H. R. HUGHES.

TUNNELING MACHINE.

APPLICATION FILED JUNE 24, 1918.

1,333,491.

Patented Mar. 9, 1920.

2 SHEETS—SHEET 1.

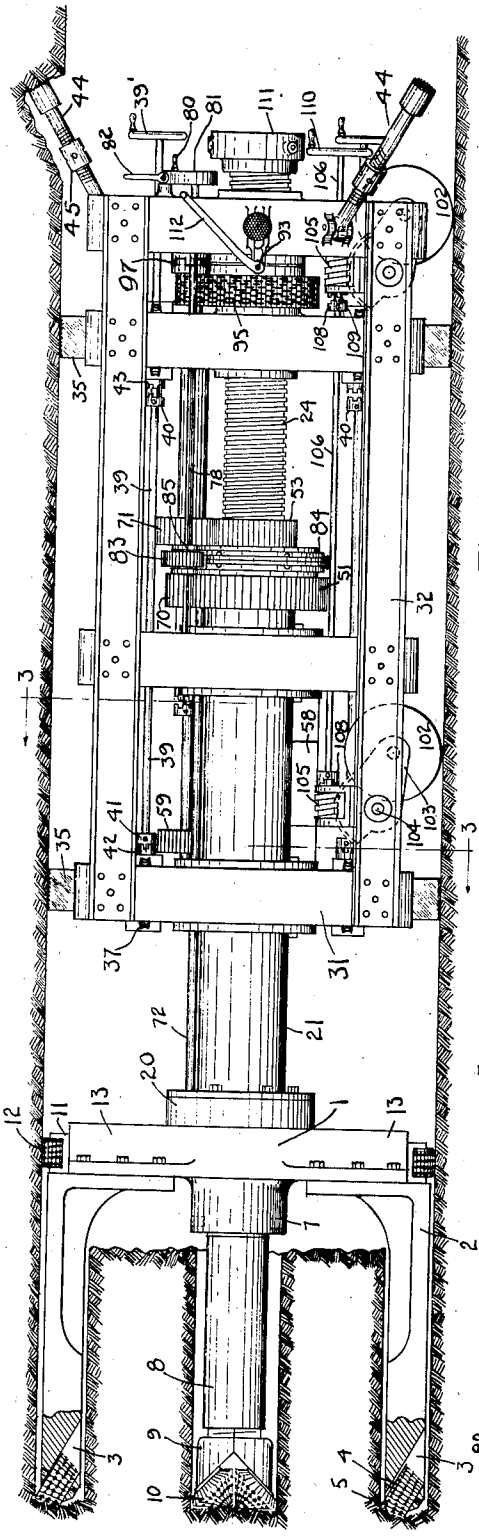


Fig. 1.

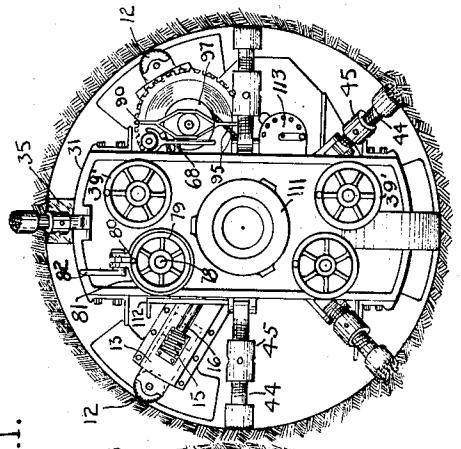


Fig. 5.

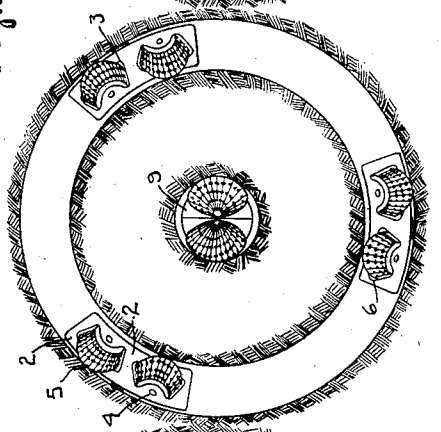


Fig. 4.

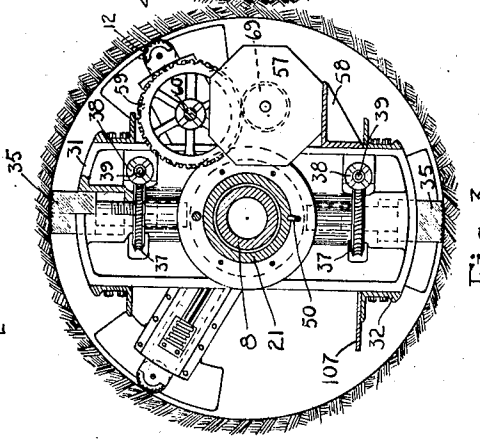


Fig. 3.

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2 SHEETS—SHEET 2.

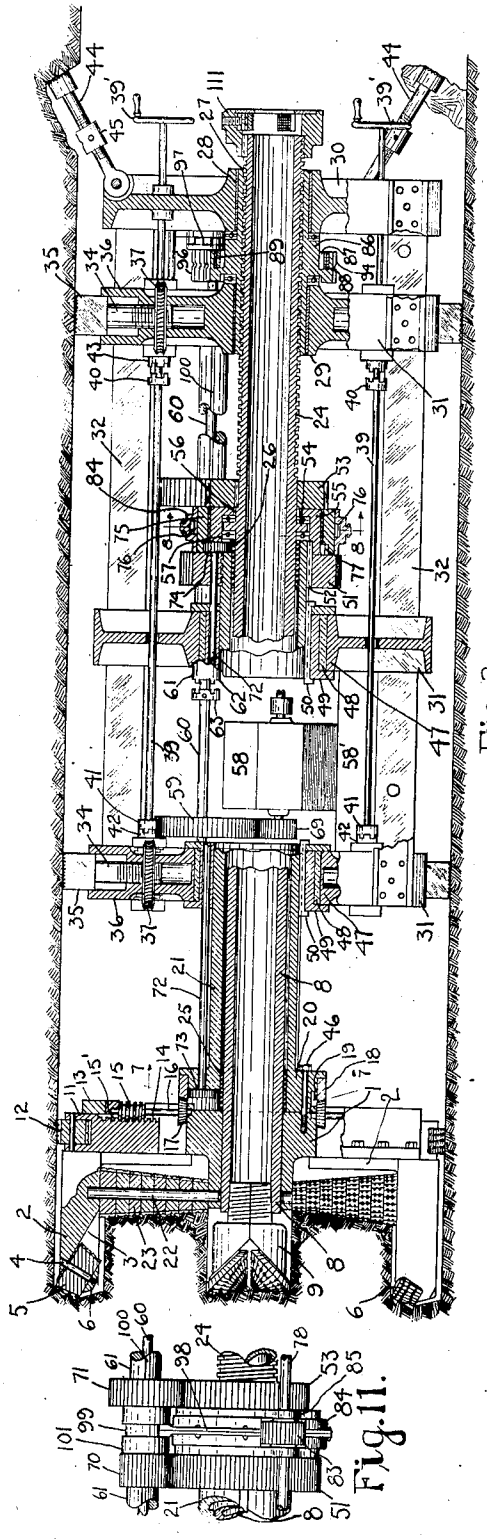


Fig. 11.

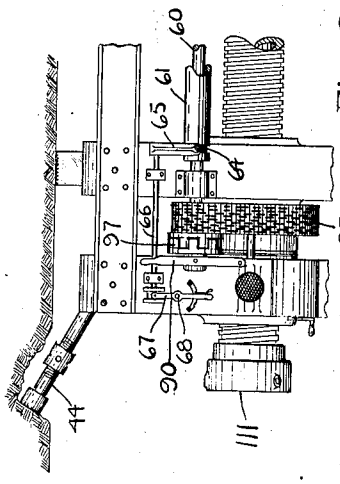


Fig. 9.

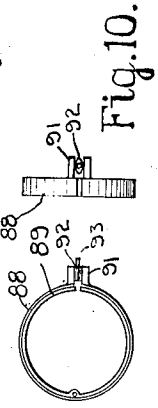


Fig. 10.

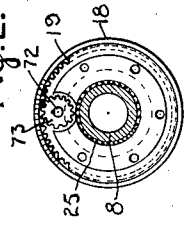


Fig. 2.

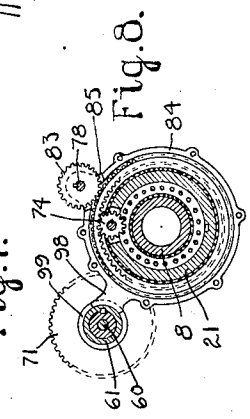


Fig. 8.

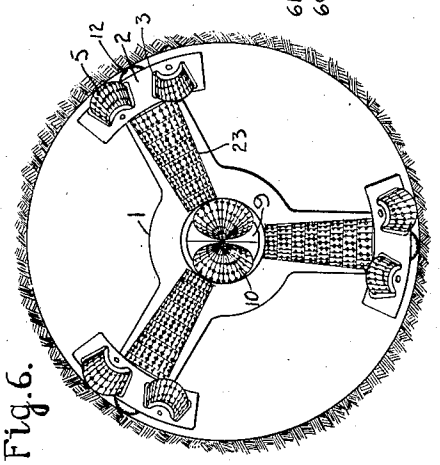


Fig. 6.

Fig. 7.

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UNITED STATES PATENT OFFICE.

HOWARD R. HUGHES, OF HOUSTON, TEXAS.

TUNNELING-MACHINE.

1,333,491. Specification of Letters Patent. Patented Mar. 9, 1920.

Application filed June 24, 1918. Serial No. 241,459.

To all whom it may concern:

Be it known that I, HOWARD R. HUGHES, a citizen of the United States, residing at Houston, Harris county, Texas, have invented a certain new and useful Improvement in Tunneling-Machines, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to tunneling machines for drilling in earth or rock and has particular reference to a device for tunneling in a horizontal or approximately horizontal direction underground.

In subterranean mining or in sapping operations in warfare, the common method is to dig the tunnel by hand by means of pick and shovel or similar implements and the process is a slow and laborious one. Tunneling machines have been devised before with the aim in view of expediting this operation, but with varying success.

The object of my invention is to provide a tunneling device which will be light and strong in construction and hence easy to transport from place to place, and which will be, at the same time, large enough to dig a hole in which a man can enter and operate.

Another object is to devise a novel means for mechanically digging a tunnel, which will operate in soft earth or hard rock with efficiency, but which is especially adapted for rock drilling.

Another object is to devise a drilling machine which will operate the drill and which will follow the drill into the hole; and wherein the operating means will serve both to drive the drill bit and to move the drilling machine forward behind the bit.

Another object is to so arrange the mechanism of the drill operating means that the operator can regulate the running thereof with a maximum of convenience.

Other objects and advantages of my invention will more clearly appear in the description which follows and the same will be indicated with more particularity in the claims appended hereto.

In the drawing forming a part of this specification, Figure 1 is a side view of my invention. Fig. 2 is a similar view showing a different form of drill bit and with certain parts broken away and in section for greater clearness. Fig. 3 is a transverse section on the line 3—3 of Fig. 1. Fig. 4 is a front elevation of the bit shown in Fig. 1 the core of the rock being shown between the drill members. Fig. 5 is a rear elevation of my assembled device. Fig. 6 is a front elevation of the bit shown in Fig. 2. Fig. 7 is a transverse section on the broken line 7—7 of Fig. 2. Fig. 8 is a similar view on the broken line 8—8 of Fig. 2. Fig. 9 is a broken detail of the rear end of my device showing a means for regulating the operation of certain parts. Fig. 10 shows a side and end view of my brake band for use in feeding the bit in a longitudinal direction, and Fig. 11 is a broken plan view of the driving gears shown adjacent the line 8—8 of Fig. 2.

In the different figures of the drawing, wherein like numerals are applied to like parts throughout the several views, I have shown my improved device in connection with two different drill bits. In Fig. 1 I have represented the preferred embodiment of drill bit which consists of a spider 1 having detachably connected thereon a plurality of forwardly projecting supports 2 upon which the cutting rollers 5 are mounted. These cutters are frusto-conical rollers, toothed on their peripheries as shown, the rollers not being considered as new. The forward end of each of the supports 2 is slotted as shown at 3 to provide a mounting for the cutting rollers 5 which are rotatable upon the spindles 4 fitted rigidly within the supports 2. Each of the supports furnishes a mounting for a plurality, preferably two, of these rolling cutters and it is contemplated that one of the cutters shall be inclined inwardly toward the center of the head and the other inclined outwardly toward the outer portion of the bore hole for the purpose of obtaining clearance for the drill on each side of the support as shown in Figs. 4 and 6. The cutters are set into the support 3 so as to partially house the cutters and also so that the support 2 will furnish a supporting means for the outer end of the pins 4 upon which the cutting rollers rotate.

Concentric with the spider 1 and forming an integral part thereof is a forwardly projecting hub or collar 7. This hub furnishes a support for the central drill stem 8 upon which the main central drill bit 9 is attached. This central bit 9 is a cone bit and is particularly disclosed in my prior Patent

No. 930,759 granted to me on August 10th, 1909. It has a flattened cylindrical head provided with a V shaped slot in one end thereof. Upon the flattened faces of said slot are mounted the cutting cones 10. The tunneling drill thus provided will, as is obvious from the drawing, drill a central cylindrical hole and an outer annular hole spaced away from and concentric with the inner hole.

In order to provide against the contingency of the wearing away of the cutters 5, thereby reducing the gage of the hole being drilled, I have provided, on outwardly projecting arms on the spider 1, a slidable block 11, on the outer end of which is mounted a reaming roller 12. The sliding block 11 is held in place upon the spider 1 by means of an outer housing 13, shown particularly in Figs. 1 and 5. This housing is bolted to or integral with the spider 1. The block 11 slides within the housing 13 and is actuated therein by means of a worm gear 15 which meshes with the rack 15′ upon the slidable block. The worm gear 15 is secured upon a rotatable pin 16 which is supported at one end in the housing 13 and at the other end in the central hub 7 of the spider 1. On the inner end of said pin 16 is fastened a beveled gear 17 meshing with the rotatable annular gear 18 which bears upon the forward enlarged end 20 of an outer operating sleeve 21. These outer slidable blocks 11, with the reaming rollers 12 mounted thereon, are three in number in the embodiment which I have shown, although it is obvious that any different number of reaming rollers may be provided. When it is desired to enlarge the hole somewhat or to take up the wear occasioned by the operation of these rollers upon the sides of the hole the blocks 11 may be forced outwardly by means of the worm 15 into firmer contact with the side of the hole in a manner which will be later described.

In Figs. 2 and 6 I have shown a bit similar to the one disclosed in Fig. 1 but which is provided with an extra set of radially mounted disk cutters for the purpose of cutting away the core which would otherwise remain between the inner drill 9 and the outer drills 5. In accomplishing this purpose the forwardly projecting supports 2 are somewhat shortened and a supporting spindle 22 is mounted in a recess in the inner side of said supports, said spindle being mounted at the opposite end within a recess in the hub 7 of the spider 1. Upon the three spindles 22 are mounted a series of separate rotating disks 23. These disks are of larger diameter toward the outer end of the spindle and decrease regularly in size toward the central bit 9. On examination of Figs. 2 and 6 it will be noted that these three radial cutters, just described, each comprise a conical cutter or group of cutters which are well adapted to roll upon the core left by the principal cutters 5 and 9 and to disintegrate the material by means of the toothed surfaces of the disks rolling upon and breaking up the material at the forward end of the hole.

The means by which the drill is rotated will now be described. With particular reference to Fig. 2, it will be noted that the main bit 9 is mounted within the central sleeve or drill stem 8. This sleeve extends backwardly within the hole for some distance and is externally threaded toward the rear end thereof as shown at 24 for a purpose which will later appear. This sleeve or drill stem 8 is rotatable within the hub 7 and the outer sleeve 21 and is fitted with bushings 25 and 26 thereon. Toward the threaded end of the drill stem is fitted an outer nut 27 in the form of a sleeve, which nut is threaded upon the portion 24 of the stem. The nut 27 ordinarily rotates with the drill stem within the bearings 28 and 29 of the main framework 30.

The framework constitutes a mounting for the rotatable parts, and for the operating means, and consists of a series of four or more transverse frame members 31 which are somewhat rectangular in shape as shown particularly in Figs. 3 and 5. Connecting these rectangular members 31 are longitudinal cross pieces 32. This framework thus constructed is supported adjustably within the tunnel drilled by the bit by means of slidable bolts or pins 34 carrying on their outer ends the toothed blocks 35 which are adapted to be projected into rigid contact with the side of the tunnel and thus retain the frame in adjusted position. The pins 34 are supported by the frame members 31 within the housing 36 provided thereon. Toward the inner end of each of the pins is mounted a disk-shaped worm gear 37 adapted to mesh with a coöperating gear 38 (see Fig. 3) upon the shaft 39 and within the framework 31 as previously described. Toward the rear end of each of the shafts 39 is provided a hand wheel 39′ with which the same may be rotated to advance or withdraw the clamping bolts 34 in an obvious manner. It will be noted, as shown particularly in Fig. 2 that the shafts 39, both at the upper and lower sides of the frame, are provided with clutches 40 and 41 by means of which either of the bolts 34 may be operated as desired. When the shaft 39, which is slidable longitudinally, is moved forwardly, the clutch 41 will be forced into mesh with a coöperating part 42 of said clutch which is connected with the worm gear 38 previously described. When the shaft 39 is moved rearwardly the clutch 41 is thrown out and the clutch 40 is forced into coöperative engagement with the clutch member 43 connected with the worm gear

38 thereon, thus allowing the operator to rotate the worm gear 37 and by that means advance or withdraw the bolt 34. To accomplish this action the gear 37 is so housed as to prevent lateral movement and is threaded upon the bolt 34. Thus the turning of the gear 37 will force the bolt 34 outwardly or inwardly according to the direction of rotation of said hand wheel 39'.

The framework is also further braced and held in rigid position by means of the supporting bolts 44 shown especially in Figs. 2 and 5. These bolts are hinged at their inner ends to the rear supporting member 31 of the frame 30 and extend backwardly and upwardly into contact with the side of the bore hole. These bolts consist of two cooperating parts connected by the threaded expanding member 45 by means of which they are lengthened or shortened in the usual manner, so as to clamp the frame in rigid position.

The center bit 9 has been described as rotated by the inner revoluble sleeve or stem 8. The outer drill members 5 and also the rollers 23 are given their rotative movement through the outer sleeve 21, the forward head 20 of which is bolted securely to the spider 1, by means of the bolts 46 or other equivalent means. The sleeve 21 extends backwardly outside the stem 8 somewhat more than half the length of said stem and has a bearing 47 in the framework. The bearing 47 is provided with a bushing 48 and within the bushing is a rotating bearing sleeve 49, held rotatable with the sleeve 21 by the key 50. On the rear end of the sleeve 21 is threaded a drive gear 51, said gear being further fixed on said sleeve by means of the key 52.

Spaced rearwardly from the gear 51 the inner stem 8 is provided with the external drive gear 53, keyed thereto in an obvious manner as shown in Fig. 2. The stem 8, at a point between the gear 53 and the rear end of the sleeve 21, is provided with an outwardly flaring integral flange 54. The gear 51 upon the sleeve 21 has an integral hub member 55 which is extended rearwardly and has at the end thereof an inwardly extending flange 56. Between the flanges 54 and 56 is a non-friction bearing, a similar bearing 57 being provided on the opposite side of the flange 54 and between that flange and the sleeve 21. This provision allows the two drill sleeves or stems to rotate independently and yet causes them to advance or recede simultaneously as will be more fully explained later.

I have shown my machine as actuated by means of an electric motor 58 seated toward the front of the framework 30, upon a shelf 58' thereon. The motor is connected to the parallel drive shaft 60 through connecting gears 69, on the motor shaft, and 59, on the drive shaft. Over the shaft 60 is fitted a longitudinally slidable drive sleeve 61, said sleeve being also rotatable on the shaft 60. At the forward end of the sleeve 61 is a clutch member 62 adapted to coöperate with the clutch member 63, fixed rigidly upon the shaft 60. It will thus be seen that when the sleeve 61 is moved on the shaft 60 to its forward position in coöperative relationship with the clutch 63 the said sleeve will rotate with the drive shaft 60. Referring to Fig. 9 it will be seen that the rear end of the sleeve 61 is provided with a circumferential slot 64 into which is fitted a projection on the arm 65, said arm being connected by means of a shaft 66 to a hand lever 67 pivoted at 68 to the forward frame member. Thus, the movement of the lever 67 on its pivot 68 will serve to slide the sleeve 61 longitudinally upon the shaft 60 for the purpose of throwing it into or out of engagement with the clutch 63.

Keyed slidably upon the outer sleeve 61 are the two gears 70 and 71 adapted to engage with the aforementioned gears 51 and 53 respectively. By reference to Fig. 11, it will be noted that when the outer sleeve 61 in its forward position meshes with the clutch 63 on the drive shaft, the said outer sleeve is rotated. This rotation is communicated through the gear 70 to the gear 51 upon the sleeve 21. The stem 8 is actuated through the gear 71 which meshes with the gear 53 upon said stem. It will also be noted, because of the relative size of the actuating gears upon these two parallel sleeves, that the outer drill sleeve 21 will be driven at a lower speed than the inner drill sleeve 8 and it will be obvious that such a differential rotation of the two drilling parts is necessary, due to the fact that the outer cutters 5 are rotated through a longer path than is the drill 9.

In order that the reaming cutters 12 may be advanced or withdrawn to or from adjusted position while the drill is being operated I have arranged the following mechanism: Mounted in the two rotating bearing sleeves 49, shown in Fig. 2, is a longitudinally extending shaft 72, which is supported at its forward end in the head 20 of the outer sleeve 21. At the forward end of this shaft 72, and within a recess provided therefor in the head 20, is fixed a gear 73, the teeth of which are adapted to mesh with internal gear teeth 19 upon the gear ring 18, previously described. At the rear end of the shaft 72 is fixed a similar gear 74, said gear fitting within a recess provided therefor interiorly of the gear 51 and its rearwardly extending hub 55. Mounted rotatably upon the rearwardly extending hub 55 is an annular gear ring 75. Said gear 75 is provided centrally thereon with external gear teeth 76 and, upon the forward end of said

ring, are interior gear teeth 77 adapted to mesh with the teeth upon the gear 74.

Referring now particularly to Figs. 1 and 5, I have provided a shaft 78 which is rotatable within the framework 31 and which has, at its rearward end, the hand wheel 79 operated by means of the crank handle 80. Outside of this hand wheel 79, is the brake band 81 having a brake handle 82 for tightening same in an obvious manner. The gear ring 75 is inclosed in the casing 84 for protection and adjacent the gear ring 75, and upon the shaft 78, is the gear 83 (see Figs. 8 and 11) adapted to mesh with the teeth 76 upon the said gear ring through an opening 85 in the casing 84. Thus it will be obvious that the rotation of the shaft 78 will be communicated by means of the gear ring 75 and the gear 74 to the shaft 72 and through this shaft and the connecting gears at the forward end thereof, will act to advance or withdraw the slidable block 11. While the drills are operating, the sleeve 21 and the gear 51 together with the shaft 72 are revolving around the central stem 8. The housing 84 of the gear ring 75 is non-rotatable (being held so by shaft 78, see Fig. 8) but it will be noted that, as the shaft 72 and the gear 74 describe a planetary revolution inside the gear ring 75, the meshing of the gear 74 with the teeth 77 of the gear ring will cause the gear ring to rotate. The rotation of the gear ring 75 will be communicated to the shaft 78 through the gear 83. Hence as the drill operates in normal manner the shaft 72 does not rotate but describes a planetary revolution around the drill stem. Its planetary revolution rotates the gear ring 75 and through that gear, the shaft 78, causing the hand wheel 79 thereon to spin or rotate constantly. When the brake band 81 is tightened on the said hand wheel, the gear 83 and the gear ring 75 will be slowed up or entirely stopped as long as the brake is applied. Hence as the planetary movement of the gear 74 inside the gear ring 75 continues, the gear 74 will be also caused to rotate in its bearings and this rotation will be communicated through shaft 72 to the gears 73, 18, 17 and 15 to cause the block 11 and roller 12 to be advanced. As soon as the roller 12 is in its desired position the brake is released and the hand wheel 79 will rotate as before. It is apparent, of course, that when the drill is not operating the rollers 12 may be advanced or withdrawn by the release of the brake 81 and the manual operation of the hand wheel 79.

When the drill stem 8 is rotating, the sleeve or nut 27 will normally rotate with it and no forward feed of the drill stem will result. Provision is made, however, so that the nut 27 may be slowed up in rotation or entirely stopped as desired. To obtain this result, the nut is provided with a central enlargement or hub 86, one side of which is recessed to form an interior drum 87. This drum has an annular brake lining 88 therein. Within this lining is an expanding brake band 89, shown in detail in Fig. 10. This brake band is broken on one side and has two laterally extending lugs 91, one at each side of the break in said band. Between these two lugs is a cam 92 arranged to expand the brake through rotation of the cam by means of the rod 93 and the lever 112 (see Figs. 10 and 1). Thus when it is desired to feed the stem forwardly the brake band is tightened and the rotation of the nut 86 is slowed up or stopped. The continued rotation of the drill stem 8 will then cause it to feed forwardly in the nut and thus advance the bit as desired. When the bit is to be withdrawn, the motor is reversed.

The outer surface of the hub 86 of the nut 27 is toothed at 94 to receive a sprocket chain 95, (shown in Figs. 1 and 9 but removed in Fig. 2). This sprocket chain connects the nut 27 with the gear 96 loosely mounted on shaft 60. This gear 96 may be clutched into rotation with the shaft 60 my means of a clutch 97 keyed slidably on the shaft 60 and operated to and from engagement with gear 96 by means of the lever 90. By means of this arrangement the nut 27 may be operated to advance or withdraw the drill stem when the rest of the machine is out of gear and not operating.

When the drill stem is fed forward or withdrawn it is desirable that the sleeve 21 and the operating gears shown in Fig. 11 move longitudinally with the drill stem. It is apparent that the flange 54 on the stem 8 will, because of its connection with the gear 51 and its hub 55, cause the sleeve 21 to move forwardly or backwardly with the drill stem. The movement of the gears 51 and 53 will carry with them the casing 84 which is provided with a laterally extending arm 98. The gears 70 and 71 are keyed slidably in the groove 100 on the drive sleeve 61 and are connected by a hub 101 having a circumferential groove 99 to receive the outer end of the arm 98. Thus the movement of the gears 51 and 53 longitudinally will carry with them the gears 70 and 71 on the parallel shaft 61.

When the drill has driven forwardly to the position shown in Figs. 1 and 2 where further advance will act to screw the stem 8 out of the nut 27, the drill is stopped and the supporting frame 30 is brought forward to a new position for further drilling. To advance the supporting frame the hand wheel 79 is rotated to advance the rollers 12 sufficiently to secure the bit firmly in the hole. The rollers 12 thus act as a clamping means to secure the drill head against movement of any kind.

To support the frame of the machine

while it is moved in the hole, I have devised two roller supports 102, which ordinarily rest on the bottom of the tunnel. The supports 102 are mounted rotatably in a frame 103 pivoted at 104 to the frame members 32. The upper end of the frame 103 is sector shaped and toothed for coöperation with a worm gear 105 on a shaft 106 mounted in the frame. The worm gears 105 are rotatable on the shaft 106 but may be thrown into or out of gear with said shaft by a clutch 108 on the shaft which is arranged to mesh with a coöperating clutch member 109 on the gears 105 when the shaft is moved longitudinally. The shaft 106 has a hand wheel 110 thereon. By reference to Fig. 1 of the drawing, it will be seen that when the hand wheel 110 is rotated in the proper direction one of the gears 105 will operate to force one of the wheels 102 downwardly into supporting engagement with the bottom of the tunnel. The shaft 106 is then shifted longitudinally to throw the other clutch 108, 109 into mesh and the shaft may then be rotated to force the other supporting wheel 102 firmly against the bottom of the tunnel. In this position of the wheels 102, the frame 30 will be supported by said wheels and the bolts 34 may be withdrawn and the brace bolts 44 may be loosened and swung back againts the frame. The frame is then ready to be moved forwardly.

To move the frame forwardly the drill is thrown out of gear with the driving mechanism and the motor is operated in reverse direction through means of a controller 113 on the rear end of the machine. The lever 90 is then operated to connect the drive shaft 60 through the sprocket chain 95 to the nut 27, rotating said nut so as to feed the same forwardly on the drill stem 8. The forward movement of the nut 27 will carry with it the frame and the machine supported thereon, the whole machine resting on the wheels 102. When the frame is moved to the desired point the motor is stopped, the bolts 34 and the jaws 35 thereon are moved out, one by one, into supporting contact with the sides of the tunnel. The bracing bolts 44 are secured in place and the wheels 102 are then released and the device is again ready for drilling.

In the use of the bit represented in Fig. 1 in which an annular core is left in the drilling operation, it is obvious that the bit must be stopped periodically and the core removed. To do this the bit is withdrawn from contact with the front of the bore hole and the core is broken up so that it may be withdrawn. The core of the rock at the forward part of the hole may be removed by any suitable means, a hydraulic cartridge placed in the annular hole outside of the core may be used to crush the core or an explosive charge may be placed in the central bore hole and detonated. The broken fragments of the core are then removed by a workman from the passage allowed at one side of the framework, as shown particularly at the left of Fig. 3. A platform or walking board 107 is provided on the side of the frame for this purpose. In the use of the form of bit shown in Fig. 2 the detritus will be removed in the same manner.

The numeral 111 designates a chuck of ordinary construction at the rear end of the hollow sleeve 8. This chuck is designed to grip a pipe of smaller diameter should it be desired to insert such a pipe through the sleeve 8 for any purpose.

Having thus described my invention the operation and advantages of which will be clear without further description what I claim as new and desire to protect by Letters Patent is:

1. A machine for tunneling comprising a central drill stem, a bit thereon, an outer drill stem, a bit thereon, reaming rollers rotating with said outer drill stem, means to operate both drill stems simultaneously and means on said outer drill stem to advance and withdraw said reaming rollers while said drills are being operated.

2. A machine for tunneling comprising a central drill, an outer drill, reaming rollers mounted adjustably on said outer drill, means to drive said drills at different speeds and means to adjust said rollers while said drills are being operated.

3. A machine for tunneling, comprising a central drill, an outer drill, separate means for operating each drill, reaming cutters on said outer drill, said cutters being mounted on a slidable block, a rack on said block, a worm gear engaging said rack and means to operate said worm gear while said drills are operating.

4. A machine for tunneling, comprising a central drill, an outer drill, separate means for operating each drill, reaming cutters on said outer drill, said cutters being mounted on slidable blocks, a rack on each of said blocks, a worm gear engaging said racks and means to operate said worm gears while said drills are operating, said means comprising a longitudinal shaft, adapted to revolve around said central drill and operating means, connecting gears between said shaft and said worm gear and means to rotate said shaft.

5. In a tunneling machine, a drill, laterally adjustable reaming cutters thereon, means to advance said cutters to clamp said bit securely in the tunnel, a longitudinally adjustable frame, operating means for said drill mounted in said frame, means actuated by said operating means to move said operating means and frame forward or backward in the hole when said bit is clamped in rigid position.

6. In a tunneling machine, a supporting frame, a central drill stem rotatable in said frame, an outer drill stem, means to rotate said stems at different speeds and means operated by said rotating means to advance said stems as desired independently of said frame.

7. In a tunneling machine, a supporting frame, an outer drill stem rotatable in the forward part of said frame, an inner drill stem rotatable within said outer stem and in said frame, means to feed said inner stem forwardly or backwardly and means on said inner stem to cause said outer stem to move longitudinally simultaneously with said inner stem.

8. In a tunneling machine, a supporting frame, two concentric drill stems mounted in said frame, means to operate said drill stems at different speeds and means to feed said stems longitudinally of said frame simultaneously at will.

9. In a tunneling machine, a supporting frame, two concentric drill stems rotatable in said frame, separate operating gears for each stem, a nut on the rear end of the said inner stem, an outstanding flange on said inner stem, said flange serving to move said outer stem longitudinally in synchronism with said inner stem and means for operating said nut to cause a longitudinal movement of said inner stem.

10. In a tunneling machine, a supporting frame, means to temporarily support said frame during movement comprising sector shaped blocks pivoted in said frame, a roller mounted in an arm on each of said blocks, a rack on the curved edge of said blocks, a worm gear mounted on a rod in said frame and coöperating with said rack to raise or lower said roller.

11. In a machine for tunneling, a compound drill comprising a central drill and an outer core drill, reamers on said core drill and means on said core drill and rotatable therewith to adjust the position of said reamers while the drills are operating.

12. In a machine for tunneling, a compound drill comprising a central drill and an outer core drill, reamers on said core drill, means to adjust the position of said reamers on said drill when the drills are operating, said means comprising a rotating shaft geared to said reamers, and adapted to be operated through means of a brake and drum.

13. In a drill for tunneling, reaming and clamping rollers capable of adjustment laterally of said drill, and means to adjust said reamers while said drill is operating.

14. In a drill for tunneling, reaming and clamping rollers adjustable laterally of said drill, said rollers being mounted on a block, a rack on said block, a worm gear coöperating with said rack and means at the rear of said drill for operating said worm gear.

15. In a tunneling machine, a supporting frame, a drill stem mounted therein, a drill bit on said stem, means comprising reaming rollers on said bit to clamp said stem rigidly in the hole, and means to advance said supporting frame along said drill stem.

In testimony whereof I hereunto affix my signature this 14 day of June, 1918.

HOWARD R. HUGHES.