Jan. 9, 1934. G. J. BENSON 1,943,103

TUNNEL EXCAVATING MACHINE

Original Filed May 29, 1930 4 Sheets-Sheet 1

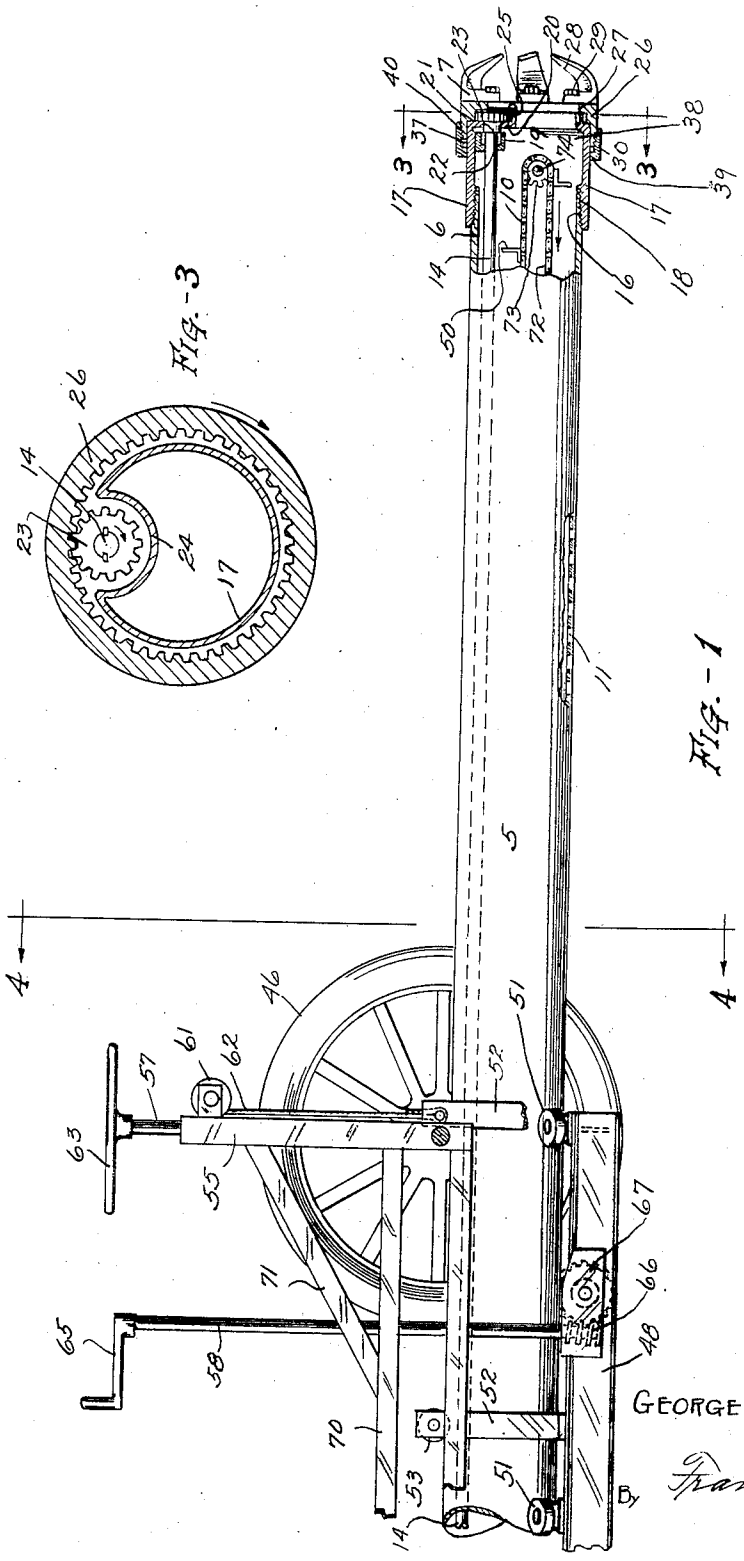


Fig. - 1

Fig. - 3

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TUNNEL EXCAVATING MACHINE

Original Filed May 29, 1930 4 Sheets-Sheet 2

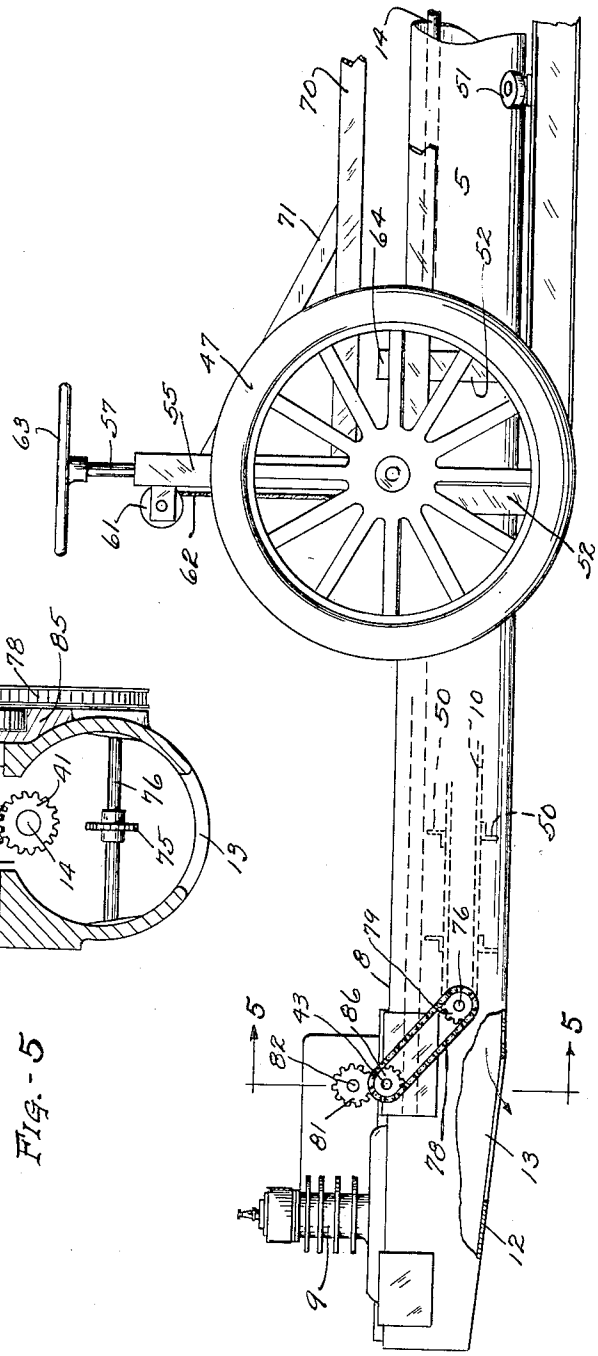


Fig. - 2

Fig. - 5

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TUNNEL EXCAVATING MACHINE

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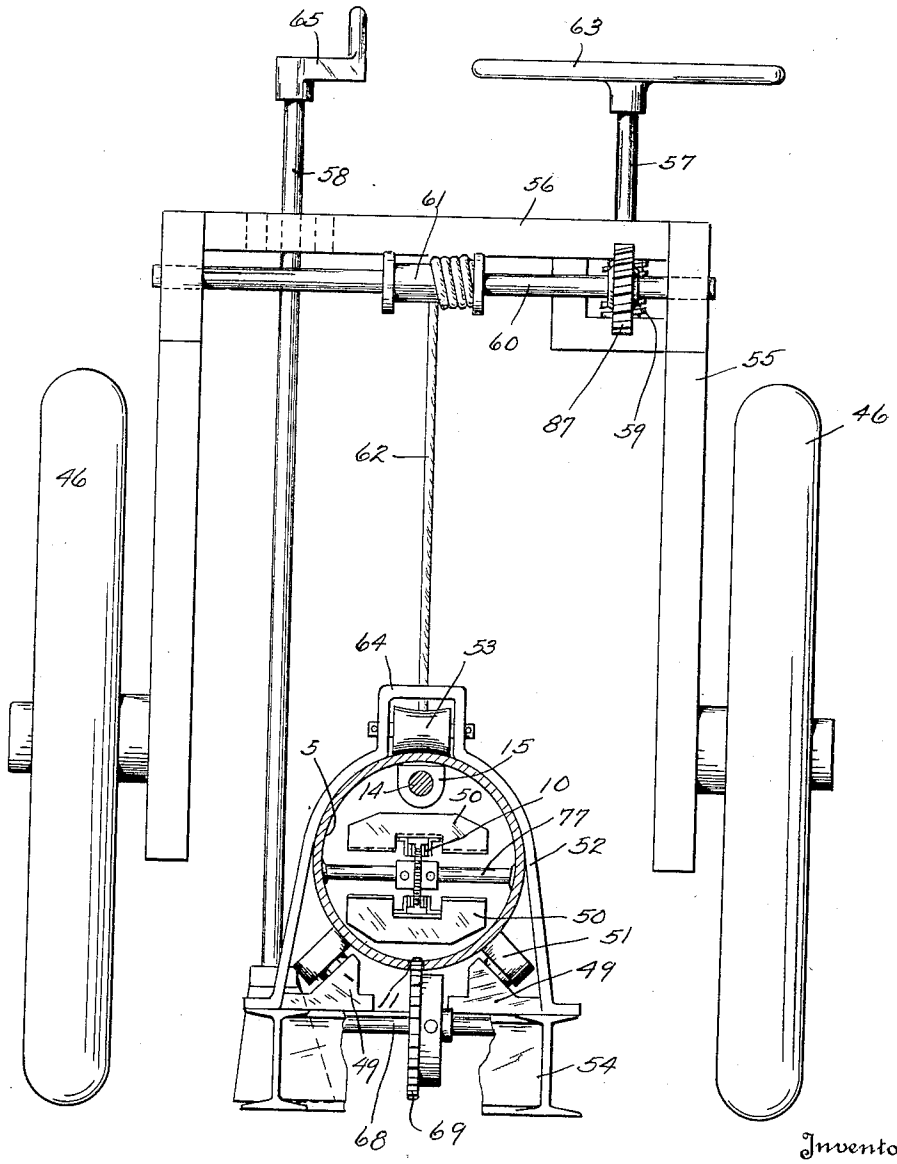


FIG.-4

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TUNNEL EXCAVATING MACHINE

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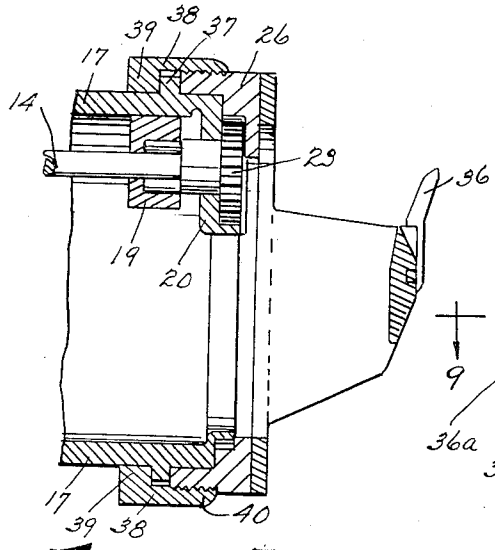


FIG. 7

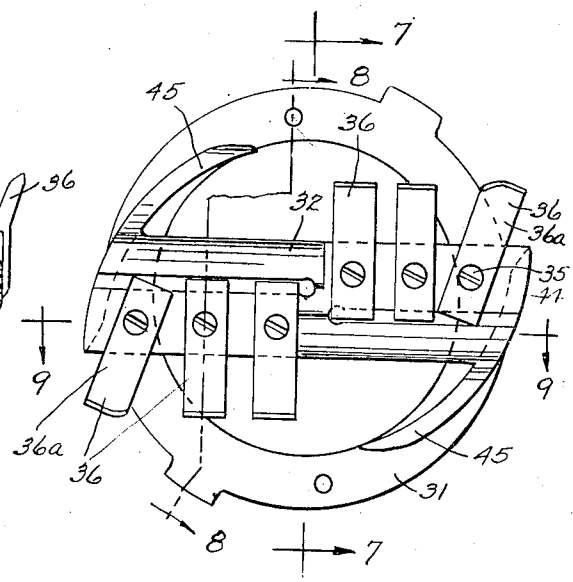


FIG. 6

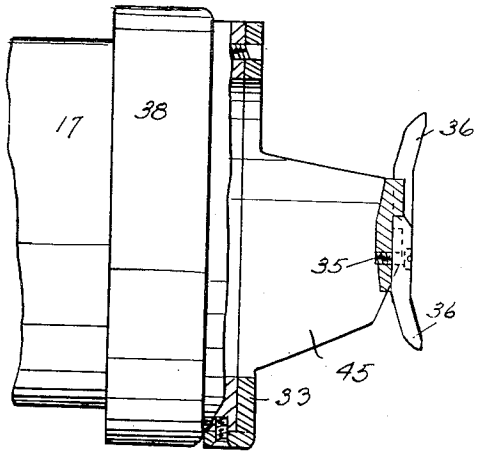


FIG. 8

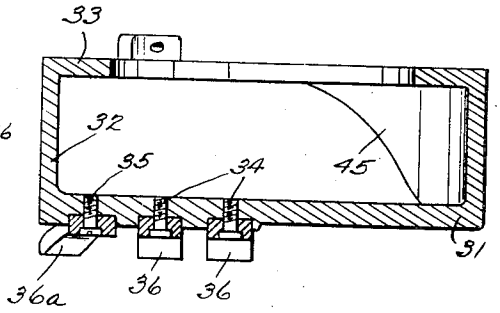


FIG. 9

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UNITED STATES PATENT OFFICE

1,943,103

TUNNEL EXCAVATING MACHINE

George J. Benson, Cleveland, Ohio

Application May 29, 1930, Serial No. 456,849
Renewed May 13, 1933

10 Claims. (Cl. 255—20)

My invention relates to tunnel excavating machines, and to portable tunnel machines, more especially. It is a special feature of my improvement that a deep, horizontal trench may be excavated at one side of, and transverse of, a body of earth to be penetrated, and my machine herein disclosed is adapted to be lowered into said trench, and is provided with power means within itself for boring directly through such earth obstruction by rotating an earth drill at the end of the machine opposite said power means, at the same time driving the machine forward through the tunnel which it bores.

A further important feature of my machine consists of the provision of a greatly elongated wheeled truck structure from which the drilling mechanism and its carrier may be suspended for transportation of the drill from place to place upon the surface of roadways, when the drill mechanism is not in direct operation, the wheeled truck being further efficient for positioning the drilling mechanism over a suitable trench where, suitable cables suspended from reels on said truck, may lower the drilling mechanism into the trench for drilling operation.

An important object of my invention is to provide a long tubular pipe which not only carries a rotating drill upon one end thereof, but is provided with an endless carrier within said pipe leading backward from the drill to the rear end of the pipe, efficient for driving the material drawn in to the drill end of the pipe, backward to the rear end, as fast as it accumulates inside the drill. The continuous pipe affords a very efficient protection for the operation of the endless conveyor.

A further object of my invention is the provision of a suitable power source, such as a gas engine, at the rear end of the said pipe, and serving to actuate the drill at the opposite end by continuous driving means also within the pipe. This common protection for both the actuating connection and the conveying mechanism, by the hollow tube is especially practicable since the control as well as the drive means for the drilling operation, must be directed from the rear end of the machine where sufficient space above the power drive exists for proper inspection of actuating parts.

With the above and other objects in view, my invention includes the following novel features and details of construction, to be hereinafter more fully described, illustrated in the accompanying drawings and pointed out in the appended claims.

In the drawings:—

Figure 1 is a side elevation of my excavating machine, the boring end of the pipe and related parts only being shown, and parts being broken away for illustration of details;

Figure 2 is an elevation of the rear end of the machine corresponding to the illustration of Fig. 1;

Figure 3 is a transverse section taken on the plane indicated by the line 3—3 of Fig. 1;

Figure 4 is a transverse section taken in the plane indicated by the line 4—4 of Fig. 1;

Figure 5 is a similar view of a section taken in the plane indicated by the line 5—5 of Fig. 2;

Figure 6 is a front elevation of a modified cutting drill which is adapted to be mounted in place of the drill shown in Fig. 1;

Figure 7 is a longitudinal section of the forward end of the main tube with the drill shown in Fig. 6 attached, and shown in the plane indicated by the line 7—7 of Fig. 6;

Figure 8 is a side elevation of such structure showing certain parts in longitudinal section taken in the plane indicated by the line 8—8 of Fig. 6, and

Figure 9 is a section of the cutting drill shown in the plane indicated by the line 9—9 of Fig. 6.

My tunnel excavator comprises as an essential part, an elongated metal pipe or tube 5, shown in Figs. 1 and 2 of the drawings, and usually provided of sufficient size in diameter to bore a tunnel of the size desired, and of sufficient length to penetrate the earth or any obstruction likely to be encountered. The forward end 6 of said tube will be provided with a suitable drill 7 having connections with driving means on the interior of the tube, and the rear end 8 being provided with power driving means 9 for actuating the drill 7 and mechanism such as an endless conveyor 10, for moving the material accumulating within the tube end 6 rearwardly to the end 8, where means will be provided for disposition of such material.

The said tube 5 is further provided with a series of alined openings forming a toothed slot 11 in its lower periphery, as shown in Figs. 1 and 4, to serve as a rack for engagement by a gear, as will later be explained. At the rear end 8, the lower surface of the tube is inclined upwardly somewhat at 12 to permit excavated material to fall downwardly and outwardly through a relatively large opening or aperture 13, as shown in Figs. 2 and 5. On the interior of the tube 5 an actuating shaft 14 is mounted in suspending ears 15 attached to the upper portion of the wall of

the tube. This shaft extends from the power means at the rear to the boring mechanism at the forward end of the tube.

The end 6 of the tube 5 is externally threaded at 16 for securing thereon a short detachable cylinder 17 having threads 18 corresponding to threads 16 of the tube. A suitable bearing member 19 is mounted on the inner surface of the forward end of the cylinder 17 in alinement with the shaft 14 to receive the latter therethrough. At the forward end of the said cylinder 17, is provided a downwardly extending flange member 20 integral with the upper portion 21 of the cylinder, the said flange being apertured at 22 to receive the forward end of the shaft 14 therethrough, the said shaft end having keyed thereto a small gear 23 positioned adjacent, but outside of, the flange. The lower edge 24 of the flange 20 is bent forwardly in an arc 25, to serve as a protection for the said gear from material in the tube.

The cutting drill 7 is detachably mounted for rotation about the forward end of the cylinder 17 by providing an outer annulus 26 having an inwardly extending flange 27 positioned just outside the gear 23, and thereby forming an annular lip upon which the separate teeth 28 are detachably secured, as by screws 29. The said annulus 26 has an inwardly extending flange 30 designed to extend rearwardly over the forward end of the cylinder 17.

In certain situations, it has been found desirable to substitute for the cutting drill 7 shown in Fig. 1, the modified form of drill shown in Figs. 6 to 9, inclusive. The drill of Fig. 1 embodies a series of peripheral teeth 28 and draws the bored material within the tube 5, but a drill head 31 may be used which comprises a hollow, box-like portion 32 which has an inner rim 33 and which may be attached by the screws 29, directly to the outer annulus 26, when the drill 7 has been removed.

This hollow cutter head 32 has the effect of advancing the cutting teeth farther forward than is the result by the use of the teeth 28 of the drill head 7, and consists of an elongated member which will extend diametrically of the head 31, and is provided with a number of screw-threaded apertures 34 for the reception of screw-bolts 35 which attach separate cutting teeth 36 to this drill head, it being found advantageous to direct half of the teeth 36 in one direction and the other half oppositely, in the manner shown in Fig. 6 of the drawings. This arrangement of the cutting teeth cut in the direction of rotation of the tube, has the further advantage of mounting the teeth in a manner making them easily replaceable.

This form of drill head has the further advantage of cutting at an advanced position of the teeth and having the effect of scooping the broken down material into the tube 5 and forcing it backward until such material reaches the grasp of the vanes 50 of the conveyor 10, which latter moves it rearward continuously to a position where it may be removed by other mechanism at the rear end 8 of the tube. These two cutting heads 7 and 31 are therefore interchangeable, and the particular drill head employed for a given job will depend upon the kind of soil, as well as many conditions thereof such as dampness and depth at which boring is done.

When either cutting head 7 or 31 is mounted upon the annulus 26 for a given boring operation, it is to be noted that the particular cutting head employed will be so connected with the power means 9 at the rear of the machine, that the teeth of the cutter, as well as the annulus 26 will be rotated on the axis of the pipe 5. To make practicable the rotatable mounting of this annulus upon the cylinder 17, the latter is provided with a peripheral guiding ridge or bearing 37 made integral with said cylinder and having smooth surfaces, and a rotatably mounted annular cap or nut 38 is detachably mounted about the cylinder, and provided with an inturned flange 39 at its rear edge, and an internally threaded forward edge 40 adapted to engage the externally threaded flange 30 of the annulus 26, whereby the parts 26 and 38 may be mounted upon the cylinder with the ridge 37 therebetween.

From the above description and the drawings it will be clear that the cylinder 17 is detachably but securely mounted upon the tube or pipe 5, both being non-rotatable. The connected parts 26 and 38 may serve therefore, as a rotatable detachable mounting guided by the peripheral ridge 37, for carrying the cutter unit and to receive thereon either of the cutter heads 7 or 31. In either case, the outer end of the shaft 14 will be provided with the pinion 23 which will engage inner teeth of the annulus 26, and thereby drive the drill head (7 or 31) attached thereto. The shaft 14 receives its power by being provided at its rear end with the gear 41 driven from the worm 42 on the shaft 43, as shown in Fig. 5.

To efficiently effect the scooping operation of the drill head shown in Figs. 6 to 9, the two outer teeth may be mounted slightly inclined to the diameter of the head, as shown at 36*a* in Fig. 6, while the other teeth 36 are at right angles to the diameter. These outer teeth 36*a* are also slightly bent forward as shown in Figs. 7 and 8.

The box-like portion 32 of the drill head 31 is also provided with a pair of cutting teeth 44 which are directed rotatably about the axis of the main teeth 36, as shown in Fig. 6, and whose inner pointed ends are drawn inwardly toward the center of the drill head, as at 45, so that the result of the rotation of the drill head 31 and its teeth will be to draw the bored-out material into the pipe or tube 5 into the reach of the vanes 50 which in their traveling action serve to push such material rearwardly to the large opening 13 through which the excavated material ultimately falls. The teeth 36 and 36*a* are detachably secured to the drill head, and the latter to the annulus 26. On the contrary, the cutting teeth 28 of the drill head 7 are directly secured to the annulus, as indicated in Fig. 1.

Means is provided for supporting the elongated boring pipe 5, which comprises front and rear wheel trucks 46 and 47, respectively, together with means for lifting the pipe out of engagement by such trucks, or lowering it to be supported by the trucks. A support frame 48 extends from one truck to the other and comprises side rails 49 which in turn have spaced rollers 51 upon which the pipe 5 may rest, and thereby be moved longitudinally with convenience in either direction. These rails 49 are connected together by metallic bands 52 which form loops extending over the pipe and provided with a roller 53 which rests upon the upper surface of the pipe and directly above the shaft 14 within the pipe. Beneath the rails 49 are transverse beams 54 which rest directly upon the bottom of the channel as it is bored.

The truck 46 comprises an overhanging arch 55 provided with outwardly directed axles for re-

ceiving the truck wheels, and actuating mechanism is carried by the arch to lift the pipe 5, and other mechanism for moving the pipe relative to the trucks 46 and 47.

As a means of raising and lowering the pipe 5 relative to the trucks, the arch 55 is provided with a transverse bar 56 through which there extends vertical shafts 57 and 58 which are spaced apart but arranged in parallelism. The shaft 57 is provided beneath the bar 56 with a worm 59 for actuating the horizontal shaft 60 mounted for rotation upon the members of the arch 55. This shaft is provided with a gear 87 and a reel 61 for winding thereon a suitable rope or cable 62 which is secured beneath to the bands 52 by which the pipe 5 may be lifted upon the reeling of the part 61. The hand wheel 63 may be used for actuating the reed. The middle portion of the band 52 is bent upward and across and then downward to form a loop 64 within which the guiding roller 53 may be pivoted for movement above the pipe 5.

The shaft 58 may be actuated by the crank 65 to drive a worm 66 somewhat beneath the pipe 5, to rotate the worm gear 67 and thereby the shaft 68 and its gear 69 mounted thereon, for adjusting the pipe 5 lengthwise as the drill head drills an opening in the earth material to receive the pipe. Lengthwise of the latter the alined openings forming a toothed slot 11 in the lower wall of the pipe provides a rack which readily engages the teeth of the gear 69, so that rotation of the crank 65 and gear 69 will adjust the pipe 5 in either direction as may be required. Further bracing of the truck frame is provided by securing together the arches of the forward and rear trucks by longitudinal bars 70 spaced somewhat above the pipe 5, and connecting the arches with such bars 70 by oblique braces 71, as shown in Figs. 1 and 2.

The endless conveyor 10 comprises the chain 72 travelling about the gear 73 rotatable upon the transverse shaft 74 whose ends are mounted upon the inner walls of the cylinder 17, and the rearward end travelling about the gear 75 upon the shaft 76 mounted across the rear end of the pipe 5.

Other suitable supporting gears similar to gears 73 and 75 are mounted on shaft 77 rotatable upon the walls of the pipe 5 and intermediate its ends, such as are shown in Fig. 4 of the drawings. The conveyor 10 is driven from the rearward end, and by an endless chain 78 connecting the gears 79 and 86 mounted on the shafts 76 and 43, respectively, exterior of the pipe wall. The shaft 43 by means of its worm 42, therefore serves to drive the elongated shaft 14 for actuating the cutter mechanism, but also drives the transverse shaft 76, and thereby the conveyor 10 whose vanes 50 travel rearwardly on their lower run, to pass the excavated material back from the cutter to the opening 13 at the rear end of the pipe.

The shaft 43 bears an intermediate gear 80 exterior of the pipe, which receives its power by engagement therewith of a gear 81 mounted on the shaft 82 above and parallel with the shaft 43. Suitable gearing connection is provided between the shaft 82 and the engine 9, whose details are not essential for a proper understanding of the operation of this excavating mechanism upon which it is mounted. It need only be said that it has been found highly desirable that the engine 9 is mounted as far to the rear of the pipe 5 as possible, and that the same engine shall by direct actuation of the shaft 82, operate the conveyor 10 as well as the drill head 7 or 31.

The rear end of the pipe or casing 5 is provided with a longitudinal opening 83 in the upper wall approximately above the lower opening or aperture 13, to permit suitable connection therein between the gear 41 and worm 42, as shown in Fig. 5; and the edges of the opening 83 are provided with bearings 84 thereon in which the shaft 43 may rotate. Outside the pipe wall and directly beneath the gears 80 and 81, a suitable block 85 is mounted upon the said wall properly shaped to provide an outer vertical surface along which the chain 78 may travel.

From the above description of my improved tunnel excavating machine, it will be observed that the mechanism employed has such parts relatively portable that not only may the entire elongated machine be transported as a unit upon the wheeled trucks 46 and 47, but when the machine is positioned in operative lowered elevation and directed toward the point where the tunneling operation is to be performed, the said trucks may remain in stationary position together with the side rails 49 and the support frame in general, while practicable means for driving the pipe 5 with its attached boring means and conveyor, is provided for operating the boring mechanism at a given position, and to adjust the tube and attachments forwardly as advancement of the machine becomes essential, in excavating and discharging the material from the passage.

It is a further advantage of my construction that the motor 9, which drives both the longitudinal conveyor for the excavated material and also the revolving cutter head for drilling out from the rock, is itself supported upon the rear end of the machine. Thus, as rapidly as the earth is bored out by the cutter head and is carried rearward by the conveyor 10, it is readily discharged through the aperture 13 from which it may be transported as desired. As a given operation is completed the pipe 5 may be released from the support rails, and the tube moved rearwardly upon the guide rollers 51, after which the boring mechanism may be lifted up on the arches 55 borne upon the trucks 46 and 47 by which the machine may be transported to another surface to be excavated.

Without making other change in the machine, the cutting heads 7 or 31 may be mounted interchangeably upon the annulus 26, the tool employed in a given case depending upon the character of earth to be excavated.

When the pipe 5 together with the related boring mechanism is raised by operating the reels 61, the cross beams 54 together with the side rails 49, are lifted together with the pipe 5, so that the entire boring device may be transported by the trucks 46 and 47 as a longitudinal unit. Such transportation will be done ordinarily when the motor 9 is idle, and when the tube 5 is held immovable within the bands 52, no further relative movement of the tube 5 within the bands and upon the rails, being necessary until the unit as a whole is lowered to a position in which the bars 54 rest permanently upon the ground surface. The pipe 5 will then be advanced forward to a position where the driving of the cutter by rotation of the parts 14 and 23, may begin cutting the channel or passage further beyond the frame 48.

In use therefore, my mechanism may include a greatly elongated cylindrical pipe having a rotating cutter mounted externally on one end,

means within the pipe for conveying the broken up material from the cutter, backward through the pipe and discharging through the opening at the rear of the machine, and power means on the rear end of the machine for driving both the cutter and the conveyor. This together with the supporting frame therefor, the means for adjusting the pipe longitudinally relative to the frame, the trucks for supporting the entire machine thereon, and the actuation of these driving and adjusting means, form a highly practicable and efficiently operable tunnelling mechanism provided with trasportable means which renders my excavator very valuable.

It will be clearly seen that the cylindrical pipe with its forward rotating cutter may be operated for boring other than horizontal tunnels. In fact, the inclination of the mechanism, might make the delivery of the bored out material at the rear end of the tube all the easier and more positive.

While the form of drill or cutter 7 is shown in Fig. 1 attached to the annulus 26, the applicant is by no means restricted to the use of such cutter other than as limited by the appended claims, the detachable cutter or drill 31 may be applied to the part 26, as shown in Figs. 7 and 8 with equal facility, the character of the rock to be bored determining to some extent the cutter most suitable in a given case. It is also obvious that other changes in details may be made within the scope of my invention.

Having thus described my invention, what I claim is new and desire to secure by Letters Patent, is—

1. A tunneling device comprising a tube, a supporting frame therefor, a cutter rotatably mounted on one end of the tube, a source of power on said tube for driving the cutter, the tube having an elongated toothed slot, means including a gear for engaging the teeth of the slot for adjusting the tube on said frame and means for lifting bodily the tube and frame vertically.

2. A tunneling device comprising a tube having an open end and a bottom aperture at the opposite end, a supporting frame therefor extending beneath the tube and longitudinal thereof, a cutter head mounted for rotation on the said open end, a motor mounted on said tube and having connections with said head for driving the same, means including a gear for adjusting the tube longitudinally of said frame, a toothed rack positioned in a slot in the wall of said tube, and with which the said gear engages, a pair of trucks mounted in spaced relation over said tube, and reeling and cable mechanism connecting said tube and frame with said trucks for lifting said tube and frame upward relative to the trucks.

3. A tunneling device comprising a tube, a supporting frame therefor extending beneath the tube and longitudinally thereof, a cutter rotatably mounted on one end of the tube, a motor mounted on said tube having driving connections with said cutter, means mounted on said frame and engaging said tube for adjusting the latter longitudinally of said frame, a pair of trucks mounted in spaced relation over and transverse of said tube and frame, and reeling and cable mechanism mounted on said trucks and engaging said tube and frame for raising said tube and frame whereby the latter may be wholly supported by the trucks for transportation thereon.

4. A tunneling device comprising a tube, an elongated supporting frame therefor, a cutter head mounted for rotation on one end of the tube, means for driving said head, means including a rack and gear for adjusting the tube longitudinally of said frame, and means including spaced trucks for raising said tube and frame vertically for transportation on said trucks when carried thereby.

5. A tunnel excavating machine comprising a cylindrical tube having an open end and a bottom aperture at the opposite end, an elongated supporting frame beneath and parallel with the tube, provided with a plurality of anti-friction rollers on either side adjacent its upper edge, for receiving the tube thereon, a cutter head mounted for rotation on the said open end, a motor mounted on said tube above said aperture, manual means including a rack and gear for adjusting the tube longitudinally on said rollers, a pair of trucks mounted in spaced relation over said tube, reeling and cable mechanism carried by said trucks and connected with said tube and frame for lifting the latter upwardly for suspension from the trucks, means within the tube for driving the bored material falling from the cutter head backward to said aperture, driving connections between said motor and said conveyor means, and between said motor and said cutter head.

6. A tunnel excavating machine comprising a tube having an open end, a short cylinder detachably mounted upon said open end having a peripheral flange and an inturned flange at its outer end a portion of which is extended radially inward on a smaller arc than the main portion of said inturned flange and perforated to receive a driving shaft therethrough, an outer rotatable annulus formed of two annuli detachably connected by threaded engagement, one of said annuli having an inner groove to receive therein the said peripheral flange and a flanged rim to engage the same, and the other of said annuli having an end flange apertured to receive attaching bolts therein, and a toothed groove adjacent the said small arc portion, a small gear keyed on the end of such shaft engaging the toothed groove of the apertured flange portion of the annulus, means for connecting said shaft with a source of power for driving said annulus therefrom, and a toothed cutter head having an annular raidal flange apertured to receive securing bolts engaging the apertures of the end flange of the annulus.

7. A tunnel excavating machine comprising a tube having an open end, a short cylinder detachably mounted upon said open end and having an external peripheral flange and an inturned flange at its outer end a portion of which is extended radially inward on a smaller arc than the main portion of said inturned flange and apertured to receive a driving shaft therethrough, an outer rotatable annulus having an inner annular groove mounted for rotation about the outer end of the said cylinder while guided thereon by the said peripheral flange engaging said inner groove and having an apertured intured end flange, means including a gear on the end of said shaft engaging a toothed portion of said annulus for rotating the latter, means for connecting the opposite end of the shaft with a source of power for driving the shaft and annulus, and a cutter head apertured to correspond with the apertures of the inturned flange for receiving securing bolts detachably mounting the cutter head on the annulus.

8. A tunnel excavating machine comprising a cylinder having an external peripheral flange and an inturned flange at its outer end a portion

of which is extended radially inward on a smaller arc than the main portion of said inturned flange and apertured to receive a driving shaft therethrough, an outer rotatable annulus having an inner annular groove mounted for rotation about said outer end while guided thereon by the said peripheral flange engaging said inner groove and having an apertured inturned end flange, means including a gear on the end of said shaft positioned between said flanges and engaging a toothed portion of said annulus for rotating the latter, means for driving said shaft and thereby the annulus, and a cutter head apertured to correspond with the apertures of the inturned flange of the annulus for receiving securing bolts detachably mounting the cutter head on said annulus.

9. A tunnel excavating machine comprising a tube having an open end and a bottom aperture at the opposite end, an elongated supporting frame therefor extending beneath and parallel with the tube, a cutter head mounted for rotation on the said open end, a motor mounted on said tube above said aperture, a driving shaft mounted for rotation within said tube and lengthwise of the same and having gearing connections at one end with said cutter head to actuate the latter and gearing connections at its opposite end with said motor whereby the latter may drive the head, an endless conveyor mounted within the tube and having spaced vanes carried thereon, the lower run of the conveyor being positioned adjacent the bottom of the tube for moving the bored material falling from the cutter head backward to said bottom aperture, driving connections between said motor and said conveyor, means including a rack and gear for adjusting the tube longitudinally of said frame, and means including spaced trucks for raising said tube and frame relative to the trucks for transportation thereon.

10. A tunnelling device comprising a tube having a series of alined openings therein forming a rack, a supporting frame therefor, a cutter rotatably mounted on one end of the tube, means including a source of power external of the tube and connections within the tube for driving said cutter, gear means engaging said rack for adjusting the tube longitudinally, spaced trucks mounted transverse of said tube and frame, and reeling and cable mechanism on said trucks and engaging said tube and frame for raising the latter for supporting tube and frame on the trucks for transportation purposes.

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