

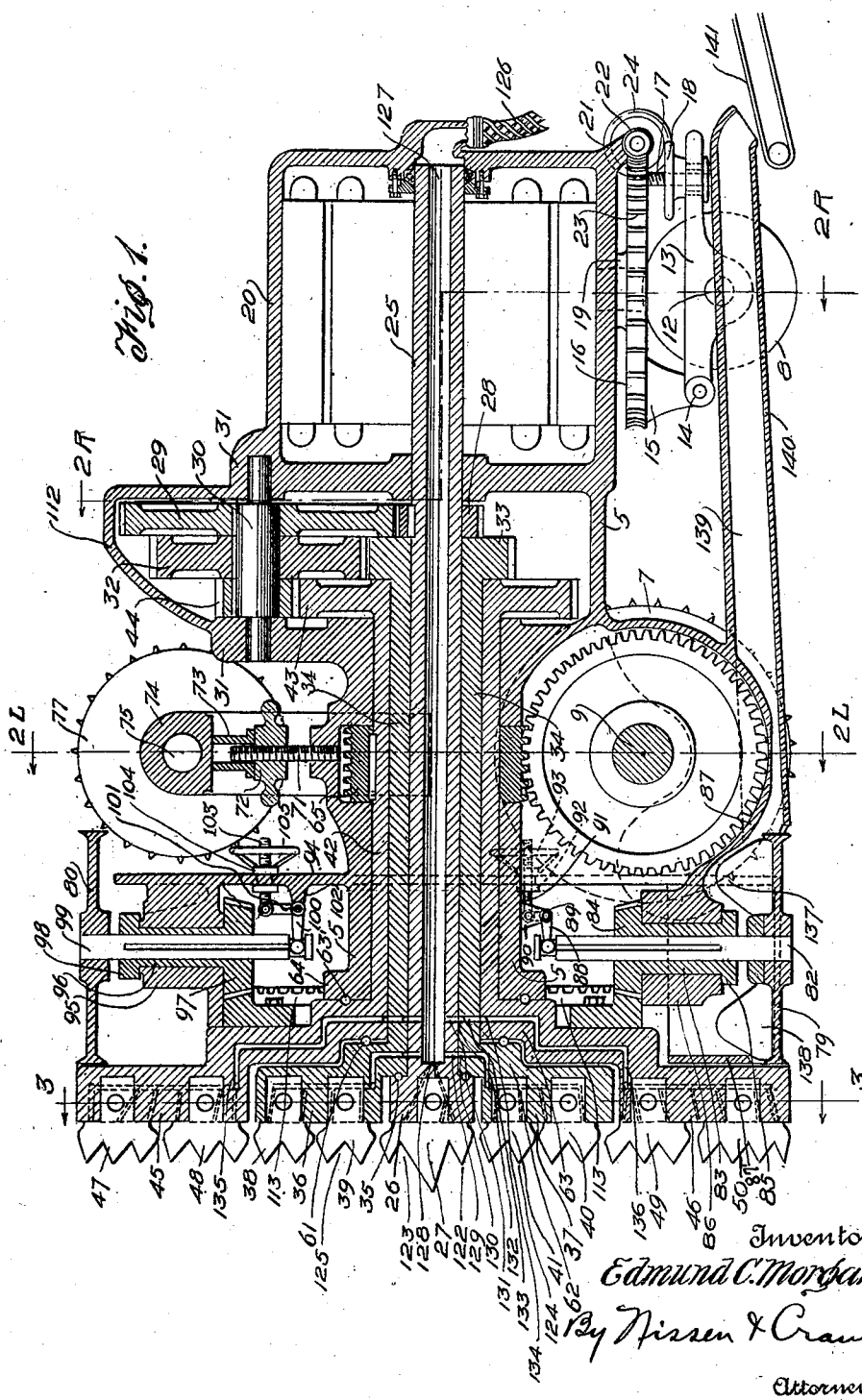
June 26, 1928.

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TUNNELING MACHINE

Filed Nov. 18, 1922

2 Sheets-Sheet 1



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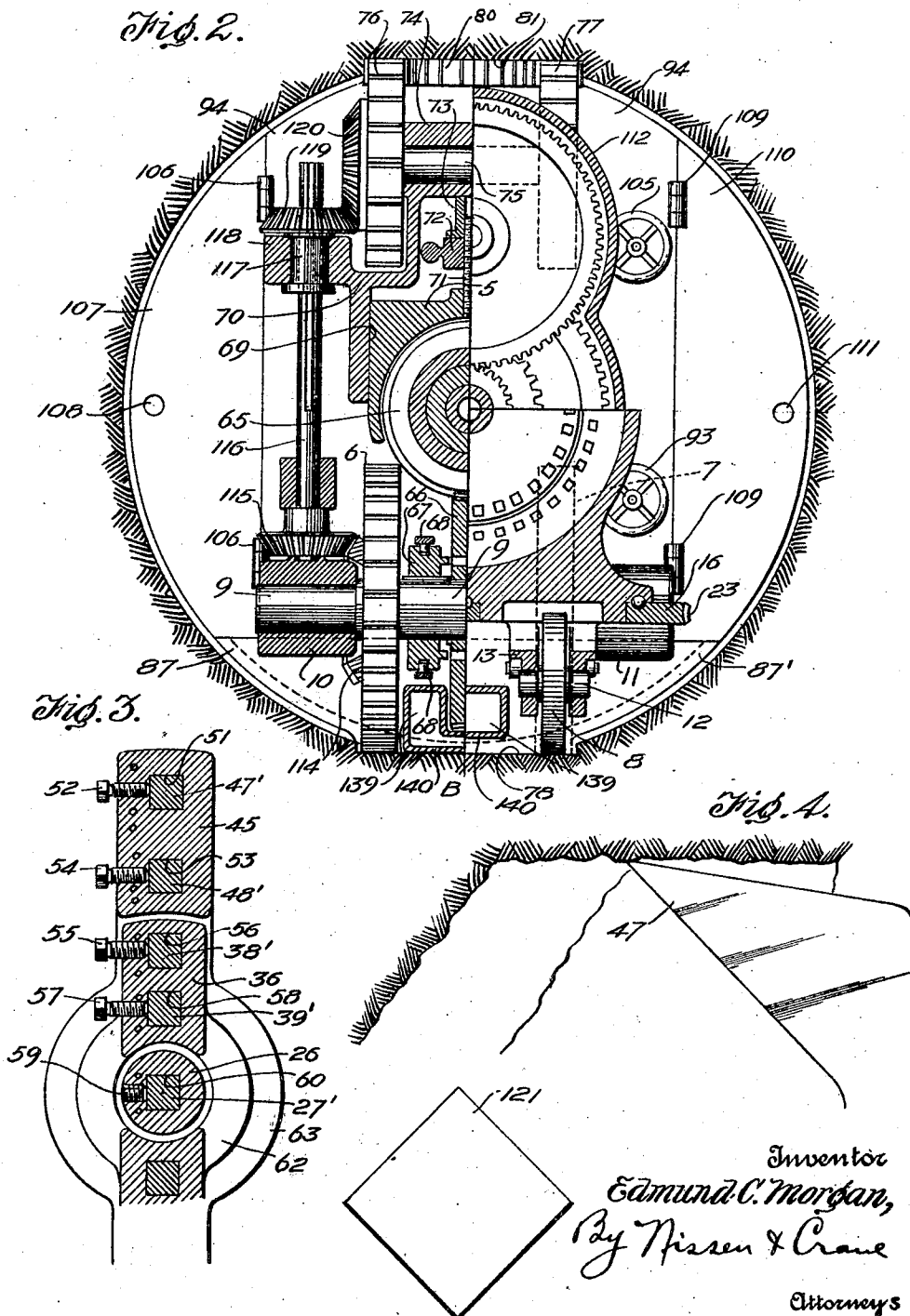
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE.

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TUNNELING MACHINE.

Application filed November 18, 1922. Serial No. 601,746.

My invention relates to tunneling machines and although it is particularly adapted for driving tunnels through rock or earth it may also be used for driving tunnels through a coal mine, particularly where entries are necessary. The invention may also have a general application.

One of the objects of my invention is the provision of improved and efficient apparatus for driving a plurality of concentrically arranged cutters at varying rates of speed, to decrease the rate of rotation of the outer cutters compared with the rate of rotation of the inner cutters.

A further object of the invention is the provision of improved and efficient feeding mechanism for a tunneling machine by providing flat paths of travel for the floor and roof feeding devices.

Another object of the invention is the provision of a series of cutters adapted to travel in spiral paths and other series of cutters following in parallel spiral paths to dislodge the material between the cutters of the first series.

A further object of the invention is the provision of improved and efficient apparatus for removing the material dislodged by spirally fed dislodging mechanism.

Another object of the invention is the provision of improved and efficient mechanism for varying the inclination laterally and vertically of a tunneling machine comprising spirally fed cutting mechanism.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

Referring to the accompanying drawings, Fig. 1 is a sectional longitudinal elevation of a tunneling machine embodying my improvements.

Fig. 2 is a view showing over its left-hand portion a sectional elevation of Fig. 1 on the line 2^L—2^L and over its right-hand portion sectional elevations on the line 2^R—2^R of Fig. 1, looking in the direction of the arrows.

Fig. 3 is a sectional elevation of part of the radial cutting mechanism taken on the line 3—3 of Fig. 1 looking in the direction of the arrows; and

Fig. 4 is a diagrammatic view illustrating the method of dislodging the material in

diamond-shaped blocks by arranging the cutters so that they will travel in parallel spiral paths.

Referring to Figs. 1 and 2, it will be seen that the main or supporting frame 5 is supported on the forward feed wheels 6, 7, and the rear steering wheel 8. The feed wheels 6 and 7 are secured to a shaft 9, which is journaled in bearings 10, 11, as shown in Fig. 2. The bearings 10 and 11 are rigidly secured to the main frame.

The rear steering wheel 8 is provided with a shaft 12 which is journaled in bearings on the pivoted frame 13. This frame 13 is pivoted at 14 to a depending bracket 15, which is secured to the bottom of the plate 16. From the bottom of the forward portion of the plate 16 extends a screw-threaded rod 17 on which is threaded wheel 18 mounted in an opening at the forward portion of the bearing block 13. The screw-threaded rod 17 is secured rigidly to the plate 16. Therefore, by turning the wheel 18, the frame 5 may be tilted up or down on the axis of the shaft 9.

The plate 16 has a pivotal or swivel connection at 19 to the bottom of the frame 5 under the motor 20. Extending from the rear lower portion of the motor frame is a bracket 21 for carrying a worm 22 which meshes with the worm gear 23 on the periphery of the circular plate 16. By means of a wheel 24 secured to the worm 22, the latter may be rotated so as to rotate the plate 16 on the pivot 19 and thereby turn the wheel 8 to the right or to the left according to the desired change of the path of travel of the tunneling machine. It will thus be seen that by means of the foregoing construction, the direction of feeding travel of the tunneling machine may be varied laterally. By tilting the main frame 5 up or down by turning the wheel 18, the direction of the feeding travel of the tunneling machine may be varied in inclination upwardly or downwardly.

The motor 20 is preferably an electric motor which may be started, stopped, reversed and controlled in speed in a well known manner. The frame of the motor 20 is rigidly connected to the main or supporting frame 5 and the motor armature shaft 25 is extended longitudinally forward

along the machine to the cutter holder 26 in which is mounted the central cutter 27. Forwardly of the frame of the motor 20 is a pinion 28 keyed to the motor armature shaft 25. This pinion 28 meshes with a large gear 29, which is keyed to a shaft 30 journaled in bearings 31, 31, on the main frame 5. Also keyed to the shaft 30 is a gear 32 which is less in diameter than the gear 29 and meshes with a gear 33 which is concentric with the gear 28, but mounted loosely on the motor shaft 25. To the gear 33 is connected a sleeve 34, which extends forwardly longitudinally of the machine to fit over the motor shaft extension and rotates loosely thereon. The forward end of the sleeve 34 engages an annular shoulder at the rear of cutter head 26; and ball bearings as indicated diagrammatically at 35, may be provided between such annular shoulder and the forward end of the sleeve 34.

Mounted on the forward end of the sleeve 34 are two diametrically opposite cutter carriers 36 and 37, each provided with two sockets for carrying double cutters. The cutter carrier 36 carries the double cutters 38 and 39 and the cutter carrier 37 carries the double cutters 40 and 41.

Mounted on the outside of the sleeve 34 is another sleeve 42, the rear end of which carries a gear wheel 43 meshing with the gear 44, which is considerably less in diameter than the gear 32. It should be noted that gear 44, as well as the gears 32 and 29, is keyed to the shaft 30.

The forward end of the sleeve 42 carries the cutter carriers 45 and 46. The cutter carrier 45 is provided with two sockets for receiving the three-pointed cutter 47 and also the three-pointed cutter 48. The cutter carrier 46 is provided with a socket for receiving the three-pointed cutter 49, and also with a socket for carrying the four-pointed cutter 50. By referring to Fig. 3, it will be seen that the various sockets for receiving the cutter shanks are each square in cross-section, and each cutter shank is held in its socket by means of a set screw. For instance the socket 51 is adapted to receive the shank 47' of the cutter 47, and the set screw 52 may be relied upon to hold the cutter 47 so that its three teeth will remain in a series extending radially from the motor shaft. In like manner, the socket 53 receives the shank 48' of the cutter 48, and the latter may be held with its three teeth in series radial position by means of the set screw 54. The set screw 55 is adapted to hold the shank 38' in the socket 56 in the carrier 36. The set screw 57 is adapted to hold the shank 39' in the socket 58. A set screw 59 may be used to hold the shank 27' in the socket 60 of the carrier 26. In the same manner the shanks of the cutters 40, 41, 49 and 50 may be held in position in the

carriers so that the whole series of cutters will extend diametrically, as illustrated in Fig. 1.

The forward end of the sleeve 42 is provided with a ball-bearing engagement, as shown diagrammatically at 61, with an annular shoulder 62 connected to the sleeve 34. There is also a ball bearing connection illustrated diagrammatically at 63', between the annular ring 63 and the collar 64 on the main frame 5.

Now, upon rotation of the motor-shaft 25, the cutter 27 will be rotated at the same speed as that of the motor shaft. The pinion 28 will operate the gears 29, 32 and 33 to rotate the sleeve 34 on the shaft 25, but at a lower rate of speed. The cutters 38, 39, 40 and 41 will be rotated as a unit on the carrier 36 and 37, but at a slower speed than the rate of rotation of the cutter 27.

When the gear 29 is rotated by the pinion 28, the gear 44 will be rotated to impart rotation to the gear 43 and the sleeve 42. It will be noted, however, that by reason of the pinion 44 being considerably smaller than both of the gears 29 and 43, the sleeve 42 will be rotated even more slowly than the sleeve 34. The cutters 47, 48, 49 and 50 being mounted on carriers 45 and 46, which are rigidly connected to the sleeve 42, will be moved along circular paths but at a slower rate of rotation than the other cutters. The farther the cutters are away from the axis of the motor shaft, the farther they have to travel during each rotation of the motor shaft and of the sleeves mounted thereon. For instance, when the sleeve 42 makes one rotation, the cutters 47, 48, 49 and 50 travel along a larger circle than the cutters 38, 39, 40 and 41 travel when the sleeve 34 makes a single rotation.

By designing the machine so that the cutter 27 will have the proper rate of rotation; and proper rate of feed to bore into the center of the tunnel head and dislodge the material therefrom, the tendency of the outer radial cutters would be to travel so fast as to dislodge material from the tunnel heading in very small particles. By slowing down the rate of speed of rotation of the outer cutters successively, the material will be dislodged in larger pieces, which is particularly desirable when the tunneling machine is used to drive entries through coal veins. The rate of feeding movement is the same for all of the cutters as will appear more fully hereinafter. When the machine is fed forward and the outer cutter carriers 45 and 46 are rotated once, the cutters on these cutter carriers will be given spiral paths extending a predetermined depth into the tunnel heading. During such rotation of the carriers 45 and 46, the carriers 36 and 37 may rotate several times, and thus cause the cutters carried thereby to travel along

spiral paths having several convolutions extending into the mine heading to the same predetermined depth to which the cutters on the carriers 45 and 46 extend. Furthermore, the outer cutters on the carrier 26 may make several more rotations than the carriers 36 and 37 along spiral paths of many more convolutions extending into the mine heading to the same predetermined depth.

It is desirable with respect to economy and power and the saving of time to have the cutters make definite cuts at such depths and such rates of feeding movements as that to which they are adapted. Preferably the material is cut from the mine heading in diamond-shaped blocks, as shown at 121 in Fig. 4. All of the cutters operate in the same plane, as shown in Fig. 1, and the forward feed of all of the cutters along the axis of the machine is at the same rate of speed. The central cutter operates the fastest and completes its cut first, which is immediately followed by the completion of the ring cut of the cutters 38 and 39, and finally the outermost cutters 47 and 48 complete their cuts. These cutting movements are all in the same direction and there is a continuous and gradual progression from the center of a tunnel heading outwardly; the central cuts facilitate the outer cuts and all of the cuts are made spirally when feeding movement of the machine along the tunnel takes place. It can readily be seen that the central cuts facilitate the outer cuts when it is considered that the cutting away of the material centrally permits the surrounding material to be broken away and expanded into the opening left by the central cuts.

In order to effect feeding of the cutting mechanism into the tunnel heading, a worm 65 is keyed to the sleeve 42 in position to mesh with the worm gear 66 mounted loosely on the shaft 9. A clutch element 67 is splined to the shaft 9 and may be moved by the mechanism indicated at 68, 68, so as to effect driving engagement between the worm gear 66 and the shaft 9. When the motor 20 is operated to drive the shaft 25 and the sleeve 34 and 42 to rotate the various cutters on the axis of the motor shaft, the worm 65 will also be rotated, and since this worm meshes with the worm gear 66, power will be transmitted to the shaft 9 when the clutch 67 has been thrown in. When the shaft 9 is rotated in the proper direction, the traction wheels 6 and 7 will be rotated slowly to feed the whole machine toward the tunnel heading while the cutters are being rotated. The shape of the cutters being as indicated at 47 in Fig. 4, it is necessary to secure proper rotation of the motor shaft and of the sleeves 34 and 42 to drive the cutters so that the points thereof will be in advanced positions. It will be seen by referring to Fig. 1 that when the motor

shaft is rotated in a certain direction, the sleeves 34 and 42 will be rotated in the same direction. The electric motor 20 can easily be reversed to secure reversed rotation of the traction wheels 6 and 7 to effect retraction of the tunneling machine from the tunnel heading, but when the cutters are rotated in proper direction to effect cutting, the gearing connected to the traction wheels 6 and 7 is such as to effect forward feeding of the machine toward the tunnel heading because, whenever the cutters are rotated and the clutch 67 has been thrown in, the traction wheels 6 and 7 will also be rotated.

Fitting over lateral spaced apart vertical faces 69 of the upper portion of the frame 5 is a supplemental frame 70 which is adjustable in elevation relative to the frame 5. Secured to the central portion of the frame 5 is a vertical screw-threaded rod 71 on which is screw-threaded a wheel nut 72, on which is supported the tube 73 for carrying the transverse bearing 74, which is mounted on the upper portion of the supplemental frame 70, as shown in Fig. 2.

A transverse shaft 75 is mounted in the journal bearing 74 and carries at its ends the traction wheels 76 and 77 in position to engage the roof of the tunnel so as to cooperate with the floor traction wheels 6 and 7 to hold the machine upright and guide it for feeding purposes. By means of the wheel 72 the traction wheels 76 and 77 may be lifted or lowered whenever desired. During the feeding of the cutting mechanism the traction wheels should firmly grip the floor and roof and by adjusting the wheel 72 such traction along both the floor and the roof may be regulated.

In order to form plane surfaces for the traction wheels to travel along, cutters are provided in advance of the traction wheels both at the floor and at the roof. The cutter for producing the plane surface 78 along the floor is indicated at 79 in Fig. 1, and is there shown in the form of a rotary disk cutter. A similar cutter 80 is mounted at the upper portion of the machine in position to cut the plane surface 81 along the roof. The rotary cutter 79 is of sufficient diameter to cut a plane surface 78 of a width somewhat greater than the distance between the outer edges of the traction wheels 6 and 7. The rotary cutter 80 is of sufficient diameter to cut a plane path for the traction wheels 76 and 77 of a width somewhat larger than the distance between the lateral edges of these traction wheels, as shown in Fig. 2.

The rotary cutter 79 is carried at the lower end of the vertical shaft 82 which is splined to a bushing 83 having the gear 84 at its upper end and the collar 85 at its lower end. The bushing 83 is journaled in

the bearing 86 which is rigidly secured to the frame 5 by means of the housing 87. The bevel gear 84 and the collar 85 fit against opposite ends of the bearing 86 and the gear 84 is therefore locked in predetermined position relative to the frame 5 for rotation on a vertical axis, so as to impart rotation to the cutter 79.

The shaft 82 being splined to the bushing 83 and the gear 84, is adjustable in elevation. Pivotally connected to the upper end of the shaft 82 is a bell crank lever 88, which in turn is pivoted at 89 to the bracket 90 depending from the frame 5. Connected to the bell crank lever 88 is a screw-threaded rod 91 which passes through another bracket 92 and has threaded thereon the wheel 93. By operating the wheel 93, the shaft 82 may be lifted or lowered to adjust the elevation of the floor cutter 79.

Extending upwardly from the upper portion of the frame 5 is a standard 94 carrying at its upper end the bearing 95 in which is journaled the bushing 96 having the bevel gear 97 at its lower end and the collar 98 at its upper end. The collar 98 and the gear 97 fit against opposite ends of the bearing 95 to lock the gear 97 in predetermined position for rotation on an upright axis. Splined in the bushing 96 so as to be capable of sliding longitudinally therein is a vertical shaft 99 to the upper end of which is secured the horizontal rotary roof cutter 80.

Pivotally connected to the lower end of the shaft 99 is a bell-crank lever 100, which in turn is pivotally connected at 101 to the bracket 102, extending forwardly from the standard 94. Connected to the bell-crank lever 100 is a screw-threaded rod 103 threaded through a nut 104 journaled in the standard 94 and provided with a wheel 105 for operating the same. By turning this wheel 105, the shaft 99 may be lifted or lowered to adjust the elevation of the roof cutter 80.

As shown in Fig. 2, the standard 94, which is rigidly connected to the frame 5, may be extended upwardly and laterally to form part of a partition to enclose the space where the cutting operations are taking place. Hinged at 106, 106, at one side of the plate 94, is a door 107 provided with a knob 108, which may be connected to suitable latch mechanism on the laterally extending housing 87. On the opposite side of the plate 94 is hinged at 109, 109 another door 110 provided with a knob 111 connected to suitable latch mechanism on the housing 87.

It should be noted that the gearing for rotating the sleeves 34 and 42 is entirely enclosed by the housing shown at 112 in Figs. 1 and 2. The worm gearing 65, 66 is also enclosed by the housing 87. In like manner the bevel gears 84 and 97 are entirely enclosed and so, also, the annular

bevel gear 113, which is secured to the sleeve 42 to rotate with latter and drive the bevel gears 84 and 97, and therefore simultaneously rotate the floor and roof cutters 79 and 80.

It should be noted by referring to Fig. 2, that not only are the traction wheels 6 and 7 positively driven when the clutch 67 is thrown in, but the roof traction wheels 76 and 77 are also positively driven by gearing intermediate the traction wheel 6 and the traction wheel 76. The traction wheel 6 is provided with the bevel gear 114 which surrounds the inner end of the journal bearing 10 and meshes with the bevel gear 115, which is secured to the lower end of the vertical shaft 116. The shaft 116 is splined to a collared bushing 117 journaled in the bearing 118, which is secured to the supplemental frame 70. The bushing 117 carries a bevel gear 119, which meshes with a bevel gear 120 secured to the shaft 75. By reason of the shaft 116 being splined to the collared bushing 117, the supplemental frame 70 may be adjusted in elevation to adjust the elevation of the traction wheels 76 and 77, without interrupting the positive driving connection between the traction wheel 6 and the shaft 75. It will thus be seen that when the traction wheels 6 and 7 are positively driven by the worm gearing 65, 66, the traction wheel 76 and 77 are at the same time positively driven so as to secure longitudinal feeding movement of the machine along parallel lines without any tendency of the machine to tilt up or down, notwithstanding the fact that the length of this type of machine is comparatively short. It should also be noted that by reason of the angular notches produced by cutting the upper and lower plane surfaces, the entire machine is maintained in its upright position illustrated in Fig. 2, because twisting strains caused by the cutting operation on the main frame will be effectually resisted by the traction wheels traveling along the flat surfaces and limited in their lateral positions by the vertical faces at the angular notches, which assist as serving as guideways. However, the steering wheel 8 may be relied upon to direct the machine along the desired path of travel, but in any event, if there is any lateral slip of the traction wheels, the angular notches or guideways along the floor and roof will limit such lateral slip and assist the traction wheels in affording the proper abutment for the cutters to operate against.

The pointed cutters considered individually are arranged to cut successively along different adjacent paths so as to cut out diamond shaped blocks of material as shown at 121 in Fig. 4. This arrangement is desired in order to secure the dislodgment of larger blocks of material, particularly when the machine is operated to mine coal. By

referring to Fig. 1, it will be seen that the cutter 27 is provided with three points, the central one of which is on the axial line of the shaft 25, but the point 122 will cut along the space over which the recess 123 travels. In a similar manner the point 124 will cut along the path left by the space designated 125 between the points of the cutter 39. In fact the cutters and the spaces between the next adjacent points will alternate radially and diametrically so that the material left between annular grooves will be engaged by the next pointed cutter that comes along with the result of dislodging the material in diamond shaped form as illustrated at 121 in Fig. 4. The blocks of coal thus dislodged will be of regular and uniform shape, as compared with an arrangement where the cutters on opposite sides of the axis are equidistant in pairs, in which event there would be considerable slack and such irregularity of cutting that it would be difficult to handle the material by hydraulic conveying mechanism. By means of the staggered relation of the points of the cutters, the coal may be dislodged in larger and comparatively regular pieces which can still be efficiently handled by hydraulic conveying apparatus.

Hydraulic conveying apparatus, which is particularly adaptable to the construction described above, comprises a hose 126 attached to the rear end of the motor frame 20, so as to communicate with the passageway 127 in the shaft 25 and the forward extension thereof. The forward end of the passageway 127 communicates with a nozzle 128 for directing streams of water to the space where the cutter 27 is to operate. Radial passageways 129 at the forward end of the tubular shaft 25 communicate with an annular passageway 130 in the sleeve 34, and this annular passageway is connected to suitable nozzles for directing streams of water adjacent the cutters 38, 39, 40 and 41. Additional radial passageways 131 communicate with an annular passageway 132 and radial passageways 133 in the sleeve 34, which in turn communicates with the annular passageway 134 in the sleeve 42. The annular passage 134 communicates with the passageways 135 and 136 in the carriers 45 and 46 which passageways 135, 136 extend to nozzles for directing streams of water adjacent the cutters 47, 48, 49 and 50.

It will be seen that when the machine is operating and the shaft 25 as well as the sleeves 34 and 42 are being rotated, the various nozzles on the carriers 36, 37, 45 and 46 will be carried along spiral paths together with the cutters mounted on these carriers. The streams of water from the nozzles may be directed with sufficient force to loosen the material as soon as it is cut so as to direct such material to the space at the lower for-

ward portion of the machine into the basin 87, 87' in the trough being continually extended by the floor cutter 79. Radial spiral blades are mounted on the upper surface of the cutter 79 as shown at 137 and 138 in Fig. 1 so that at the same time that the cutter 79 is being rotated these spiral blades will receive the dislodged material and the water and direct the mixture with sufficient force to cause the same to flow rearwardly along the tubular passageway 139 which is rigidly connected to the housing 87. That is to say, by extending the housing rearwardly along the floor, as shown at 140, a tubular passageway may be afforded for taking the mixture of water and dislodged material from the space enclosing the propeller blades 137 and 138 and directing such mixture on to the endless belt conveyor 141 for transfer to position for loading into mine cars or for removal from the tunnel.

It should be understood that the spaces in which the gearing 65, 66, 84, 97 and 113 are enclosed, are not in communication with the space enclosing propeller blades 137 and 138. The housing 112 encloses the gearing for transmitting power to the cutters at the forward face of the machine. The partition comprising the plate 94 and the doors 107 and 110 divides the space where the attendant controls the operation of the machine from the space where the water is being forced from the nozzles against the mine heading adjacent the cutters to wash the dislodged material into the open basin or recess, 87, 87' on to the propeller for transfer along the passageway 139 onto the conveyor 141.

Obviously those skilled in the art may make various changes in 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 therefore not to be restricted to the precise construction herein disclosed.

Having thus fully described an embodiment of my invention what I desire secured by Letters Patent of the United States is:

1. In a mining machine, the combination with a supporting frame, of cutting mechanism mounted thereon, means for operating said cutting mechanism, rotatable traction mechanism for engaging the floor and roof of the mine chamber, and additional cutting mechanism rotatable on upright axes for cutting plane surfaces at the floor and at the roof for the paths of travel of said traction mechanism.

2. The combination with a mining machine, of traction mechanism for engaging the floor and roof of the mine chamber, cutting mechanism rotatable on an upright axis for cutting plane surfaces at the floor and roof in advance of the traction mechanism, means for driving said cutting mechanism, and mechanism for individually varying the

elevation of the cutting mechanism at the roof and cutting mechanism at the floor.

3. The combination with a mining machine, of lower traction mechanism therefor, upper traction mechanism therefor, a rotary floor cutter in advance of the lower traction mechanism, an additional rotary cutter at the roof in advance of the upper traction mechanism, means supporting said rotary cutters with their axes vertical, and means for individually varying the elevation of each of said rotary cutters.

4. The combination with a mining machine comprising dislodging mechanism, of means for directing a plurality of streams of water to said dislodging mechanism, a floor cutter, propeller blades mounted on said floor cutter, loading mechanism associated with said propeller blades, and means for simultaneously operating said cutter and said propeller blades to cut a plane surface at the floor and at the same time direct the mixture of water and dislodged material to said loading mechanism.

5. The combination with a mining machine comprising a supporting frame and cutting mechanism mounted thereon for rotation on a longitudinal horizontal axis, traction mechanism for said mining machine, a floor cutter in advance of said traction mechanism, a propeller, loading mechanism comprising a chute, and means for operating said floor cutter and at the same time for operating said propeller to direct dislodged material to said loading mechanism.

6. In a mining machine, the combination with a supporting frame, of cutting mechanism mounted thereon, means for operating said cutting mechanism including the feed thereof, additional cutting mechanism rotatable on an upright axis in position to cut a horizontal plane surface along the floor of the mine chamber, and traction wheels connected to said frame in position to travel over said horizontal plane surface.

7. In a mining machine, the combination with a supporting frame, of mining mechanism mounted thereon, means comprising a driving shaft operating on a longitudinal axis for driving said mining mechanism, a worm concentric with said axis, a worm gear meshing with said worm and journaled on a transverse axis, traction mechanism on said transverse axis for the lower portion of said supporting frame, additional traction mechanism for the upper portion of said supporting frame, power transmission gearing between the upper and lower traction mechanisms, and a clutch for connecting said worm gear to the lower traction mechanism.

8. In a mining machine, the combination with a supporting frame, of cutting mechanism mounted thereon, means for operating said cutting mechanism, traction mechanism for said supporting frame, and additional

cutting mechanism comprising a rotary cutter operable on an upright axis for cutting a horizontal plane surface for said traction mechanism to operate on.

9. In a tunneling machine, the combination with a supporting frame, of means mounted thereon in position to excavate a cylindrical tunnel, traction mechanism on said frame in position to engage the floor and roof of the tunnel, and means on said frame in position to cut elongated flat surfaces at the floor and at the roof for engagement by said traction mechanism and to guide the machine in its feeding movements along the longitudinal length thereof.

10. In a tunneling machine, the combination with a supporting frame, of a plurality of radially stepped cutter frames nested one within another in spaced relation, cutters respectively secured to said cutter frames to move bodily therewith while being non-rotary relatively thereto and to have circular translating paths of cutting travel parallel to the paths of travel of said cutter frames, and means for operating said cutters including the feed thereof on a predetermined axis and rotation thereof all in the same direction on such axis at varying rates of speed to impart feeding movements to said cutters corresponding to the movements of said cutter frames.

11. In a tunneling machine, the combination with a supporting frame, of a plurality of radially stepped cutter carriers nested one within another in spaced relation, means for rotating said cutter carriers at varying rates of speed along a circular tunnel heading, and cutters respectively fixed to said cutter carriers in position to cut away the entire circular face of the tunnel heading, said cutters being respectively connected to said cutter carriers to be non-rotary relatively thereto but to move bodily therewith along arcuate cutting paths of travel concentric with the axis of rotation of said cutter carriers.

12. In a tunneling machine, the combination with a supporting frame, of a plurality of radially stepped cutter carriers arranged in nested spaced relation at different distances from a predetermined axis of arcuate feeding movement, cutters mounted on said cutter carriers in position to have circular translating movements along circular parallel paths bodily with said cutter carriers to cut away the entire circular face of the tunnel heading, and means for moving the outer cutter carriers along the tunnel heading more slowly than the inner cutter carriers for a given feeding path of travel.

13. In a mining machine, the combination with a supporting frame, of a plurality of radially stepped cutter carriers arranged in nested spaced relation at different distances from a predetermined axis of arcuate feeding

movement but all approximately in the same plane, cutters mounted on said cutter carriers to move bodily therewith to have circular translating paths of travel parallel to each other in closely adjacent relation to cut the material from the approximately flat face of the circular tunnel heading over the entire area thereof, and means for imparting movements to the outer cutter carriers at progressively lower rates of speed.

14. In a tunneling machine, the combination with a supporting frame, of a plurality of concentrically mounted and radially stepped cutter carriers arranged in nested spaced relation at varying radial distances from the predetermined axis of rotation and approximately in the same plane, cutters mounted on said cutter carriers to move bodily therewith and have circular translating paths of travel parallel to each other and successively closely adjacent each other to effect the cutting of the material from the entire flat circular face of the tunnel heading, and means for imparting rotative movement to said cutter carriers at varying rates of speed to cause the outer cutters to be rotated at lower rates of speed than the cutters closer to the axis of rotation.

15. In a mining machine, the combination with a supporting frame, of spaced-apart and radially stepped cutter carriers arranged in nested relation and each elongated in radial direction and each adapted to travel along circular paths, and double pointed cutter bits mounted on said cutter carriers in staggered relation so that the following cutter points will cut along the spaces between the cutter points on the advanced carrier.

16. In a mining machine, the combination with a supporting frame, of a plurality of pairs of radially stepped and diametrically arranged elongated cutter carriers spaced and nested one within the other at varying distances from the predetermined axis of rotation and mounted concentrically, a plurality of cutters spaced radially on each of said carriers in position to cut along circular concentric paths of travel successively closely adjacent to each other, means for feeding the cutters longitudinally of said axis of rotation, and means for rotating the outer cutter carriers and the cutters thereon at a lower rate of speed than the inner cutter carriers with the cutters thereon to secure approximately uniform spiral feeding movement of all of the cutters during said feeding movement along said axis.

17. In a mining machine, the combination with a supporting frame, of a motor mounted thereon, a central cutter carrier connected to the motor shaft for rotation concentric therewith, a cutter fixed to said cutter carrier to rotate bodily therewith on the axis of the motor shaft while remaining fixed

thereto, a sleeve mounted to rotate on said motor shaft concentric to the axis of the latter, cutter carrying mechanism mounted on the forward end of said sleeve, cutters fixed to said cutter carrying mechanism to move bodily therewith while remaining fixed thereto to enlarge the cylindrical cut made by said first-named cutter, said cutter carriers each being radially stepped and nested one within the other in spaced relation, and speed reduction gearing between said shaft and said sleeve to cause said shaft and sleeve to rotate simultaneously at different rates of speed.

18. In a mining machine, the combination with a supporting frame, of a central cutter carrier mounted thereon, a cutter connected to said cutter carrier to rotate bodily therewith, a driving shaft connected to said cutter carrier, a sleeve mounted on said shaft to rotate concentrically therewith but at a different rate of speed, cutter carrying mechanism mounted on said sleeve for circular paths of travel closely adjacent said first-named cutter carrier, cutting mechanism connected to said second-named cutter carrying mechanism to move bodily therewith in position to cut along circular paths of travel adjacent said first-named cutter carrier to enlarge the cut of the latter, each of said cutter carriers being radially stepped and nested one within the other in spaced relation, and reduction gearing between said shaft and said sleeve.

19. In a mining machine, the combination with a supporting frame, of a central boring cutter, means comprising a shaft for driving said cutter, a sleeve mounted on said shaft, cutting mechanism mounted on said sleeve closely adjacent said boring cutter to move along a circular cutting path of travel to enlarge the space cut by said boring cutter, said cutting mechanism comprising a radially stepped cutter-frame in which a central boring cutter is nested, and means for rotating said shaft and said sleeve simultaneously with the sleeve rotating at a lower rate of speed than the rotation of said shaft while said central cutter and said cutting mechanism move along closely adjacent concentric paths of travel in substantially the same plane to cut out from the mine vein a cylindrical space.

20. In a mining machine, the combination with a supporting frame, of a driving shaft mounted thereon, a plurality of concentric sleeves mounted on said shaft, reduction gearing between said shaft and said concentric sleeves to effect rotation of said shaft and of said sleeves respectively at varying rates of speed, and radially stepped cutting mechanism mounted on said shaft and on said sleeve successively closely adjacent each other in nested spaced relation to one another in position to have cutting paths of

travel successively closely adjacent each other in circles to effect the complete cutting away of the material in a cylindrical space with the driving shaft and its axis.

21. In a mining machine, the combination with a plurality of concentric sleeves, of pairs of radially stepped and diametrically opposed cutter carrying arms carried respectively by said concentric sleeves in nested spaced relation to one another for rotation along circular paths closely adjacent to each other, radially arranged cutting mechanism mounted on said cutter carrying arms and confined to paths of cutting travel concentric with said sleeves, and power transmission mechanism rotating said sleeves simultaneously at varying rates of speed to drive said cutting mechanism to effect the complete cutting away of the material from a cylindrical space having as its axis the center of rotation of said sleeves.

22. In a mining machine, the combination with a supporting frame, of cutting mechanism mounted thereon for cutting material from the circular face of a tunnel heading over the entire surface thereof, means comprising circular cutters mounted on said frame for rotation on upright axes for cutting a flat floor and a flat roof along the cylindrical tunnel produced by the machine, traction feeding mechanism engaging the flat floor and flat roof, and means for positively operating said traction feeding mechanism along such flat floor and flat roof while said cutting mechanism is being driven to cut the material away from the circular face of the tunnel heading.

23. In a mining machine, the combination with a supporting frame, of rotating cutting mechanism mounted thereon in position to cut material from the entire circular face of a tunnel heading to extend a cylindrical tunnel, floor traction mechanism connected to said frame, roof traction mechanism mounted on said frame, means for driving the cutting mechanism, and means comprising worm gearing concentric with the rotating cutting mechanism for positively driving both the floor traction mechanism and the roof traction mechanism to secure feeding movement of the supporting frame and the cutting mechanism carried thereby during the driving of the latter.

24. In a mining machine, the combination with a supporting frame, of a cutter carrier comprising a frame rotatable on a longitudinal horizontal axis, cutters on said carrier in position to cut material from the upright face of a mine vein, a worm secured to said rotatable frame to rotate therewith, a worm gear in mesh with said worm, spaced-apart floor and roof traction wheels adapted to be connected to said worm gear to be positively driven thereby to effect feeding movement of said cutting mechanism in the direc-

tion of said longitudinal axis during the operation of said cutters, floor and roof cutters located on said supporting frame between said traction wheels and said first-named cutters in position to cut flat surfaces for said traction wheels, and means for adjusting the elevation of the roof traction wheels while maintaining a positive driving connection thereto as well as to said floor traction wheels.

25. In a mining machine, the combination with a supporting frame, of a rotary cutter head, mechanism mounted on said cutter head, means for driving cutting mechanism by rotating said cutter head relatively to said frame, floor traction mechanism, floor cutting mechanism rotatable on an upright axis for preparing a path for said floor traction mechanism, roof traction mechanism, roof cutting mechanism rotatable on an upright axis for preparing a path for said roof traction mechanism, means for supporting said roof traction mechanism at adjusted elevation relative to said frame, means for adjusting the elevation of said roof cutting mechanism in accordance with the elevation of said roof traction mechanism, and means for positively driving both the floor traction mechanism and the roof traction mechanism irrespective of the adjustment and elevation of the latter.

26. In a mining machine, the combination with a supporting frame, of rotatable cutting mechanism adapted to be driven on a longitudinal horizontal axis, a pair of traction wheels adapted to engage the floor, an additional pair of traction wheels adapted to engage the roof of the mine chamber, cutting mechanism in advance of the traction wheels at the roof and in advance of the rotatable traction wheels at the floor on an upright axis for preparing flat passageways for said traction wheels, and means for simultaneously driving both pairs of traction wheels during the rotation of said first-named cutting mechanism to effect feeding of the latter along lines parallel to said axis.

27. In a mining machine, the combination with a supporting frame, of excavating mechanism mounted thereon, a pair of spaced-apart floor traction wheels, floor cutting mechanism in advance of said traction wheels and operable on an upright axis to prepare a flat passageway for such wheels, an additional pair of spaced-apart roof traction wheels, additional cutting mechanism rotatable on an upright axis for preparing a flat passageway for the roof traction wheels, means for adjusting the elevation of said additional cutting mechanism, means for adjusting the elevation of the roof traction wheels in accordance with the adjustment of elevation of said additional cutting mechanism, means for driving said excavat-

ing mechanism, and mechanism for positively driving said traction wheels including the roof wheels at the various elevations thereof to secure feeding movement of said excavating mechanism.

28. In a mining machine, the combination with a supporting frame, of traction mechanism for supporting said frame, cutting mechanism mounted on the forward end of said frame, means for driving said cutting mechanism, floor cutting mechanism rotatable on an upright axis for preparing a flat passageway for said traction mechanism, and means for operating said traction mechanism to effect feeding of said cutting mechanism.

29. In a mining machine, the combination with a supporting frame, of cutting mechanism mounted thereon, traction mechanism for supporting said frame, a floor cutter rotatable on an upright axis in position to cut a flat passageway for said traction mechanism, and means for operating said traction mechanism to effect feeding of said cutting mechanism.

30. In a mining machine, the combination with a supporting frame, of mining mechanism mounted thereon, traction mechanism connected to said frame, means rotatable in a horizontal plane to form a horizontal plane surface for said traction mechanism, and means for operating said mining mechanism.

31. In a tunneling machine, the combination with a supporting frame, of excavating mechanism mounted thereon, traction mechanism on said frame in position to engage both the floor and the roof of a mine chamber, rotated cutting devices operable on upright axes for cutting flat passageways for said traction mechanism at the floor and at the roof, means for spreading apart the traction mechanism relative to the floor and roof to cause said traction mechanism to firmly grip the floor and the roof, means for adjusting the elevation of the cutting devices at the roof, means for driving said excavating mechanism, and means for operating said traction mechanism in its spread apart positions to effect feeding of the machine.

32. In a tunneling machine, the combination with a supporting frame, of diametrically opposite elongated cutter carriers having radially stepped cutter-carrying frames at their outer ends adapted to occupy an upright position in nested spaced relation to one another for transportation, cutters mounted on said cutter carriers, means for rotating said cutter carriers to operate said cutters, traction mechanism for engaging both the floor and the roof of the mine chamber, means for adjusting the elevation of the roof traction mechanism, and means for

driving said traction mechanism to effect feeding of said cutters.

33. In a tunneling machine, the combination with a supporting frame, of radial cutter carrying arms adapted to have an upright folding relation for transportation, cutters mounted on said arms, traction mechanism for engaging the floor and roof of the tunnel, and cutting devices at the floor and at the roof for cutting passageways for said traction mechanism along the roof and the floor of the tunnel.

34. In a tunneling machine, the combination with a supporting frame, of a plurality of pairs of diametrically arranged cutter carrying arms mounted for concentric rotation about a longitudinal horizontal axis and adapted to have an upright nested relation for transportation, cutters carried by said arms, traction wheels for engaging the longitudinal central portion of the floor and the longitudinal central portion of the roof of the tunnel, cutting mechanism rotatable on upright axes for cutting flat passageways along the central portion of the floor and along the central portion of the roof in advance of the said traction wheels, and means for driving said traction wheels to effect feeding movement of said first-named cutters.

35. In a mining machine, the combination with a supporting frame, of a plurality of radially stepped cutting devices mounted on said frame in nested concentric relation, means for rotating said cutting devices at different rates of speed, means for effecting feed of said cutting devices in a direction along the axis of rotation thereof, means for directing water along such axis and to said cutting devices to produce streams of water adjacent the latter, and loading apparatus comprising a rotatable mechanical propeller for directing dislodged material rearwardly along the under side of said supporting frame away from said cutting devices.

36. In a tunneling machine, the combination with a supporting frame, of a plurality of radially stepped concentric cutter carriers nested one within the other and spaced at different distances from a predetermined axis of arcuate feeding movement, cutters each mounted on its corresponding cutter carrier to move bodily therewith along a circular path, said cutters being mounted to cut along circular paths successively adjacent and concentric to cut in small particles the entire circular face of the tunnel heading to extend the tunnel gradually by such cutting, and means for driving the outer cutters along such tunnel heading more slowly than the inner cutters for a given feeding path of travel.

37. In a mining machine, the combination with a supporting frame, of a plurality of

radially stepped concentric cutter carriers arranged in nested spaced relation, means for driving said cutter carriers at varying rates of speed progressively slower from the inner toward the outer carriers, a plurality of closely adjacent cutters mounted on said carriers to move bodily therewith in approximately the plane of the circular tunnel heading, the center cutter being adapted to bore a hole and the outer cutters being in position to cut along circular concentric paths successively closely adjacent to each other to cut away in small pieces the entire circular face of the heading to extend the tunnel by such cutting, and means for feeding the machine to effect spiral feed of the cutters.

38. In a mining machine, the combination with a supporting frame, of cutter-carrying mechanism comprising a central shaft and concentric sleeves mounted thereon with radially stepped cutter arms arranged in nested spaced relation to one another in position to move along a tunnel heading, a plurality of cutters closely adjacent to each other successively along radial lines extending from the axis of said central shaft in position to cut along concentric circular path successive-

ly closely adjacent to each other to cut away the entire face of the heading to extend the tunnel by such cutting, and means for rotating said shaft and sleeves at different rates of speed to vary the rates of movement of said cutters along said heading according to the distance thereof from the axis of said shaft.

39. In a mining machine, the combination with a supporting frame, of a central shaft and a sleeve concentric therewith, gearing interconnecting said shaft and sleeve to predetermine the relative speeds of rotation of said shaft and sleeve, radially stepped cutter carriers on said shaft and sleeve arranged in nested spaced relation to one another in position for movement along the plane of a circular heading of a tunnel, a plurality of cutters mounted on said carriers to cut along paths closely adjacent successively to command the entire area of said heading to extend the tunnel by such cutting, and means for operating said cutters by rotating the sleeve more slowly than the shaft.

In testimony whereof, I have signed my name to this specification this 18th day of November, 1922.

EDMUND C. MORGAN.