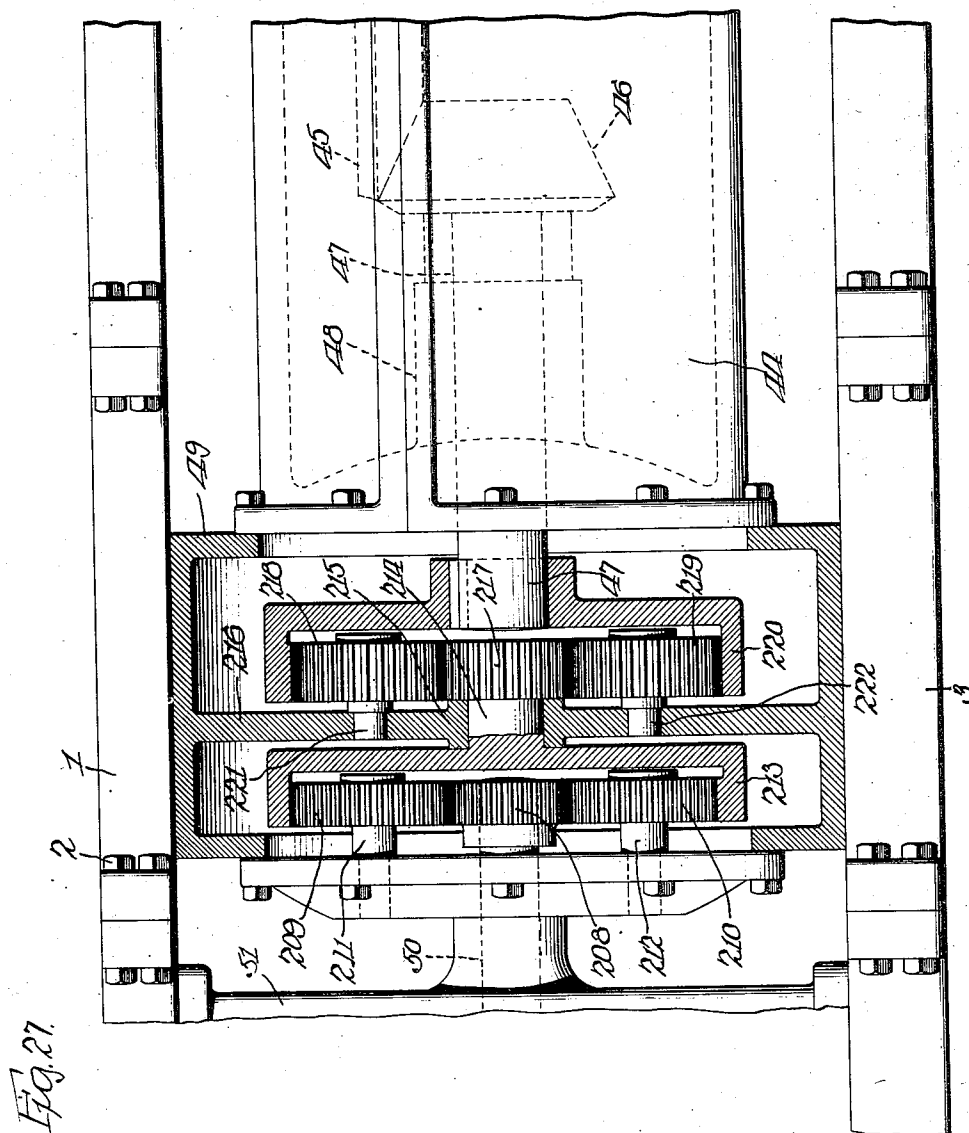


Fig. 27.

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E. C. MORGAN

TUNNELING MACHINE

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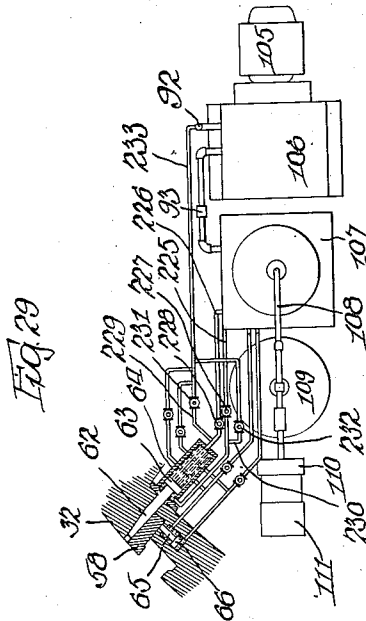
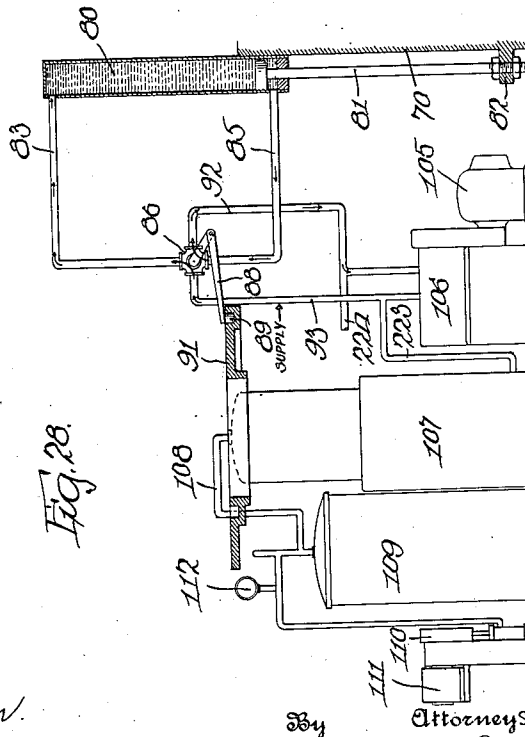


Fig. 28.



Witness.
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Patented Nov. 6, 1923.

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UNITED STATES PATENT OFFICE.

EDMUND C. MORGAN, OF RICHMOND HILL, NEW YORK; OLIVE EUGENIE MORGAN
EXECUTRIX OF SAID EDMUND C. MORGAN, DECEASED.

TUNNELING MACHINE.

Application filed October 6, 1917. Serial No. 195,034.

To all whom it may concern:

Be it known that I, EDMUND C. MORGAN, a citizen of the United States, and a resident of Richmond Hill, New York city, in the county of Queens and State of New York, have invented certain new and useful Improvements in Tunneling Machines, of which the following is a specification.

This invention has for its object the provision of a machine of the class named which shall be of improved construction and more efficient and economical in operation than machines for a similar purpose previously constructed.

The invention is exemplified in the combination and arrangement of parts shown in the accompanying drawings and described in the following specification and it is more particularly pointed out in the appended claims.

In the drawings—

Fig. 1 is a top plan view of one embodiment of the present invention shown in operating position in a tunnel.

Fig. 2 is a side elevation of the machine shown in Fig. 1.

Figs. 3, 4, 5 and 6 together constitute a side elevation, on a larger scale than Fig. 2, of the machine shown in Fig. 2 with parts broken away, each figure representing a portion of the machine.

Figs. 7, 8, 9 and 10 constitute a top plan view of the machine, the figures corresponding respectively in order to Figs. 3, 4, 5 and 6.

Fig. 11 is a horizontal sectional view of the front portion of the machine taken substantially on line 11—11 of Fig. 6.

Fig. 12 is a vertical sectional view substantially on line 12—12 of Fig. 11.

Fig. 13 is a fragmentary horizontal sectional view substantially on line 13—13 of Fig. 12.

Fig. 14 is a fragmentary vertical sectional view substantially on line 14—14 of Fig. 11.

Fig. 15 is a fragmentary vertical sectional view substantially on line 15—15 of Fig. 11.

Fig. 16 is a perspective view showing the sliding frame for one of the tool holders.

Fig. 17 is a perspective view of one of the tool holders with the cutting bits in place.

Figs. 18, 19 and 20 are detail views showing the construction of one of the cutting

bits together with the method of grinding.

Fig. 21 is a fragmentary horizontal sectional view showing a slightly modified construction for holding the tool holder frames in place.

Fig. 22 is a side elevation of the rear portion of the discharge conveyer and a car for receiving the excavated material.

Fig. 23 is a top plan view of the parts shown in Fig. 22.

Fig. 24 is a vertical sectional view on line 24—24 of Fig. 23;

Figs. 25 and 26 are a top plan view and a vertical sectional view respectively of a modified form of construction.

Fig. 27 is an enlarged view of a portion, of Fig. 2, with the reduction gearing shown in sectional elevation.

Fig. 28 is a diagrammatic view of the fluid pressure connections shown in Figs. 12 and 14.

Fig. 29 is a diagrammatic view of the fluid pressure connections shown at the upper portion of Fig. 11.

Although the present invention is applicable to machines of various sizes, the embodiment of the invention shown in the accompanying drawings is designed for cutting tunnels of a very considerable bore, as for example eighteen or twenty feet square, and the machine as illustrated is so constructed that it is capable of driving such a tunnel through solid rock as well as through softer material. A machine of this capacity requires heavy construction and it is therefore desirable that it be made in sections to facilitate handling. The main framework of the machine, as shown in the drawings, comprises an upper plate 1, the sections of which are held together by bolts 2, and a lower plate 3 having bolts 4 for holding the sections together. The rear end of the lower plate 3 is provided with a projection 5, Figs. 2 and 3, which fits between a pair of projections 6, the projections 5 and 6 forming eyes through which a pivot pin 7 passes to connect the rear portion of the plate 3 with a framework 8 with which a plurality of hydraulic jacks 9, 10 and 11 are connected which form an anchorage by means of which the machine is fed forwardly in the tunnel. The jacks 9, 10 and 11 are each provided with an opening 12

in their base portions in which plungers 13 are slidably mounted and which receive the liquid for forcing the plungers into contact with the roof of the tunnel to hold the
 5 jacks firmly in position. Each jack is provided with a hollow piston rod 14 which has one end firmly secured to the base of the jack and which is provided with a piston
 10 15 on its forward end. The pistons 15 are arranged to reciprocate in cylindrical chambers 16 in the frame 8, and relative movement between the pistons and cylinders is produced by forcing liquid into the
 15 cylinders on opposite sides of the pistons through pipes 17 and 18. The cylinders 8 are connected with the openings 12 in the jacks through pipes 19 which extend through the hollow piston rods 14. In this way the pressure within the chamber 12 is
 20 equal to the pressure within the chamber 16 so that when liquid is forced into the chamber 16 in front of the piston 15 to force the tunneling machine forward, the upper section 13 of the jack will be forced
 25 upwardly into contact with the roof of the tunnel with a pressure proportional to the forward pressure on the tunneling machine, and hence proportional also to the backward pressure on the jack. On the other
 30 hand, when the pressure on the front of the piston 15 is removed and liquid forced into the cylinder in the rear of the piston, the pressure within the jack will also be removed so that the jack will be freed from
 35 contact with the roof of the tunnel and will therefore be moved forwardly toward the tunneling machine.

The central jack 10 is of heavier construction than the two outside jacks 9 and
 40 11, and in operation is intended to alternate with the outside jacks so that the machine is forced forward first by the two outside jacks and then when the limit of their movement has been reached, the pressure is
 45 transferred to the central jack, the two outside jacks being drawn forwardly while the forward movement of the machine is accomplished by the center jack.

A hydraulic pump 20 is mounted on the
 50 frame 8 and is driven by an electric motor 21 for supplying liquid under pressure to operate the jacks. Pump 20 also supplies liquid through pipes 22 and 23 to jacks 24 and 25, located near the forward end of the
 55 machine, Fig. 1. These jacks have shoes 26 and 27, respectively, arranged to bear against the sides of the tunnel so that the machine may be shifted laterally for directing its forward movement, the pivotal connection formed by the parts 5, 6 and 7 permitting such lateral shifting of the frame of the machine. Each of the pipes 22 and 23 is provided with a pair of branches 28 and 29 controlled by valves 30 and 31 so
 65 that liquid under pressure may be trans-

mitted through the pipes, or the liquid in the jacks may be permitted to exhaust through the pipes, depending upon which of the valves 30 and 31 is operated.

The cutting operation by which the
 70 material is removed to form the tunnel opening is performed by a rotary drum or cutter head shown at 32 in Fig. 1 of the drawings as of sufficient diameter to provide ample clearance for the sides of the machine.
 75 This drum, as shown in Fig. 12, is mounted to rotate about an upright stationary shaft 33 rigidly secured to the forward portion of the frame plates 1 and 3. The drum is rotated by a pair of spur gears 34 and 35
 80 keyed to the drum adjacent the upper and lower ends thereof respectively and meshing with gears 36 and 37. The gears 36 and 37 are idler gears mounted on a vertical shaft 38 and transmit power from gears 39 and 40
 85 which are rigidly secured to a vertical shaft 41 which rotates in bearings 42 and 43 as well as bearings in the frame plates 1 and 3, as shown best in Fig. 5. The bearings 42 and 43 are supported from the base plate 3
 90 and form a part of a gear casing 44 which encloses a bevel gear 45 on the shaft 41 and a bevel pinion 46 meshing with the gear 45 and secured to a horizontal shaft 47. The shaft 47 is journaled in a bearing 48 pro-
 95 jecting from a gear casing 49 which contains a series of reduction gearing driven from the main shaft 50 of the motor 51. The casing for the motor 51, as well as the gear casing 49, are secured to the frame
 100 plates 1 and 3 by lag screws 52. By this power transmission train, the cutter head or drum 32 is given a comparatively slow and powerful rotation about the shaft 33 as an upright axis.
 105

In Fig. 27 I have shown reduction gearing which may be used. As shown in Fig. 2, the gear casing 49 is secured rigidly to the main frame or supporting framework. In this gear casing, as shown in Fig. 27, are
 110 mounted two trains of gears, so that a comparatively slow and powerful rotation of the cutter-head may be secured from the electric motor 51. Mounted on the motor shaft 50 is a spur gear 208 which meshes
 115 with upper and lower spur gears 209 and 210. The gears 209 and 210 are respectively mounted on bearings 211 and 212 which are fixed to the gear casing 49. It will thus be seen that when the motor 51 is operated the
 120 gears 208, 209 and 210 simply rotate on their own axes, but transmit rotary movement to the internal or annular gear 213 with which the gears 209 and 210 are in mesh. The gear 213 is provided with a shaft 214
 125 which is journaled in a center bearing 215 in the partition 216 in the casing 49. The shaft 214 carries a gear 217 which meshes with the upper and lower gears 218 and 219, which are in mesh with the internal or an-
 130

nular gear 220. The upper and lower gears 218 and 219 are respectively mounted on bearings which are fixed respectively at 221 and 222 to the central partition 216. It will thus be seen that when the gear 217 is rotated, rotary movement will be transmitted to the annular gear 220. The latter is keyed to the shaft 47 which is journaled in the bearing 48. The shaft 47 carries the bevel gear 46 which meshes with the bevel gear 45 for transmitting rotary movement to the cutter-head through the gears, 39, 36 and 34, as shown in Figs. 2 and 6. The reduction gearing shown in Fig. 27 is in duplicate form so as to secure greater reduction in speed of the shaft 47, and also to secure rotation of the shaft 47 in the same direction as the rotation of the motor shaft 50. The rotation of the shaft 214 will be the reverse of the rotation of the shaft 50, but the next reversal of rotation causes the shaft 47 to have the same direction of rotation as the motor shaft 50.

The drum 32 preferably comprises two sections having upper and lower circular portions respectively designated as 201 and 202 in Fig. 12. The sections of the drum are provided with inner central annular flanges 203 and 204 through which extend bolts 205 held in place by nuts 206 so as to securely hold the two sections of the drum together while leaving a large circular opening. The drum is hollow, but since it is substantially closed, all the parts within this drum are protected from dust and cuttings.

The periphery of the drum 32, as shown in Figs. 6, 10 and 11, is provided with a series of vertical dove-tailed grooves in which the cutting tools are secured, the grooves being arranged in groups of three, and the grooves of each group differ somewhat from one another. The rearmost groove of each group, designated by the numeral 53, extends the full length of the drum and retains a holder 54 supplied with a series of cutting bits 55. The holder 54 terminates somewhat short of the upper and lower ends of the drum, as shown in Fig. 6, and is positioned opposite an elongated notch 57 extending along one side of the groove 53, but being somewhat shorter than the main groove so that it corresponds in length to the tool holder 54. A retaining block 58 is mounted in the opening 57 and is provided with a shoulder 59 (Fig. 11) arranged to overlie one of the longitudinal ribs 60 extending along the inner edges of the tool holder 54. A fixed flange 61 engages the opposite rib 60 of the tool holder, as shown in Fig. 11. The retaining block 58 is held in place by a sliding wedge 62 operated by a piston 63 and a hydraulic cylinder 64. The block 58 may be moved laterally away from the tool holder 54 by a hydraulic plun-

ger 65 mounted in a cylindrical opening 66 formed in the body of the drum 32. By this construction the tool holder 54 can be locked or unlocked in its position in the periphery of the cutter head, the locking operation being performed by hydraulic pressure. (See Fig. 11.)

Since the drum 32 is held between the supporting plates 1 and 3, it of course does not extend to the floor and roof of the tunnel and hence means must be provided for cutting the material away above and below the drum to provide clearance for the supporting framework of the machine which is located beyond the ends of the main portion of the cutter head. To accomplish this result, the other two peripheral grooves of each group, which are designated by the numerals 67 and 68, respectively, are provided with sliding tool holder frames 69 and 70 which carry tool holders 71 and 72 at their outer ends in position to be projected beyond the ends of the main drum, as shown in Fig. 6. The frames 69 and the tool holders 71 are arranged to be slid upwardly and the frames 70 and the tool holders 72 are slid downwardly while they are passing through that portion of the rotation of the drum 32 in which the cutting is performed. The frames are retracted inwardly, as shown at the left in Fig. 6, during the idle portion of the rotation of the drum so that the tool holders will pass between the upper and lower plates of the supporting frame. The mechanism for operating the sliding frames will best be understood from Figs. 11, 12, 14, 15 and 16. Frames 69 and 70 are balanced against one another by means of a spur gear 75 mounted to rotate on a shaft 76 and meshing with racks 77 and 78 formed along adjacent edges of the two frames, as shown best in Fig. 15. Hydraulic cylinders 79 and 80 are supported within the wall of the drum 32 in the rear of the frames 69 and 70, respectively, and each cylinder is connected with its corresponding tool holder frame by a piston rod 81 which connects with a piston within the corresponding cylinder. The piston rods are secured to the rear of the tool holder frames by projections 82, as shown in Fig. 14. Each cylinder is provided with hydraulic pipes 83 and 85 connected with the opposite ends of the cylinder, and these pipes lead to four-way valve 86 controlled by a lever 87 and link 88, the link 88 being provided with a cam roller 89 which operates in a cam groove 90 formed in a circular bracket 91 secured to the post 33. Pipes 92 and 93 connect with a source of hydraulic pressure and an exhaust chamber, respectively, as will be described, so that the pressure within the cylinders 79 and 80 may be controlled automatically by the cam groove 90 to move the piston rods 81 in either direction within the cylinders.

The arrangement of the various parts relative to the cam groove is such that the sliding frames 69 and 70 will be moved outwardly to extend beyond the ends of the drum 32 when the drum reaches a point in its rotation to bring the cutters carried by the respective frames into position to engage the surface of the mine chamber. When a given pair of cutters has passed beyond its operative position, however, the frames 69 and 70 are automatically retracted so that they will pass between the upper and lower frame plates of the machine. A set screw 95 provided with a hand wheel 96 is shown in Fig. 14 of the drawings for limiting the downward movement of the sliding tool holder frame. Similar set screws may be provided if found desirable for the upwardly moving frames.

Each of the tool holder frames 69 and 70 is provided with flanges 97 (Fig. 16) which form a dove-tail groove for receiving flanges 98 (Fig. 17) formed on the inner edges of the side members 99 of tool holders 100 in which the cutting bits 101 are clamped. The cutting bits 101, as shown more clearly in Figs. 18 to 21, are provided with grooves 102 which engage ribs 103 (Fig. 17) formed on the inner surfaces of the side members 99 of the cutter holders. The side members are clamped together against the bits by bolts 104 which pass through the side members of the holder. It will be seen from Figs. 16 and 17 that each cutter holder may be readily slid from its position in the sliding frame when it is desired to renew the cutter bits within a given holder.

The apparatus for supplying fluid under pressure to the cylinders 79 and 80 is mounted within the drum 32, as shown in Figs. 11 and 12, and comprises an electric motor 105 which operates a hydraulic pump 106 connected with a liquid reservoir 107 from which liquid is supplied to the various cylinders. The upper portion of the reservoir 107 is connected by means of a pipe 108 with the upper portion of an air tank 109 into which air is forced by a pump 110 operated by a motor 111. A gauge 112 is provided for indicating the pressure within the air tank. The compressed air tank constitutes an accumulator which will maintain an elastic pressure upon the upper surface of the liquid within the reservoir 107, thus providing a live medium for operating the hydraulic cylinders 79 and 80. The fluid for the cylinders 64 and 66 is also taken from the reservoir 107. The pipes 92, which supply the fluid under pressure for the cylinders 79 and 80, are connected with the reservoir 107, while the pipes 93, through which the liquid is exhausted from these cylinders, are connected with the intake of the pump 106.

Fig. 28 represents diagrammatically the fluid pressure connections for operating the fluid pressure motor 80, shown in Fig. 14. The motor 111 operates the air pump 110 to supply air pressure to the tank 109 which is connected by a pipe 108 to the water tank 107, the upper portion of which is provided for air pressure. The water tank 107 is connected by a pipe 223 to the hydraulic motor 106 which is operated by the electric motor 105. The fluid pressure from the pump 106 is exerted through the pipe 93 and the valve 86 to either the pipe 83 or the pipe 85. In the position of the parts shown in Fig. 28 the arrows indicate the direction of flow of the liquid to the top of the piston in the motor 80 and from the space below said piston. It will be seen that the water flows through the pipe 83 to the space above the piston, and through the pipe 85 from the space below the piston. The return pipe 92 may be provided with an extension 224 to serve as a drain pipe for the excess water which cannot be taken care of by the pump 106.

Fig. 29 is a diagrammatic illustration of the fluid pressure connections for operating the tool holding and tool releasing mechanism, the details of which are more clearly shown in Fig. 11. The cylinder 64 of the hydraulic motor for operating the wedge 62, is supplied with two pressure pipes, 225 and 226, leading from the water tank 107 to opposite sides of the piston 63. These pipes may be provided with hand-operated valves 227 and 228 respectively. Branching from the pipes 226 and 225 are auxiliary pipes 229 and 230 provided respectively with valves 231 and 232 for controlling the exhaust fluid from the cylinder 64 into the drain pipe 233 which is connected to the pump 106. If the valves 227, 228, 231 and 232 are all closed, the piston 63 will be locked in adjusted position by the liquid in the cylinder 64. If it is desired to release the wedge 62, the valves 227 and 231 may be opened so that pressure may be exerted from the tank 107 ahead of the piston 63 and the water back of the piston 63 exhausted through the pipe 229 and valve 231 into the drain pipe 233. In a similar manner the wedge 62 may be moved in the opposite direction by having the valves 231 and 227 closed and opening the valves 228 and 232. The piston 66 may be locked in position in the same manner as above described in connection with the piston 63, and also in the same manner the piston 66 may be moved in either direction by proper operation of the valves in the pipes connected between the tank 107 and the cylinder in which the piston 66 moves, and also the valves between said connecting pipes and the drain pipe 233.

Current for operating the motors 105 and 111 is supplied to the interior of the drum 32 through brushes 113 which bear upon in-

sulated slip rings 114 carried on the lower surface of the upper plate 1 and connected with wires 115 of an electrical circuit.

An opening 116 extends through the shell 5 of the drum 32 and provides a manhole through which an operator may pass into and out of the interior of the drum. An attendant should preferably remain in the drum during the operation of the machine.

10 In order to supply a lubricating and cooling liquid to the various cutting bits during their operation, a pipe line 117 is connected with an opening 118 extending longitudinally along the interior of the shaft 33 and 15 communicating with a reservoir 119 which surrounds the shaft 33 within the drum 32 and is provided with packing 120 to prevent leaking of the liquid from the reservoir. The reservoir 119 rotates with the drum 32 20 and connects with a series of pipes 121 which feed the liquid to the different cutters and which are controlled by valves 122. The valves 122 are provided with operating levers 123 and links 124 connected with cam 25 rollers 125 controlled by a cam bracket 126 similar to the bracket 91 of Fig. 14. By this arrangement the liquid is automatically shut off during the time the cutters are passing through the inoperative portion of the 30 revolution of the drum 32. This arrangement is best shown in Figs. 12 and 13.

A series of openings 127 are bored in the frame of the drum 32, there being one opening adjacent each of the tool holders 54 and 35 each of these openings, as shown in Figs. 12 and 13, is provided with a series of discharge tubes 128 which direct the fluid against the cutters in the cutter frames. Each opening 127 is connected with one of the 40 pipes 121. The sliding frames 69 and 70 are also provided with openings 130 (Fig. 14) which discharge the cooling fluid onto the cutters carried by the holders 100 through orifices 131. Each opening 130 is connected 45 with one of the pipes 121 through a vertically arranged pipe 132 which telescopes within the opening 130, as shown in Fig. 14. Water, either clear or soapy, or any other liquid which may be found suitable, is supplied to 50 the reservoir 119 through the pipe 117 which may be connected with a tank or any other suitable source for supplying the liquid with sufficient pressure to force it from the openings onto the cutting tools and thus keep the 55 tools from heating and provide a lubricant and also serve to prevent dust.

In order to keep the cutting tools sharp and to avoid the delay necessary to remove the tools for sharpening, mechanism is provided for sharpening the tools while they are 60 traveling in their operative position upon the cutter carrying drum. This mechanism is best illustrated in Figs. 6 and 11. The sharpening mechanism is supported between 65 plates 133 and 134 which are secured by

bolts 135 and 136, respectively (Fig. 5) to the framework of the machine and which extend forwardly to a position adjacent the rear portion of the drum 32. A pair of upright shafts 137 and 138 are journaled be- 70 tween the plates 133 and 134 and carry sprocket wheels 139 about which sprocket chains 140 pass. The sprocket chains 140 are distributed along the upright shafts 137 at different vertical positions and are connected 75 by upright slats 141 on which are mounted a series of electric motors 142 each of which is provided with a grinding wheel 143. Guide bars 144 are secured to the plates 133 and 134, respectively, in position to en- 80 gage the ends of the slats 141 and guide the run of the chains 140 adjacent the periphery of the drum 32, so that the grinding wheels 143 will be maintained at a fixed distance from the periphery of the drum during their 85 travel through this part of their course. The grinding wheels 143 are spaced along the sprocket chains 140 distances equal to the peripheral distance between the cutters on the drum 32. It will be seen that by this 90 arrangement each cutter, as it comes adjacent the grinding mechanism, will engage the rear face of one of the wheels 143 and will continue in contact with the face of the wheel during the movement of the cutter ad- 95 jacent the grinding mechanism. Since the grinding wheel is being rotated during this time by the motor with which it is connected, the edge of the cutter will be ground and put into condition for its next cutting operation. 100 The sprocket chains 140 are driven by the engagement between the cutters and grinding wheels 143 and the pressure between the cutters and grinding wheels may be regulated by a brake band 145 which surrounds 105 a brake drum 146 on the shaft 137 and is controlled by an operating lever 148. It will be apparent that the grinding wheels 143 if they become worn may be replaced or trued up during their passage along the inopera- 110 tive run of the sprocket chains 140.

As shown in Figs. 18, 19 and 20, each of the cutter bits 101 is tapered to provide clearance and is so arranged that it may be ground away in sharpening from the front 115 edge to the back along the broken lines 149, Fig. 19, without destroying the clearance of the tool. The cutter bits are provided with duplicate cutting edges so that each bit may be reversed after one side has been worn 120 away.

When it is desired to reverse the bits in one of the holders, or to replace the bits with new ones, the holder is removed from the drum 32 and carried to the rear of the 125 machine by one of a series of grapples shown at 150 in Fig. 3. Grapples 150 are supported from fall blocks 151 which are carried on trolleys 152 arranged to run on a track 153. The track 153 is carried by 130

brackets 154 secured to the upper plate of the machine frame and extends entirely around the frame of the machine from a position adjacent the rear of the cutter drum 32 on one side of the machine to a position adjacent the rear of the cutter drum on the opposite side of the machine, there being a pair of loops 155 and 156, respectively, at the opposite sides of the machine adjacent the cutter drum, as shown in Figs. 1 and 11. The track 153 is double, as is also shown in these views, so that the trolleys 152 with the grapples thereon may be brought up to the drum along one run of the track and returned along the other. The track is of sufficient length to accommodate trolleys and grapples to support a complete set of tool holders for the cutter drums. When it is desired to renew the cutters, the grapples on the track are supplied with a complete set ready to be installed and as the holders with the old cutters are removed at one side of the drum, say the side adjacent the loop 155, other holders with renewed cutters may be inserted from the grapples as they are passed around the loop 156. When the holders with the worn out cutters have all been removed they will be suspended from the track 154 and since the drum has been supplied with new cutters the tunneling operation may go on uninterruptedly while the old cutters are being removed from their holders and new ones substituted, thus preparing the holders to be replaced in the drum when new cutters are again required. In this way a minimum amount of time is consumed in renewing worn out cutters and since the cutters are ground while the machine is in operation no time is lost in sharpening.

As the cuttings are disconnected from the front wall of the tunnel they fall, as shown in Fig. 6, to the floor of the tunnel in the path of movement of the downwardly projecting tool holder frames 70 and are carried around in front of these frames as the drum 32 rotates to a position at one side of the tunnel and toward the rear of the cutter drum. At this point there is located an inclined chute 157, Figs. 6 and 10, which receives the cuttings and directs them onto the end of a conveyer 158 which is provided with an endless chain 159 passing over a sprocket 160 and extending to a point in the rear of the mining machine, as shown in Fig. 22. The chute 157 has its inner wall shaped to conform to the path of movement of the sliding cutter holder frames and is inclined at such an angle that the frames move over the bottom of the chute as they are drawn upwardly by their respective hydraulic cylinders into position to pass between the upper and lower plates of the tunneling machine frame. The rear end of the conveyer 158

is supported on a platform 161 by means of a bracket 162 and the conveyer is driven by a motor 163, as shown in Figs. 22 and 23. The conveyer 158 discharges into a lateral conveyer 164 which is also carried by the platform 161 and is driven by a motor 165. The conveyer 164 discharges into a car 166 which runs on a track 167 extending rearwardly from the rear of the tunneling machine.

In Fig. 21 is shown a slightly modified arrangement for holding the sliding tool holder frames in place in the cutter drum 32. In this form the sliding frames 170 correspond in all respects to the sliding frames 69 and 70 but a recess 171 is formed in the shell of the drum 32 at the side of the sliding frame opposite that which carries the rack by which it is counterbalanced against its complementary frame. A wedge 172 is arranged to operate in the recess 171 and is moved by a piston 173 which is reciprocated in a cylinder 174 in a manner similar to the hydraulic wedges 62. The wedges 172 are for the purpose of holding the sliding frames 170 against any tendency to chatter which may be present when the machine is operating on hard material.

In Figs. 25 and 26 is shown a modified and somewhat simpler form of the invention in which a bar cutter 175 is rigidly mounted on an upright shaft 176 which is driven by a gear 177. The cutter 175 has its opposite ends shaped to form cutting edges as shown in the drawings so that the ends of the bar alternately contact with the tunnel wall to make a cut across the surface thereof. The gear 177 is driven by a pinion 178, the two gears having a ratio to one another of one to two. The pinion 178 is carried by a shaft 179 which has loosely mounted thereon a disc 180 which carries a motor 181 arranged to drive a grinding wheel 182. The motor 181 is pivotally connected to the disc 180 by a pivot bolt 183 arranged beneath the portion of the grinding wheel 182 against which pressure is brought to bear during a grinding operation. The frame of the motor 181 has an arm 184 connected therewith which is controlled by coil springs 185 and 186 arranged to hold the motor 181 resiliently against rotation about its pivotal connection with the disc 180. The springs 185 and 186 will permit of sufficient pivotal movement of the motor about its support to allow the face of the grinding wheel 182 to automatically adjust itself to conform to the surface being ground. The disc 180 is driven by a projection 187 extending upwardly from the pinion 178 and arranged to operate within a slot 188 formed in the disc 180. A spring 189 provides a yielding connection between the pinion 178 and the disc 180. A brake 190 is arranged to bear against the periphery of the disc 180

and is operated by a hydraulically controlled piston 191. A projection 192 formed on the periphery of the disc 180 is arranged to contact with the brake 190 once for each revolution of the disc and thus check the rotation of the disc while the cutting portion of the bar 175 is in contact with the grinding wheel 182. Since the gears 177 and 178 have a one to two ratio, it is apparent that the grinder 182 will be brought into position to engage the cutter bar 175 each time that one end of the cutter bar comes opposite the disc 180. The projection 192 is so arranged that when the grinder and the cutter bar are in contact with one another, the disc will be retarded by the brake 190, the resiliency of the driving connection between the disc and the pinion 178 being arranged to permit such action of the brake. This will cause sufficient pressure between the grinding wheel and the cutter bar to effect sharpening of the bar, and the amount of pressure may be regulated by increasing or decreasing the pressure of the brake 190.

The shaft 179 may be driven by any suitable source of power and the entire mechanism will be supported by a frame of suitable construction. For this purpose suitable means may be used so that the cutter bar 175 can be raised up and down in order to make a complete cut from the floor to the roof of the tunnel.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of my invention as defined by the claims hereto appended, and I wish therefor not to be restricted to the precise construction herein disclosed.

I claim:

1. In a tunneling machine, the combination with a supporting frame, of a cylindrical cutter-head carried by said frame, a plurality of series of cutters, means for supporting the respective series of cutters removably on said cutter-head longitudinally thereof and substantially parallel to the axis, each series being in spaced-apart relation to the next adjacent series, means for rotating said cutter-head on such axis to impart arcuate cutting paths of travel to said cutters, and means for feeding said cutter-head and said cutters to effect the cutting of material and the opening of a tunnel in a mine.

2. In a tunneling machine, the combination with a supporting frame, of a cylindrical cutter-head carried at one end of said frame, a plurality of series of cutters, means for mounting said cutters on the periphery of said cutter-head for adjustment longitudinally thereof parallel to the axis, each series of cutters being in spaced-apart relation to the next adjacent series on the

periphery of said cutter-head, means for rotating said cutter-head, and means for advancing said cutter-head to effect the feed of said cutters to open a tunnel in a mass of material.

3. A tunneling machine comprising supporting framework, a rotary drum mounted on the forward end of said framework, a plurality of supplemental frames spaced apart circumferentially on the periphery of said drum in position for adjustment lengthwise thereof, a multiplicity of cutters on each of said supplemental frames, and means for moving said supplemental frames lengthwise of said drum to adjust the positions of said cutters relative to said drum.

4. In a tunneling machine, the combination with supporting framework, of a rotary drum mounted on the forward end of said framework for support thereby and bodily movement therewith, a plurality of cutters spaced apart circumferentially on the periphery of said drum and adjustable lengthwise thereof, means for projecting said cutters rectilinearly beyond the ends of said drum into position to remove material to provide clearance for said supporting framework, and means for operating said cutters by rotating said drum and advancing said framework.

5. In a tunneling machine, a cutter head comprising a rotary drum, a cutter carried on the periphery of said drum and movable longitudinally relative thereto, a frame for supporting said drum, connected to the end thereof, means for advancing said drum and frame to cause said cutter head to form a tunnel in a mass of material, and means for sliding said cutter longitudinally of said drum and beyond the end thereof to cause said cutter to remove material to provide clearance for said frame.

6. In a tunneling machine, a cutter head comprising a drum mounted to rotate about an upright axis, a frame for supporting said drum, connected with the end thereof, cutting tools mounted on the periphery of said drum, and means for extending some of said cutting tools rectilinearly beyond the end of said drum to cause said tools to remove material in the path of advance of said frame.

7. In a tunneling machine, a cutter head comprising a drum having cutters mounted on the periphery thereof, means for rotating said drum to cause said cutters to dislodge material to be excavated, and means for sliding some of said cutters longitudinally on said drum to cause said cutters to project beyond the end of said drum, said sliding means being arranged to retract said cutters during a portion of the rotation of said drum.

8. In combination, a cutter head comprising a drum, a frame for supporting said

drum connected with one end thereof, means for rotating said drum, a cutter carried by said drum and rotatable therewith, means for projecting said cutter rectilinearly beyond the end of said drum during a portion of the rotation of said drum to cause said cutter to remove material from the path of movement of said frame, and means for retracting said cutter during another portion of the rotation of said drum to permit said cutter to pass said frame.

9. In combination, a cutter head comprising a rotary drum, a cutter frame mounted on the periphery of said drum and slidable longitudinally thereof, and automatic mechanism for projecting said cutter frame beyond the end of said drum and retracting said cutter frame relative to said drum.

10. In combination, a cutter head comprising a drum, a frame for supporting said drum connected with one end thereof, a cutter frame mounted on the periphery of said drum and slidable longitudinally of said drum, means for rotating said drum, means for sliding said cutter frame beyond the end of said drum during a portion of the rotation thereof to cause the removal of material in the path of said drum supporting frame, and means for retracting said cutter frame relative to said drum to permit said cutter frame to pass said drum supporting frame.

11. A tunneling machine comprising upper and lower frame members, a drum mounted to rotate about an upright axis, between said members, cutters carried on the periphery of said drum, means for rotating said drum to cause said cutters to open a tunnel in a mass of material, and means for removing the material beyond the ends of said drum to form a clearance space for said frame members.

12. A tunneling machine comprising upper and lower frame members, a drum mounted to rotate about an upright axis between said members, cutters carried on the periphery of said drum, means for rotating said drum to cause said cutters to open a tunnel in a mass of material, means for advancing said drum and frame members, and means for projecting some of said cutters beyond the ends of said drum during a portion of the rotation thereof to cause said cutters to remove material in the path of advance of said frame members and for retracting said cutters during another portion of the rotation of said drum to permit said cutters to pass between said frame members.

13. In a tunneling machine, the combination with a cylindrical cutter head having slideways on the periphery thereof, of cutter frames mounted in said slideways, a plurality of cutters on each of said frames arranged in series parallel to the adjacent slideway, and means for moving said cutter

frames together with said cutters along said slideways.

14. In a tunneling machine, the combination with a cylindrical cutter-head, of a series of cutters fixed to the periphery of said cutter-head along a line substantially parallel to the axis of said cutter-head, and an additional series of cutters mounted on the periphery of said cutter-head along a line parallel to the axis thereof and movable longitudinally of said cutter-head.

15. In a tunneling machine, the combination with a supporting frame, of a rotary cutter carrier mounted thereon for rotation relatively thereto, a plurality of cutters on the periphery of said carrier in spaced-apart relation circumferentially, a plurality of supplemental cutters on the periphery of said carrier and each movable rectilinearly into positions to project beyond the ends of said carrier to vary the distance between the plane surfaces effected by operation of the machine, means for rotating said carrier to drive said cutters, and means for effecting the feed of said cutters to extend the tunnel to have a plane floor, a plane roof and plane spaced-apart upright walls.

16. A cutter head comprising a rotary drum, cutters mounted in fixed position upon the periphery of said drum, supplementary cutters mounted on said drum and slidable longitudinally thereof, means for supporting said supplementary cutters beyond the end of said drum during a portion of the revolution of said drum to cause said cutters to dislodge material beyond the path of said drum, and means for retracting said cutters during another portion of a revolution of said drum.

17. In a tunneling machine, a frame comprising upper and lower members, a drum mounted to rotate about an upright axis between said members, cutters carried by said drum having means for holding them in fixed position thereon, supplementary cutters mounted on the periphery of said drum and arranged to slide longitudinally thereof, means for rotating said drum to cause said cutters to drive an opening through a mass of material, means for automatically projecting said supplementary cutters beyond the ends of said drum during a portion of the rotation thereof to cause said supplementary cutters to dislodge material beyond the ends of said drum to form clearance for said frame members, means for retracting said supplementary cutters to permit said cutters to pass between said frame members during another portion of the rotation of said drum, and means for automatically controlling the operation of said cutter moving means.

18. In a tunneling machine, the combination with a cutter-head, of a tool holder slidably carried by said cutter-head for move-

ment relatively thereto transversely of the direction of feed of said cutter-head, and a fluid-operated device for moving said tool holder relatively to said cutter-head transversely of such direction of feed.

19. In a tunneling machine, the combination with a cutter-head, of a tool holder mounted thereon for movement in an upright direction transversely of the direction of feed of said cutter-head, and fluid operated mechanism for moving said tool holder relatively to said cutter-head transversely of the direction of feed.

20. In a tunneling machine, the combination with a cutter-head, of a supporting frame on which said cutter-head is mounted for rotation on an upright axis, vertically movable tool holders mounted on the periphery of said cutter-head, and means for counterbalancing said tool holders against one another.

21. In a tunneling machine, a cutter head comprising vertically movable tool holders, means for counterbalancing said tool holders relative to one another, and fluid actuated mechanism for moving said tool holders relatively to said cutter head.

22. In a tunneling machine, a cutter head comprising a drum arranged to rotate about an upright axis, tool holders carried on the periphery of said drum and arranged to slide longitudinally thereof, means for counterbalancing said tool holders relative to one another, and means for moving said tool holders relative to said drum.

23. In a tunneling machine, a cutter head comprising a drum arranged to rotate about an upright axis, tool holders carried on the periphery of said drum and arranged to move longitudinally thereof, and rack and pinion connection between said tool holders to counterbalance oppositely movable tool holders against one another.

24. In a tunneling machine, the combination with a cutter-head, of a plurality of individual tool holders thereon in spaced-apart relation each separately adjustable relatively to said cutter-head, and hydraulically operated mechanism for moving said tool holders longitudinally of the cutter-head and transversely of the longitudinal axis of the machine and of the direction of feed thereof.

25. In combination, a cutter head having a slot in the periphery thereof, a tool holder mounted in said slot, a wedge for releasably holding said tool holder in place, and fluid pressure mechanism for operating said wedge.

26. In combination, a cutter head comprising a drum having slots in the periphery thereof, tool holders removably mounted in said slots, and hydraulically operated wedges for removably holding said tool holders in place.

27. In a mining machine, the combination

with a supporting frame, of a cutter-head having grooves in the circumferential portion thereof, tool holders mounted in said grooves, means for rotating said cutter-head, and self-acting power operated mechanism for automatically adjusting said tool holders in said grooves relatively to said support to enable said tool holders to pass over a portion of said supporting frame during a predetermined portion of the rotation of said cutter-head.

28. In combination, a cutter head comprising a rotatable drum having a dove-tailed groove in the periphery thereof, a tool holder mounted in said groove, a movable bar for holding said tool holder in place, and a hydraulically operated wedge for pressing said bar against said tool holder.

29. In combination, a cutter head having a recess in the periphery thereof, a tool holder mounted in said recess, a power operated wedge for securing said tool holder in place within said recess, and means for controlling the automatic operation of said power operated wedge.

30. In a tunneling machine, the combination with a cutter-head having a recess in the periphery thereof, of a tool holder mounted in said recess, a locking device for engaging said tool holder to retain the latter in position in said recess, power operated mechanism for holding said locking device against said tool holder, and additional power-operated mechanism for forcing said locking device out of operative relation with said tool holder to permit the removal of the latter.

31. In combination, a cutter head having a dovetailed recess therein, a tool holder mounted in said recess, a block for engaging said tool holder, a wedging device for forcing said block into contact with said tool holder, a plunger for forcing said block out of engagement with said tool holder, and fluid actuated pistons for operating said wedging device and said plunger.

32. In combination, a cutter head, a tool holder carried by said cutter head, and a fluid operated wedging device for holding said tool holder in place on said cutter head.

33. In combination, a cutter head having a pair of slideways thereon adjacent to one another, tool holders mounted in said slideways, rack and pinion connection between said tool holders arranged to cause said tool holders to move in opposite directions, and fluid actuated pistons for moving said tool holders in said slideways.

34. In a tunneling machine, the combination with a cutter-head having a slideway on the periphery thereof, of a frame mounted for movement along said slideway, a multiple tool holder having a dove-tailed connection with said frame and removably carried thereby, fluid pressure mechanism

for moving said frame together with said multiple tool holder along said slideway to adjust the position of said multiple tool holder relatively to said cutter-head, and means for moving said cutter-head to feed said multiple tool holder transversely of said slideway.

35. In combination, a cutter head having a pair of slideways therein, tool holders mounted for opposite movement in said slideways, means for counterbalancing said tool holders against one another, and fluid actuated pistons for operating said tool holders.

36. In a tunneling machine, the combination with a supporting frame, of a cutter-head mounted thereon for rotation on an upright axis, upright slideways on said cutter-head, a pair of tool holders mounted in said slideway in spaced apart positions, means for counterbalancing said tool holders against one another, means for moving said tool holders in opposite directions along said slideways, tools carried by said tool holders, and means for rotating said cutter-head on said upright axis relatively to said supporting frame while said tool holders remain in upright position counterbalanced against one another during such rotation of said cutter head.

37. A cutter head comprising a drum arranged to rotate about an upright axis, slideways formed on the periphery of said drum and extending longitudinally thereof, a pair of tool holders movably mounted in said slideways, means for counterbalancing said tool holders against one another, and means for simultaneously moving said tool holders in opposite directions in said slideways.

38. In combination, a cutter head comprising a drum arranged to rotate about an upright axis, vertical slideways in the periphery of said drum, a pair of frames mounted for movement in said slideways and counterbalanced against one another, tool holders removably carried by said frames, and fluid actuated pistons for simultaneously moving said tool holders in opposite directions in said slideways.

39. In a tunneling machine, the combination with a cutter head comprising a hollow drum, of cutting mechanism carried on the periphery of said drum, means for varying the position of said cutting mechanism relatively to said drum, and mechanism within said drum for controlling said varying means.

40. In a tunneling machine, the combination with a cutter-head comprising a hollow drum, of slideways on the periphery of said drum, tool holders mounted on the periphery of said drum to slide along said slideways, means for sliding said tool holders along said slideways relatively to said drum, and mechanism entirely within said hollow drum

and enclosed thereby, for supplying motive power to said moving means.

41. In a tunneling machine, the combination with a cutter-head comprising a hollow drum, of a tool holder, means for releasably holding said tool holder on the periphery of said drum while confining said tool holder to movements along such periphery and preventing movement of said tool holder away from said drum radially, and mechanism carried wholly within said drum for controlling the position of said tool holder relative to said drum.

42. In a tunneling machine, the combination with a cutter-head comprising a hollow drum, of a slideway on the periphery of said drum, a tool holder fitting in said slideway, interlocking connections between said tool holder and said drum to prevent movement of said tool holder radially away from said drum but permitting movement of said tool holder longitudinally of said drum along said slideway, means for sliding said tool holder along said slideway, and mechanism entirely within said drum for supplying motive power to said sliding means.

43. In combination, a cutter head comprising a hollow drum, cutting tools movably mounted on said drum, fluid actuated means for shifting said cutting tools relative to said drum, and mechanism mounted within said drum for supplying fluid under pressure to said shifting means.

44. In combination, a cutter head comprising a hollow drum, cutting tools mounted on the periphery of said drum, fluid actuated means for controlling the position of said cutting tools relatively to said drum and mechanism mounted within said drum for supplying fluid under pressure to said controlling means.

45. In combination, a cutter head comprising a hollow drum, a motor mounted within said drum, fluid compression mechanism driven by said motor, cutters carried by said drum, and mechanism operated by fluid from said compression mechanism for controlling the position of said cutters on said drum.

46. A tunneling machine comprising a cutter-head having cutting mechanism mounted thereon, hydraulically operated mechanism for varying the position of said cutting mechanism relatively to said cutter-head, a pump within said cutter-head for supplying liquid to said hydraulically operated varying mechanism, a motor for driving said pump, and accumulator mechanism for supplying yielding pressure to said liquid.

47. In combination, a cutter head comprising a hollow drum, cutters mounted on the periphery of said drum for movement relatively thereto, hydraulic mechanism for controlling the position of said cutters rela-

tive to said drum, a pump mounted within said drum for supplying liquid to said hydraulic mechanism, a compression tank within said drum, a reservoir for containing said liquid, a connection between said compression tank and said reservoir, means for forcing air into said compression tank, and an opening through the wall of said drum to permit access to the interior thereof.

48. In a tunneling machine, the combination with a supporting frame, of a rotary cutter-head mounted thereon, cutting tools movably mounted on the periphery of said cutter-head, actuating mechanism for moving said cutting tools relatively to said cutterhead, and means for automatically controlling said actuating mechanism to cause said tools to move intermittently beyond the ends of said cutter-head in timed relation with the rotation of said cutter-head.

49. A cutter head comprising a rotary drum, tool holders carried on the periphery of said drum, actuating mechanism for projecting said tool holders rectilinearly beyond the end of said drum and for retracting said tool holders, and means for automatically controlling said actuating mechanism to cause the movement of said tool holders to occur in timed relation with the rotation of said drum.

50. A cutter head comprising a rotary drum, a frame for supporting said drum, tool holders carried on the periphery of said drum and movable rectilinearly relatively thereto, actuating mechanism for shifting said tool holders relative to said drum, and means for automatically controlling said actuating mechanism to cause said tool holders to be projected beyond the ends of said drum during a portion of the revolution thereof and to be retracted during another portion of the revolution of said drum to permit said tool holders to pass said frame.

51. In combination, a cutter head comprising a rotary drum, tool holders movably mounted on the periphery of said drum, hydraulic mechanism for moving said tool holders, mechanism within said drum for supplying liquid to said hydraulic mechanism, valves for controlling said hydraulic mechanism, and means for automatically opening and closing said valves to control the movement of said tool holders in timed relation with the rotation of said drum.

52. In combination, a cutter head comprising a rotary drum, a frame for supporting said drum, cutter holders mounted to slide longitudinally along said drum on the periphery thereof, hydraulic mechanism for sliding said cutter holders, means within said drum for supplying liquid under pressure to said hydraulic mechanism, valves for controlling said liquid, and cam mechanism for operating said valves in timed relation with the rotation of said drum so that said cutter

holders will be extended beyond the ends of said drum during a portion of the rotation thereof and retracted during another portion of the rotation of said drum to permit said cutter holders to pass said frame.

53. In a tunneling machine, the combination with a supporting frame, of a cylindrical cutter head mounted thereon for rotation on an upright axis and having a diameter larger than the width of said supporting frame, means for enabling the machine to cut its own way by producing a tunnel having a flat floor, a flat roof and upright spaced-apart flat side walls, a plurality of spaced-apart cutters carried by said cutter head in upright positions, means for driving said cutters by rotating said cutter head relatively to said supporting frame, means for advancing said supporting frame to effect the feed of said cutters, and means for automatically supplying a cooling fluid to said cutters during the operation thereof by directing such cooling fluid through the cutter head to the cutters during the rotation of said cutter head.

54. In a tunneling machine, a cutter head having a plurality of cutters thereon periodically brought into operative position by said cutter head, and mechanism for automatically supplying a cooling liquid to said cutters during the operation thereof and for discontinuing the supply of said liquid during the period when said cutters are inoperative.

55. In combination, a cutter head comprising a rotary drum, cutters carried by said drum and arranged to operate during a portion of the rotation of said drum, mechanism for supplying a cooling liquid to said cutters during their operative period, and means for automatically discontinuing the supply of said liquid during the idle portion of the rotation of said cutters.

56. In a tunneling machine, the combination with a supporting frame, of a rotary cutter-head mounted on said frame, cutting tools mounted on said drum and movable relatively thereto, means for effecting the operation of said cutting tools by rotating said drum and advancing said frame together with said drum, and means for supplying liquid directly into contact with said cutting tools during the cutting operation thereof in any of the adjusted positions of said tools on said drum.

57. A cutter head comprising a rotary drum, cutting tools mounted on the periphery of said drum and slidable longitudinally thereof, mechanism for supplying a cooling liquid to said cutting tools independently of the position of said tools on said drum, and means for automatically discontinuing the supply of said liquid during a portion of the rotation of said drum.

58. In a tunneling machine, the combina-

- tion with a supporting frame, of a rotary drum mounted thereon, cutting tools carried on the periphery of said drum, means for effecting the operation of said cutting tools by rotating said drum relative to said frame and advancing said frame together with said drum, means for supplying liquid to the interior of said drum independently of the rotation thereof, and means for distributing said liquid from the interior of said drum directly into contact with said cutting tools.
59. In a tunneling machine, the combination with a supporting frame, of an upright stationary shaft secured to said frame, a cutter-head mounted on said shaft for rotation on an upright axis extending through said shaft, cutting tools carried by the periphery of said cutter-head, means for supplying liquid through said shaft to the interior of said cutter-head, means for effecting the operation of said cutting tools by rotating said cutter-head on said upright axis and advancing said supporting frame together with said cutter-head, and means for distributing the liquid from the interior of said cutter-head into contact with said cutting tools.
60. A cutter head comprising a rotary drum, a shaft upon which said drum rotates, a reservoir within said drum, means for supplying liquid through said shaft to said reservoir, cutting tools carried on the exterior of said drum, and means for distributing liquid from said reservoir into contact with said cutting tools.
61. In combination, a cutter head comprising a rotary drum, means for supplying liquid to the interior of said drum during the rotation thereof, cutting tools mounted on the exterior of said drum, means for distributing liquid from the interior of said drum into contact with said cutting tools, and means for automatically disconnecting the supply of liquid to said tools during a portion of the rotation of said drum.
62. In combination, a cutter head comprising a rotary drum, a stationary shaft upon which said drum rotates, a reservoir within said drum and surrounding said shaft, means for supplying liquid through said shaft to said reservoir, cutting tools mounted on the exterior of said drum, pipes for distributing liquid from said reservoir into contact with said cutting tools, valves for controlling said pipes, and cam mechanism for operating said valves to regulate the supply of liquid to said cutting tools in timed relation with the rotation of said drum.
63. In a tunneling machine, the combination with a supporting frame, of a rotary cutter-head mounted thereon, cutting tools mounted on the periphery of said cutter-head, and mechanism mounted on said supporting frame for sharpening said cutting tools while in position on said cutter-head and during the rotation of said cutter-head.
64. In a tunneling machine, a cutter head having cutting tools thereon, and a sharpening device arranged to travel with said tools during a portion of their movement to sharpen said tools while said cutter head continues to operate.
65. In a tunneling machine, a cutting tool, means for continuously driving said cutting tool so that it shall engage the material operated on during a portion of its movement, and a sharpening device arranged to travel with said cutting tool during a portion of its movement to sharpen said tool during another portion of the movement of the sharpening tools.
66. In a tunneling machine, a cutting tool, a flexible conveyer positioned adjacent the path of movement of said cutting tool, and a sharpening device carried by said conveyer and arranged to move in unison with said cutting tool during a portion of the movement of said tool to sharpen said tool.
67. In a tunneling machine, a cutter head comprising a rotary drum, cutting tools carried on the periphery of said drum and arranged to engage material to be excavated at one side of said drum, and a sharpening device movably mounted adjacent the path of movement of said tools at the side of said drum away from the operating portion and arranged to travel in unison with said tools and in contact therewith to sharpen said tools during the operation of said cutter head.
68. In combination, a cutter arranged to engage the work during a portion of the movement of said cutter, and a sharpening device having a path of movement arranged to conform to the path of movement of said cutter and to travel with said cutter during a portion of the movement thereof to sharpen said cutter.
69. In a tunneling machine, a cutter head having a cutting tool thereon, and a sharpening device having a path of movement arranged to conform to the path of movement of said cutting tool but separate from the latter path to permit said sharpening device to travel in unison with said cutting tool and in contact therewith to sharpen said tool while said cutter head continues to operate.
70. A cutter head comprising a rotary drum, a plurality of cutting tools mounted on the periphery of said drum and arranged to engage the material to be dislodged during a portion of their movement, a movable supporting device positioned adjacent said drum away from the operating side thereof, grinders carried by said supporting device for engaging the tools on said drum, said grinders being arranged to move in unison with said tools and in contact therewith,

and means for driving said grinders during their contact with said tools for causing said grinders to sharpen said tools while said drum continues to rotate.

5 71. In a tunneling machine, a circular cutter head having cutting tools on the periphery thereof, a flexible conveyer mounted adjacent the periphery of said cutter head and having grinders thereon
10 arranged to engage said tools during a portion of the movement thereof and to be moved by said tools in unison therewith, and means for retarding the movement of said grinders to produce pressure between
15 said grinders and said tools.

72. In combination, a cutter head having a plurality of cutting tools spaced along said head in the direction of the axis thereof, grinders for said tools located adjacent the
20 path of movement thereof, and means for movably supporting said grinders in position to be engaged by said cutting tools and moved along by the latter.

73. In a tunneling machine, a cutter head comprising a rotary drum, a plurality of conveyers located adjacent the periphery of said drum, supporting bars carried by said conveyers, grinders mounted on said supporting bars and distributed thereon in the
30 direction of the axis of said drum, and cutters carried on the periphery of said drum and distributed thereon in the direction of the axis of said drum and in position to engage said grinder to cause said grinders
35 to move in unison therewith during a portion of the movement of said cutters.

74. In a tunneling machine, a cutter head comprising a rotary drum having cutting tools carried on the periphery thereof,
40 flexible conveyers arranged adjacent the periphery of said drum, means for guiding said conveyers in a curve conforming to the curvature of the periphery of said drum, grinders carried by said conveyers in position to engage said cutting tools during a
45 portion of the rotation of said drum, and mechanism for operating said grinders to cause them to sharpen said cutting tools while said drum continues to rotate.

50 75. A tunneling machine comprising a cutter-head having a plurality of removable tool holders thereon, a supporting frame for said cutter-head, and means mounted on said supporting frame for transporting
55 tool holders toward and away from said cutter-head.

76. A tunneling machine comprising a supporting frame, of a cutter-head mounted thereon, detachable tool holders mounted on said cutter-head, and means mounted on said
60 supporting frame for transporting said tool holders toward and away from said cutter-head, said transporting means having a capacity sufficient to hold a reserve supply of
65 tool holders.

77. In a tunneling machine, the combination with a supporting frame, of a cutter-head mounted thereon, means for detachably securing a plurality of cutting tools to said
70 cutter head, and means on said frame for transporting cutting tools toward and away from said cutter head, said transporting means having a capacity sufficiently large to accommodate a complete set of cutting tools for said cutter head.
75

78. In a tunneling machine, a cutter head, tool holders for said cutter head having cutting tools detachably held thereby, and means for conveying tool holders toward and away from said cutter head, said conveying means having a capacity sufficiently large to accommodate a complete set of tool holders for said cutter head so that tool holders having worn tools therein may be held by said conveying means for refilling
80 with unworn tools while said cutter head is in operation.
85

79. A tunneling machine comprising an elongated frame, a cutter head at one end of said frame, and a conveyer on said frame
90 and extending along the same for carrying cutting tools toward and away from said cutter head.

80. A tunneling machine comprising a cutter head, a supporting frame therefor and a
95 conveyer on said frame and extending rearwardly along the same from said cutter head and having one end located adjacent thereto for transporting cutting tools toward and away from said cutter head.
100

81. A tunneling machine comprising a cutter head, a supporting frame therefor, removable tools carried by said cutter head, and a conveyer on said frame and having the ends thereof located adjacent said cutter head at different positions relative to said head and having the intermediate portion of said conveyer arranged on said frame in a rearwardly extending loop connecting said
105 ends.
110

82. A tunneling machine comprising an elongated frame, a cutter head located at one end of said frame, and a conveyer for transporting cutting tools toward and away from said cutting head, said conveyer having the ends thereof located adjacent said
115 cutter head on opposite sides of said frame and having the intermediate portion arranged to form a loop extending toward the rear portion of said frame and connecting said ends.
120

83. A tunneling machine comprising a cutter head, a supporting frame therefor, tool holders removably carried by said cutter head, a track on said frame and having a portion thereof located adjacent said cutter head, and grapples movably supported on said track in position to grasp
125 said tool holders.

84. A tunneling machine comprising a
130

cutter head, a supporting frame therefor, tool holders removably carried by said cutter head, a track on said frame and having a portion thereof located adjacent said cutter head, a trolley mounted to travel on said track, and a grapple supported by said trolley and having a gripping portion arranged to conform to said tool holders to support said tool holders from said trolley.

85. In a tunneling machine, a tool holder comprising slide bars adapted to fit in and slide along a groove in a cutter-head, a plurality of cutting tools between said slide bars, and a plurality of spaced apart bolts alternating with said tools for clamping said slide bars against said tools.

86. In a tunneling machine, the combination with a pair of slide bars, of a plurality of cutting tools arranged between said slide bars, interlocking connections between said cutting tools and both of said slide bars, and a plurality of spaced-apart bolts for clamping said slide bars against said tools to hold the latter in spaced-apart relation rigidly connected to said slide bars.

87. A tool holder for tunneling machines comprising a pair of slide bars each provided with a rib on sides facing each other, a plurality of cutting tools arranged between said slide bars and each having oppositely facing grooves to fit the corresponding ribs, and a plurality of bolts extending between said bars for clamping them together and to hold said cutting tools in spaced-apart relation rigidly connected together and with the cutting portions of said cutting tools extending beyond the edges of said bars.

88. In a tunneling machine, the combination with a bodily movable frame, of a rotary frame mounted on the forward end of said first-named frame, cutting apparatus carried by said rotary frame, means for rotating said rotary frame continuously in one direction to effect cutting of a semi-cylindrical cavity in the head of the tunnel and form a flat roof and a flat floor for continuous advance of the machine therebetween, and multiple anchorage mechanism at the rear end of said first-named frame between the floor and roof of the mine chamber for effecting advance of said first-named frame and feed of said cutting apparatus step by step.

89. In a tunneling machine, the combination with a comparatively narrow elongated supporting frame, of a rotary drum cutter mounted on the forward end of said frame to rotate on an upright axis and having a diameter larger than the width of said frame to provide clearance for the forward movement of said frame, means for rotating said drum to drive the cutters thereon to effect the cutting of a flat floor and a flat roof and dislodge the material in the space between, a plurality of hydraulic roof props at the rear

end of said frame, and hydraulic motors between said roof props and said supporting frame for advancing the latter over the flat floor formed by said rotary drum cutter.

90. In a tunneling machine, the combination with a narrow elongated supporting frame adapted to rest on a flat floor in an upright position without being anchored, of a drum cutter-head mounted on the forward end of said frame for rotation on an upright axis, cutting mechanism mounted on the cylindrical portion of said drum in position to dislodge material in advance of the frame and leave a flat floor and a flat roof with the side walls in spaced-apart upright planes affording sufficient clearance for forward movement of said frame, self-supporting upright roof props adapted to rest on the floor of the tunnel back of said supporting frame between upright planes extending through the sides of said frame, hydraulic mechanism connected between said supporting frame and said roof props, means for rotating said drum to drive said cutters, and means for operating said roof props and said hydraulic mechanism to effect the advance of said supporting frame over said flat floor to effect feeding of said cutting mechanism.

91. In a tunneling machine, the combination with a supporting frame adapted to move over a flat floor, of cutting apparatus mounted on the forward end of said frame in position to cut material from an upright wall including the cutting of a flat floor for continued advance thereover of said frame, anchorage mechanism adapted to occupy upright positions at the rear of said supporting frame between the floor and roof of the tunnel, motor mechanism between said anchorage mechanism and said supporting frame, means for operating said anchorage mechanism and said motor mechanism for effecting the advance of said supporting frame and the feed of said cutting apparatus, and means for actuating said cutting apparatus during the feeding movement of said supporting frame over said flat floor.

92. A tunneling machine comprising a supporting frame, a cutter-head mounted at the forward portion of said frame for rotation on an upright axis, a plurality of cutters mounted on the periphery of said cutter-head, means for effecting the operation of said cutters by rotation of said cutter-head on said upright axis and advance of said frame together with said cutter-head, a conveyer mounted on said frame, and a chute extending from the floor of the tunnel to said conveyer in the path of movement of the lower ends of said cutters to cause the latter to move the cuttings of the cutters along said chute onto said conveyer during the rotation of said cutter-head.

93. A tunneling machine comprising a

supporting frame, a cutter head carried at the forward portion of said frame, a conveyor having a portion thereof located adjacent said cutter head, an upwardly inclined chute in delivery communication with said conveyor, and cutters carried by said cutter head in position to move cuttings upwardly along said chute onto said conveyor.

94. A tunneling machine comprising a supporting frame, a cylindrical cutter-head having a diameter of approximately the width of said frame and mounted on said frame for rotation on an upright axis, a multiplicity of cutters on the periphery of said cutter-head, a conveyor mounted on said frame, means for effecting the operation of said cutters by rotating said cutter-head and advancing said frame to dislodge material in fine particles onto the floor of the tunnel at one of the side walls thereof at one side of said cutter-head, and means for effecting the transfer of the dislodged material from the floor of the mine chamber automatically onto said conveyor.

95. A tunneling machine comprising a frame, a cutter-head carried at the forward portion of said frame for rotation on an upright axis, cutting tools movably mounted on said cutter-head and arranged to travel over the surface upon which cuttings are deposited by said cutter head and to move said cuttings along said surface, a conveyor having a portion thereof located adjacent said cutter-head, and means for directing the cutting tools upwardly relatively to the cutter-head while at the same time directing the cuttings onto said conveyor.

96. In a tunneling machine, the combination with a rotatable cutter frame, of cutting tools mounted thereon for adjustment relatively thereto longitudinally thereof into position to engage the cuttings produced thereby, a conveyor having a portion thereof located adjacent the paths of travel of said cutting tools where the latter engage the cuttings, and means for causing the cuttings to be deposited on said conveyor.

97. In a tunneling machine, a cutter head, vertically sliding tools mounted on said cutter head and arranged to travel adjacent the surface on which cuttings from said cutting head are deposited, means for moving said tools upwardly away from said surface at a given position in the travel thereof, an inclined platform located at said position for receiving the cuttings moved by said cutter, and a conveyor for receiving the cuttings from said platform.

98. A tunneling machine comprising a supporting frame, spaced-apart abutments adapted to be anchored between the floor and roof of the mine chamber, spaced-apart hydraulic motors respectively connected between said spaced-apart abutments and said

frame, and means for operating said hydraulic motors alternately to permit shifting of the abutments alternately so that the tunneling machine may be moved forward continuously.

99. A tunneling machine comprising a supporting frame, a pair of anchorage devices between the floor and roof of the tunnel, and alternately operating hydraulic motors respectively engaging said anchorage devices and act thereon alternately for effecting the continuous forward rectilinear movement of said supporting frame.

100. The combination with a tunneling machine, of a multiple anchorage adapted to engage opposite faces of a mine chamber along straight and parallel axes, connections between said multiple anchorage and said tunneling machine for effecting advance of the latter away from said anchorage, and means for effecting the selective control of said multiple anchorage to secure operation of portions of said multiple anchorage intermittently and alternately.

101. In a tunneling machine, the combination with a supporting frame, of cutting mechanism mounted thereon, means for operating said cutting mechanism, a plurality of hydraulic motors comprising cylinders on said frames, pistons and piston rods, a plurality of upright hydraulic roof jacks connected respectively to said piston rods and each movable over the mine floor when released, and connections for effecting the operation of the roof jacks to anchored position when said cylinders receive pressure to effect forward movement of the said frame and cutting mechanism.

102. In combination, a tunneling machine, a plurality of alternately operable hydraulic cylinders for advancing said tunneling machine, hydraulic props for each of said cylinders arranged to form anchors therefor, and a connection between each of said cylinders and its corresponding props to cause pressure to be exerted by said prop during the operation of the corresponding cylinder.

103. A tunneling machine comprising a frame adapted to rest on the flat floor of a mine, said frame having a joint therein, cutting apparatus mounted on the forward end of said frame, means for driving said cutting apparatus, means for exerting pressure on one portion of said frame to advance the machine over such flat floor to effect feeding of said cutting apparatus, means for shifting another portion of said frame laterally, and guide shoes on said shifting means to engage the side walls to guide the machine when fed forward.

104. A tunneling machine comprising a frame having a rear portion and a forward portion connected by a pivotal joint, each

of said frames being flat on the bottom for movement over the floor of the mine chamber, means for exerting pressure on the rear portion of said frame for advancing the tunneling machine as a whole, and means for shifting the forward portion about said pivotal joint for guiding said tunneling machine while being moved over such flat floor.

105. A tunneling machine comprising a frame having a joint therein on an upright axis, means for exerting pressure on the rear portion of said frame to advance said machine, and means for shifting the forward portion of said frame laterally to guide the said machine as to its direction of advance.

106. A tunneling machine comprising a frame having a rear portion and a forward portion connected by a pivotal joint on an upright axis, means for exerting pressure on the rear portion of said frame for advancing said tunneling machine, and means for shifting the forward portion of said frame about said upright pivot for varying the direction of advancing movement of said tunneling machine.

107. In a tunneling machine, the combination with supporting framework, of cutting apparatus mounted at one end of said framework, means for effecting arcuate cutting movement of said cutting apparatus across the mine wall, vertical anchoring mechanism at the rear of said framework, means connected between said anchoring mechanism and said framework for advancing the latter together with said cutting apparatus, and devices extending laterally from the forward portion of said framework near said cutting apparatus for guiding the advance movements of said framework and resisting twisting strains on said framework due to the arcuate cutting of said cutting apparatus.

108. In a mining machine, the combination with supporting framework flat on the bottom to adapt the same to slide over the floor of a mine chamber, of cutting apparatus mounted on the forward end of said framework, guiding devices extending laterally from the forward portion of said framework near said cutting apparatus in position to engage the side walls of the mine chambers as said flat bottom is slid over the mine floor, means for operating said guiding devices for shifting the forward portion of said framework together with said cutting apparatus laterally, and means for operating said cutting apparatus including the feeding movement thereof by the advance of said framework along the floor of the mine chamber while said guiding devices engage the lateral walls of the mine chamber and guide the feeding movement of the cutting apparatus along a predetermined path of travel.

109. In a tunneling machine, the combination with supporting framework, of cutting

apparatus mounted on the forward end thereof, a supplemental frame pivoted to the rear end of said framework, means for anchoring said supplemental frame, means mounted on the forward portion of said framework in position to engage the lateral walls of the tunnel to shift the framework laterally on its pivotal connection with said supplemental frame, and means for operating said cutting apparatus including the feed thereof.

110. In a tunneling machine, the combination with a supporting frame, means for pivotally holding the rear portion of said frame, cutting apparatus mounted on the forward portion of said frame, mechanism mounted on the forward portion of said frame in position for engaging the side walls of the tunnel to move the forward portion of the frame and the cutting apparatus laterally on its rear pivot, and means for operating said cutting apparatus including the feed thereof.

111. In a tunneling machine, the combination with a supporting frame, of means for pivotally holding the rear end of said frame, a pair of fluid operated motors mounted on the forward portion of said frame one extending from one side thereof and the other extending from the other side thereof in position to engage the side walls of the tunnel, cutting apparatus mounted on the forward end of said supporting frame, and means for effecting the independent operation of said fluid operated motors to shift the forward portion of said frame and said cutting apparatus laterally on the pivot at the rear end of said frame.

112. In a tunneling machine, the combination with a supporting frame, of a supplemental frame pivotally connected to the rear end thereof, cutting apparatus mounted on the forward end of said supporting frame, means for actuating said cutting apparatus, wall jacks extending laterally from the forward portion of said supporting frame in position for engaging the side walls of the tunnel to shift the cutting apparatus and the forward portion of said supporting frame laterally in either direction on the pivotal connection between said supporting frame and said supplemental frame, said wall jacks being also adapted to engage the side walls to guide the movement of the tunneling machine along the tunnel, multiple anchorage mechanism, and motor mechanism connected between said multiple anchorage mechanism and said supplemental frame for advancing said supporting frame and said cutting apparatus along the tunnel to secure feeding movement of the cutting apparatus during the actuation thereof.

113. A mining and loading machine comprising a supporting frame, of a single drum having a diameter approximately

equal to the width of the chamber to be cut in a mine vein and mounted on said supporting frame for rotation on an upright axis, a multiplicity of cutters mounted on the exterior surface of said drum in position to dislodge in small particles the mass of material from the entire arcuate space between a flat floor and a flat roof onto the floor at one side of the mine chamber, conveyor mechanism extending from the forward portion of said supporting frame at one side of the latter near said conveyor mechanism longitudinally along said frame to the rear thereof, and a chute for directing the dislodged small particles of material from the floor to said conveyor mechanism.

114. A mining and loading machine comprising a supporting frame, mechanism for dislodging material from a mine vein toward the forward end of said supporting frame at one side of the latter, said dislodging mechanism comprising upwardly movable cutter frames, loading apparatus mounted on said frame and extending to a position at one side thereof adjacent said dislodging mechanism, and means co-acting with said upwardly movable cutter frames for transferring dislodged material from the floor at the base of the mine wall onto said loading apparatus.

115. In a tunneling machine, the combination with a supporting frame, of a cutter-head mounted thereon, a cutter carried on the periphery of said cutter-head and movable longitudinally relative thereto, means for operating said cutter including feeding movement of said cutter-head to cause said cutter to form a tunnel in a mass of material, and means for sliding said cutter longitudinally of said cutter-head and beyond one end thereof to cause said cutter to remove material to provide clearance for advance of the entire machine.

116. In a tunneling machine, the combination with a cutter-head, of cutters mounted on the periphery thereof, means for operating said cutters to dislodge material to be excavated, and means for sliding said cutters longitudinally on said cutter-head to cause said cutters to project beyond the ends of said cutter-head.

117. In a tunneling machine, the combination with a supporting frame, of a cutter-head mounted thereon, a cutter mounted on the periphery of said cutter-head and slidable longitudinally thereof, means for operating said cutter, means for sliding said cutter beyond one end of said cutter-head during a portion of the rotation thereof to cause removal of the material in the path of said frame, and means for retracting said cutter relatively to said cutter-head to permit said cutter to pass along a portion of said frame.

118. In a tunneling machine, the combination with a supporting frame, of a rotary

cutter-head mounted thereon, a plurality of spaced apart cutters mounted in fixed position on the periphery of said cutter-head, intermediate spaced apart supplementary cutters mounted on said cutter-head and slidable longitudinally thereof, means for supporting said supplementary cutters beyond the ends of said cutter-head during a portion of the rotation of said cutter-head to cause said cutters to dislodge material in advance of said frame, and means for retracting said cutters during another portion of the rotation of said cutter-head.

119. In a tunneling machine, the combination with a supporting frame, of a rotary cutter-head mounted thereon, vertically sliding cutting tools mounted on the periphery of said cutter-head, a conveyor mounted on said frame, and an inclined chute in position to direct the cutting tools upwardly along said cutter-head while said cutting tools engage the cuttings and move the latter along said chute onto said conveyor.

120. In a tunneling machine, the combination with a cutter-head, of a multiple cutting tool mounted thereon in position to cut material in parallel planes, and means for automatically shifting the multiple cutting tool to different planes of operation relatively to each other while maintaining the same in substantially parallel planes.

121. In a tunneling machine, the combination with a supporting frame, of a cutter-head pivotally mounted on said supporting frame, a cutter slidably mounted on said cutter-head, means for effecting sliding movement of said cutter along said cutter-head in a predetermined relation to the rotation of said cutter-head, and means for operating said cutter including the feed thereof to cut a tunnel having plane walls.

122. In a tunneling machine, the combination of a cutter-carrier, a cutter slidable along said carrier, means for sliding said cutter along said cutter-carrier, a frame for pivotally supporting said cutter-carrier, and means for operating said cutter to cut in parallel planes substantially perpendicular to the axis of rotation of said cutter-carrier.

123. In a tunneling machine, the combination with a supporting frame, of hydraulic mechanism for anchoring said frame, cutting apparatus mounted on said frame for movement in a horizontal arc from one side of a mine chamber to the other and adapted to be advanced with said supporting frame into positions for new cuts, means for operating said cutting apparatus to cut across the face of the tunnel heading and cause the cuttings to be deposited at a side wall, and means connected between said supporting frame and said hydraulic mechanism for advancing said frame and said cutting apparatus over the flat floor of the tunnel.

124. In a tunneling machine, the combination with a supporting frame, of a rotary

- nation with a frame having a bifurcated extension at its forward end, a vertical post fixed to the said bifurcated extension, a rotary drum pivoted on said post, a plurality of spaced apart cutters slidably mounted on the periphery of said drum, hydraulic motors for sliding said cutters longitudinally beyond the ends of said drum, a cam within said drum fixed to said post, and means operated by said cam to automatically control the operation of said motors to slide said cutters back and forth along said drum in timed relation to the passage of said cutters through said bifurcated extension.
125. In a tunneling machine, the combination with a frame, of a vertical bearing secured to the forward end thereof, a hollow drum mounted on said fixed vertical bearing for rotary movement on the upright axis of said bearing, a cam within said drum and fixed to said bearing, cutters mounted on the periphery of said drum and slidable beyond the ends thereof, motors for sliding said cutters beyond the ends of said drum and retracting said cutters for passage along said frame, and means operated by said cam for automatically controlling said motors to prevent said cutters from interfering with the rotation of said drum, and causing said cutters to be extended beyond the ends of said drum to cut a tunnel with sufficient clearance for free advance movement of said supporting frame.
126. In a tunneling machine, the combination with a supporting frame having a forked extension, of a rotary cutting mechanism comprising a multiplicity of cutters operating in juxtaposed planes extending entirely across the working face of a tunnel from the floor to the roof thereof, said rotary cutting mechanism being journaled between the forks of said extension, and means for operating said cutting mechanism including continuous rotation thereof to cut a tunnel providing ample clearance for continued advance of the entire machine including said frame, said forks and said cutting mechanism.
127. A tunneling machine comprising a cutter carrier with cutters thereon, a drum for supporting said cutter carrier in operative position, and means for moving said cutter carrier rectilinearly to project the same beyond one end of said drum.
128. In a tunneling machine, the combination with a cutter head, of a plurality of elongated tool holders carried by said cutter head for movement relatively thereto transversely of the direction of feed of said cutter head into position to cut a tunnel having spaced-apart upright approximately flat walls, a multiplicity of tools mounted on each elongated tool holder in rectangular alignment with each other, means for moving the tool holders relatively to said cutter head transversely of such direction of feed to adjust the cross-sectional area of the tunnel to be excavated, and means for operating said cutter head to drive such tunnel.
129. In a tunneling machine, the combination with a cutter head, of spaced-apart elongated tool holders mounted on said cutter head in spaced-apart relation to each other in position to cut a tunnel leaving a flat roof, a flat floor and spaced-apart upright flat walls, a multiplicity of cutting tools mounted on each of said elongated tool holders, means for operating said cutting tools to dislodge material from the mine head, and means for adjusting the tool holders longitudinally on said cutter head to cause said cutting tools to project beyond the ends of said cutter head and thereby adjust the cross-sectional area of the tunnel to be cut.
130. In a tunneling machine, the combination with a cutter-carrier, of an elongated cutter bar, a plurality of closely spaced cutters on said bar, means for adjusting said bar along said heading, a frame for supporting said carrier, and means for operating said cutters to cut in parallel planes substantially perpendicular to the axis of movement of said cutter-carrier.
131. In a tunneling machine, the combination with a cutter-head, of cutter-frames, guideways between said cutter-frames and said cutter-head, a plurality of cutters on each of said frames arranged in series parallel to the adjacent guideways, and means for moving said cutter-frames together with said cutters along said guideways.
132. In a mining machine, the combination with a cutter head, of an elongated tool holder slidably connected to said cutter head for adjustment in an upright direction transversely of the direction of feed of said cutter head, and self-acting power-operated mechanism for sliding said tool along said cutter head transversely of the direction of feed.
133. In a mining machine, the combination with a cutter-head, of a supporting frame on which said cutter-head is mounted for rotation, tool holders mounted on said cutter-head for movement relatively thereto parallel to the axis of rotation of said cutter-head, and self-acting power-operated mechanism for adjusting said tool holders by moving the same relatively to said cutter-head parallel to the axis of rotation thereof.
134. In a tunneling machine, the combination with a cutter-head, of a supporting frame on which said cutter-head is mounted for rotation on an upright axis, elongated tool holders mounted on said cutter-head for adjustment relative thereto in an upright direction to adjust the height of the excavation at the upright tunnel heading, a multiplicity of closely adjacent cutters

mounted on said tool holders in position to dislodge the material at the heading in small particles to excavate over the entire area of the mine heading, and means for moving the tool holders with the cutters thereon relatively to said cutter-head to secure such adjustment of said cutters.

135. In a tunneling machine, the combination with a supporting frame, of a cutter-head mounted thereon for rotation on an upright axis, upright guideways on said cutter-head, a pair of tool-holders mounted in said guideways in spaced-apart positions, means for moving said tool holders in opposite directions along said guideways, tools carried by said tool holders, and means for rotating said cutter-head on said upright axis relatively to said supporting frame while said tool holders remain in upright position during such rotation of said cutter-head.

136. In a tunneling machine, the combination with a cutter-head having a guideway on the periphery thereof, of a frame mounted for movement along said guideway, a multiple tool-holder removably carried by said frame, means for moving said frame together with said multiple tool holder along said guideway to adjust the position of said multiple tool holder relative to said cutter-head, and means for moving said cutter-head to effect feeding of said multiple tool holder transversely of said slideway.

137. In a tunneling machine, the combination with a supporting frame, of a cutter-carrier mounted thereon, elongated cutting tools movably mounted on said cutter-carrier, actuating mechanism for moving said cutting tools relatively to said cutter-carrier, and means for automatically controlling said actuating mechanism to cause said elongated tools to move intermittently beyond the ends of said cutter-carrier in timed relation with the movement of said cutter-carrier.

138. In a tunneling machine, the combination with a supporting frame, of a cutter-head comprising a drum mounted on said frame to rotate on an upright axis, a series of elongated cutter holders spaced apart circumferentially on the surface of said drum, and mounted thereon to extend in upright directions, a plurality of cutters mounted on each of said cutter holders in position to dislodge the material from a mine heading in small particles, means for driving the cutters by rotating the drum, means for advancing said frame together with said cutter-head and said cutters to effect the feed of the latter, and means for automatically supplying a cooling fluid to said cutters during the rotation of said drum.

139. In a tunneling machine, the combination with a bodily movable frame, of a rotary frame mounted on the forward end

of said first-named frame, cutting apparatus carried by said rotary frame, means for automatically moving the cutting apparatus beyond the ends of said rotary frame during predetermined portions of the rotation thereof to dislodge material from a tunnel-heading and thereby provide sufficient space for the advance of said frames, means for rotating said rotary frame to actuate said cutting apparatus, and means for advancing said movable frame to effect feeding of said cutting apparatus.

140. In a tunneling machine, the combination with a bodily movable frame, of a cutter-carrier mounted on the forward end of said frame to rotate on an upright axis, a multiplicity of cutters on said carrier in position to completely cut away a semi-cylindrical cavity in the head of the tunnel and form a flat roof and a flat floor for continuous advance of the machine therebetween, and means for operating said cutters while advancing said frame to effect the cutting of such a cavity.

141. In a tunneling machine, the combination with a supporting frame, of a cutter frame mounted on the forward end of said supporting frame to move in horizontal planes from one side of said frame to the other side thereof, a multiplicity of cutters on said cutter frame in position to cut a flat floor and a flat roof and dislodge all the material in small particles in the space between and form side walls of a gradually extended tunnel, means for operating said cutting apparatus including the feeding thereof to extend such tunnel, and means for adjusting the extent of projection of said cutters upwardly to vary the height of such flat roof.

142. In a tunneling machine, the combination with a supporting frame, of a rotary cutter frame mounted on said supporting frame on an upright axis, a multiplicity of cutters on said rotary cutter frame in position to operate in horizontal planes to cut a flat floor in a flat roof and cut the material therebetween from one side of the tunnel to the other into comparatively fine particles, means for rotating said rotary cutter frame on such upright axis together with said cutters, means for advancing said supporting frame to effect feeding of said cutters, and means for adjusting the reach of said cutters from one end of said rotary cutter frame.

143. In a mining machine, the combination with a supporting frame, of rotary cutting mechanism mounted on the forward end of said frame, means for driving said cutting mechanism, and hydraulic walking mechanism comprising upright roof jacks for moving said frame and said cutting mechanism forward gradually to effect feeding of said cutting mechanism while the

latter is being driven, said hydraulic walking mechanism being adapted to rest on the floor of the mine chamber in upright position when released.

144. In a mining machine, the combination with a narrow elongated supporting frame, of a rotary drum cutter-head mounted on the forward end of said frame to rotate relatively thereto on an upright axis, cutting mechanism mounted on said drum in position to dislodge material in advance of said cutting frame and to leave a flat floor and a flat roof between spaced-apart upright plane side walls, means for rotating said drum to effect the driving of said cutting mechanism, a plurality of upright hydraulic roof jacks each adapted to rest on the floor of the mine chamber by its own weight, and means for effecting alternate operation of said upright roof jacks and the forward gradual movement of said frame to effect feeding movement of said cutting mechanism while the latter is being driven.

145. The combination with a mining machine, of a pair of spaced-apart roof jacks, a pair of fluid pressure motors for moving said jacks toward or away from said mining machine, an intermediate roof jack, an additional fluid pressure motor for moving said intermediate roof jack to and from said mining machine, and means for controlling said fluid pressure motors to effect such alternate operation of the said additional fluid pressure motor relative to said first-named pair of fluid pressure motors.

146. A tunneling machine comprising a supporting frame, a pair of fluid pressure motor devices adapted to rest on the floor back of said frame, means for operating said fluid pressure motor devices to effect the anchoring thereof between the floor and the roof of the tunnel, mechanism connected between said devices and said frame for effecting advancing movements of the latter, and means for selectively controlling said advancing mechanism and said fluid pressure motor devices to effect alternating operation of the latter.

147. A tunneling machine comprising a supporting frame, roof jack mechanism located back of said frame between the upright planes extending through the spaced-apart sides of said frame, said roof jack mechanism being adapted to rest on a flat floor and be self-sustaining when in released position and comprising a fluid pressure cylinder with a plunger extending upwardly therefrom, and fluid pressure motor mechanism between such upright spaced-apart planes for moving said frame forward when said roof jack mechanism is anchored and for moving the latter forward to a new position when not anchored.

148. A machine for producing a tunnel having a flat floor, an abutment adapted to

rest on such floor by its own weight between spaced-apart upright planes extending through the sides of said machine, means for anchoring said abutment while located between such spaced-apart planes, and fluid pressure motor mechanism between the rear end of said machine and said abutment for moving the machine forward to effect feeding thereof when said abutment is anchored.

149. In propelling mechanism for mining machines, the combination with a supporting frame, of anchoring mechanism adapted to rest by its own weight on a flat floor and be projected against the roof of the mine chamber to form an abutment located between spaced-apart upright planes extending through the sides of the machine, powerful propelling mechanism comprising a longitudinally extending horizontal fluid pressure motor connected between the rear end of said frame and said abutment, and means connected between said motor and said anchoring mechanism to cause the latter to be anchored more firmly when said propelling mechanism meets with greater resistance in moving said frame.

150. The combination with a mining machine comprising a supporting frame, of a pair of spaced-apart anchoring devices adapted to form rigid abutments, an intermediate anchoring device to form an additional rigid abutment, a pair of spaced-apart fluid pressure motors connected respectively to said pair of anchoring devices, an additional fluid pressure motor connected to said intermediate anchoring device, and means for controlling said anchoring devices and said fluid pressure motors to effect propulsion of said mining machine by the alternate action of the fluid pressure motor connected to said intermediate anchoring device and of the fluid pressure motors connected to said pair of anchoring devices.

151. The combination with a mining machine comprising a supporting frame, of a pair of spaced-apart roof jacks, an intermediate roof jack, a pair of spaced-apart motors connected respectively to said pair of spaced-apart roof jacks, an intermediate motor connected to said intermediate roof jack, and means for controlling said motors and said roof jacks to effect the propulsion of said frame by the alternate action of the motor connected to the intermediate roof jack and of the motors connected to the said spaced-apart roof jacks.

152. In a tunneling machine, the combination with a supporting frame, of a fluid pressure operated anchoring device, fluid pressure propelling mechanism comprising a hollow piston connected to said anchoring device, a fluid passageway extending through said hollow piston from said fluid pressure propelling mechanism to said anchoring device, and means for supplying a

fluid pressure medium to said anchoring device and to said propelling mechanism simultaneously.

153. In a tunneling machine, the combination with a supporting frame, of a fluid pressure operated anchoring device adapted to form an abutment, a fluid pressure motor comprising a cylinder and a piston, an operating connection between said piston and said abutment, and means to establish direct communication between said cylinder and said fluid pressure operated anchoring device through said piston and said operating connection.

154. In a tunneling machine, the combination with a supporting frame, of a fluid pressure operated anchoring device adapted to form an abutment, a fluid pressure motor connected to said frame and comprising a piston, an operating connection between said piston and said abutment, and a fluid pressure passageway extending from said fluid pressure motor through said piston and along said connection to the fluid pressure chamber of the anchoring device.

155. In a tunneling machine, the combination with a supporting frame, of a fluid pressure operated anchoring device adapted to form an abutment, a fluid pressure motor comprising a cylinder, a piston movable in said cylinder, a piston rod connected to said anchoring device, and a fluid pressure passageway extending from said cylinder through said piston and through said piston rod to the fluid pressure chamber of said anchoring device to establish fluid pressure communication between said cylinder and the fluid pressure chamber of the anchoring device.

156. The combination with a mining machine, of multiple anchorage mechanism comprising a plurality of upright roof jacks adapted to rest on the floor of the mine chamber when in released position in readiness to be projected against the roof automatically, propelling mechanism between said roof jacks and said mining machine, and means for effecting a selective control of said roof jacks and said propelling mechanism to secure a walking action of said roof jacks and a forward movement of the mining machine step-by-step.

157. The combination with a mining machine comprising a supporting frame, of a plurality of anchoring devices adapted to be thrust against the floor and roof of a mine chamber in fixed anchored position against movement in any direction to form abutments spaced from the rear end of said frame, propelling mechanism connected to said anchoring devices and to said frame, said propelling mechanism being adapted to move said anchoring devices toward said frame when said anchoring devices are released and out of contact with the roof and

to move said frame forward when an anchoring device is in fixed position acting as an abutment, and means for controlling said propelling mechanism to effect a walking action of said anchoring devices intermittently and alternately to effect forward movement of the mining machine step by step.

158. In a mining machine, the combination with a rotary cutter carrier, of an elongated tool holder slidably mounted on said cutter carrier for adjustment relatively thereto, cutting mechanism carried by said tool holder, and self-acting power operated mechanism for sliding said tool holder along said cutter carrier to adjust the position of said tool holder and said cutting mechanism relative to said rotary carrier.

159. In a mining machine, the combination with a cutter carrier, of a tool holder adjustably mounted thereon, a fluid pressure motor for moving said tool holder relatively to said cutter carrier, said fluid pressure motor comprising a piston rod having a screw-threaded portion outside of said motor, and means between said tool holder and the screw-threaded portion of said piston rod for adjusting the extent of movement of said tool holder relative to said cutter carrier.

160. In a mining machine, the combination with a cutter carrier, of a frame for supporting said cutter carrier for rotation relatively thereto, an elongated tool holder movably mounted on said carrier for adjustment relative thereto, cutting mechanism on said tool holder, a fluid pressure motor connected to said tool holder for adjusting the position thereof relative to said cutter carrier and holding said tool holder together with said cutting mechanism in adjusted position, and means for rotating said cutter carrier to drive said cutting mechanism, and means for moving the frame to feed said cutting mechanism.

161. In a mining machine, the combination with a cutter-head, of a tool holder slidably mounted thereon, a fluid pressure motor on said cutter-head and comprising a piston rod, and means connected between said piston rod and said tool holder for adjusting the extent of movement of said tool holder relative to said cutter-head.

162. In a mining machine, the combination with a rotatable cutter-head, of a tool holder mounted thereon for adjustment relatively thereto, cutting mechanism mounted on said tool holder, a frame for supporting said cutter-head in position for said cutting mechanism to cut material away from the mine heading to leave a flat floor and flat roof, and self-acting power-operated mechanism for adjusting the position of said tool holder beyond the end of said cutter-head.

163. In a mining machine, the combination with a cutter-head, of a frame for pivotally supporting said cutter-head, cutting mechanism mounted on said cutter-head to move bodily therewith, self-acting power-operated means for adjusting the position of said cutting mechanism to vary the width of the cut made in the mine vein, and means for operating said cutting mechanism by rotating said cutter-head to effect driving and by moving said frame bodily to effect feeding.

164. In a mining machine, the combination with a cutter-head, of a plurality of cutting devices adjustably mounted thereon to extend from the ends of said cutter-head, and self-acting power-operated mechanism for projecting the cutting devices beyond the ends of said cutter-head to vary the width of the cut in a mine vein.

165. In a mining machine, the combination with a cutter-head, of cutter frames adjustably mounted on said cutter-head to extend beyond the ends thereof, cutting mechanism mounted on said cutter frames in close spaced relation to cut away all the material at the mine heading, and mechanism for projecting the cutter frames beyond the ends of said cutter-head to vary the effective cutting width across such mine heading.

166. In a mining machine, the combination with a cutter-head, of a pair of cutter frames mounted on said cutter head for adjustment relatively thereto, one cutter frame beyond one end of said cutter-head and the other cutter frame beyond the other end of said cutter-head, and means for simultaneously moving said cutter frames in opposite directions to adjust the effective cutting length of the machine.

167. In a mining machine, the combination with a supporting frame, of a rotary cutter-head mounted on the forward portion of said frame, a plurality of spaced-apart cutter frames mounted on said cutter-head for adjustment relatively thereto, some beyond one end thereof and the others beyond the other end thereof, and means for adjusting the positions of said cutter frames to vary the distance between the surfaces left at the ends of the cutter frames after cutting operations in a mine vein.

168. The combination with a tunneling machine, of a hydraulic operating anchor comprising a fluid pressure cylinder, hydraulically operating mechanism connected with said anchor for advancing said machine, said hydraulic operating mechanism comprising an additional fluid pressure cylinder with a piston movable therein, and

a tandem connection between said cylinders comprising a fluid pressure passageway extending between said cylinders through said piston to effect the flow of pressure fluid through said additional cylinder to said first-named cylinder thereby varying the pressure used to operate said anchor in accordance with the pressure for operating said advancing mechanism.

169. The combination with a tunneling machine, of a power device for advancing the machine, said power device comprising a fluid pressure cylinder with a piston therein, an anchor arranged to form an abutment for said power device, said anchor comprising an additional fluid pressure cylinder, and a connection between said cylinders extending through said piston to compel the pressure fluid to flow through the first-named cylinder to said additional cylinder to effect variation of pressure between said anchor and the support therefor in accordance with the pressure exerted by said power device.

170. The combination with a tunneling machine, of an anchor arranged to engage the floor and roof of the tunnel, said anchor comprising an upright hydraulic cylinder and a plunger movable therein, a power device for advancing said tunneling machine, said power device comprising an additional hydraulic cylinder with a piston therein, means for introducing fluid into said additional cylinder to operate said power device, and a permanent connection between said cylinders and extending through said piston to introduce liquid pressure into the upright cylinder from said additional cylinder and thereby increase the pressure exerted by said anchor on the floor and roof in accordance with the force exerted by said power device for advancing the tunneling machine.

171. In a tunneling machine, the combination with a cutter carrier, of a cutter adjustable along said carrier, means for advancing said cutter along said carrier, a supporting frame, means for supporting said carrier on said frame for pivotal movement relatively thereto, and means for operating said cutter including pivotal movement of said carrier relatively to said frame to cause said cutter to cut in parallel planes spaced between opposite walls of the tunnel at the heading thereof and substantially perpendicular to the axis of rotation of the said carrier.

In testimony whereof I have signed my name to this specification, on this 4th day of October, A. D. 1917.

EDMUND C. MORGAN.