

March 7, 1967

D. H. AKKERMAN
TUNNELLING MACHINE HAVING CYLINDRICAL
ROTOR AND CENTRAL CONVEYOR

3,307,876

Filed June 22, 1964

2 Sheets-Sheet 1

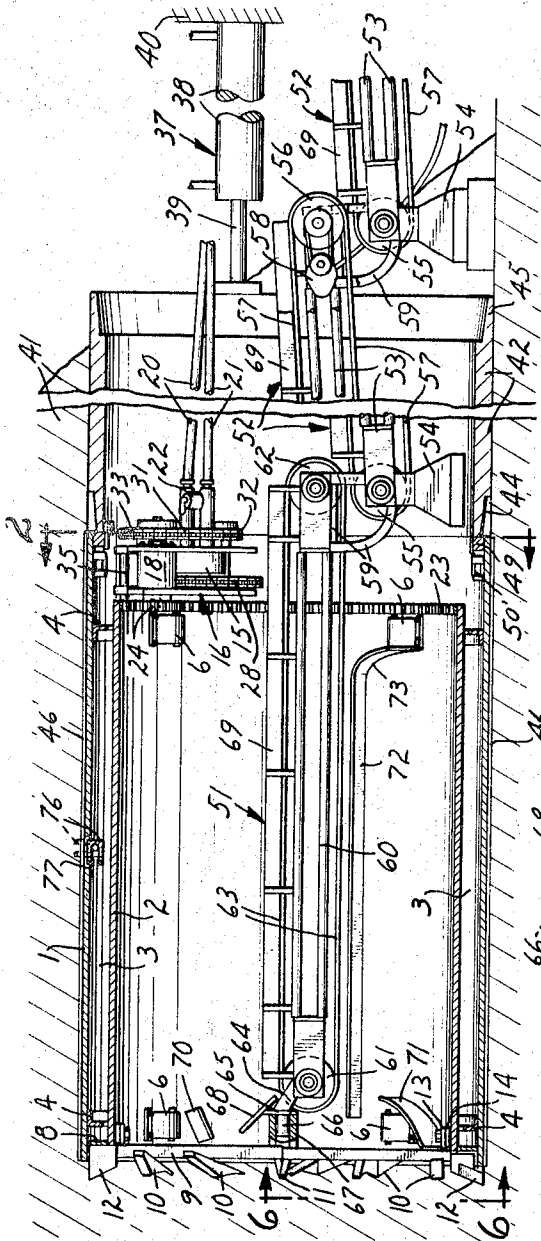


FIG. 1

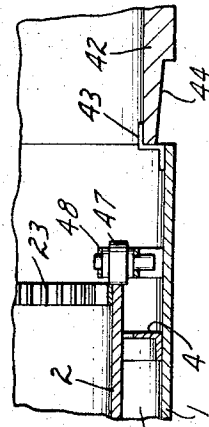


FIG. 5

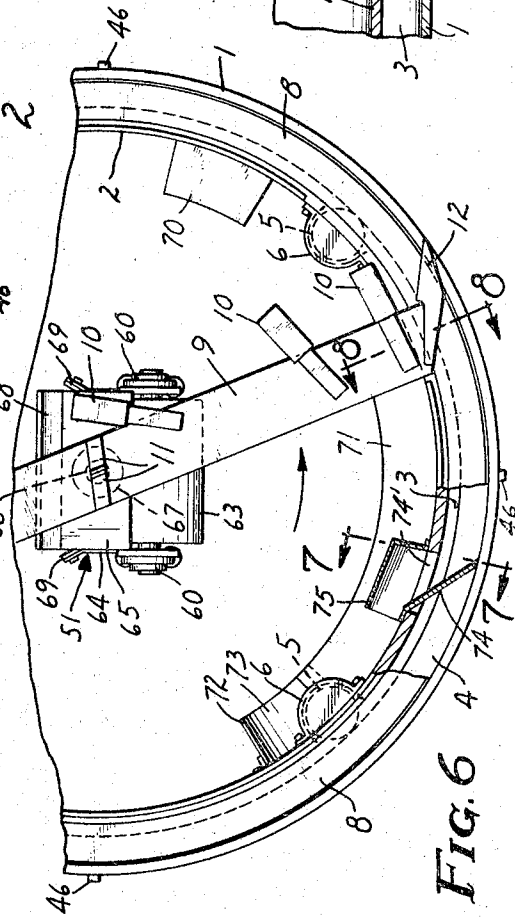


FIG. 6

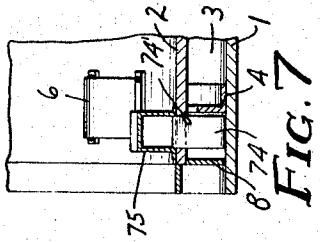


FIG. 7

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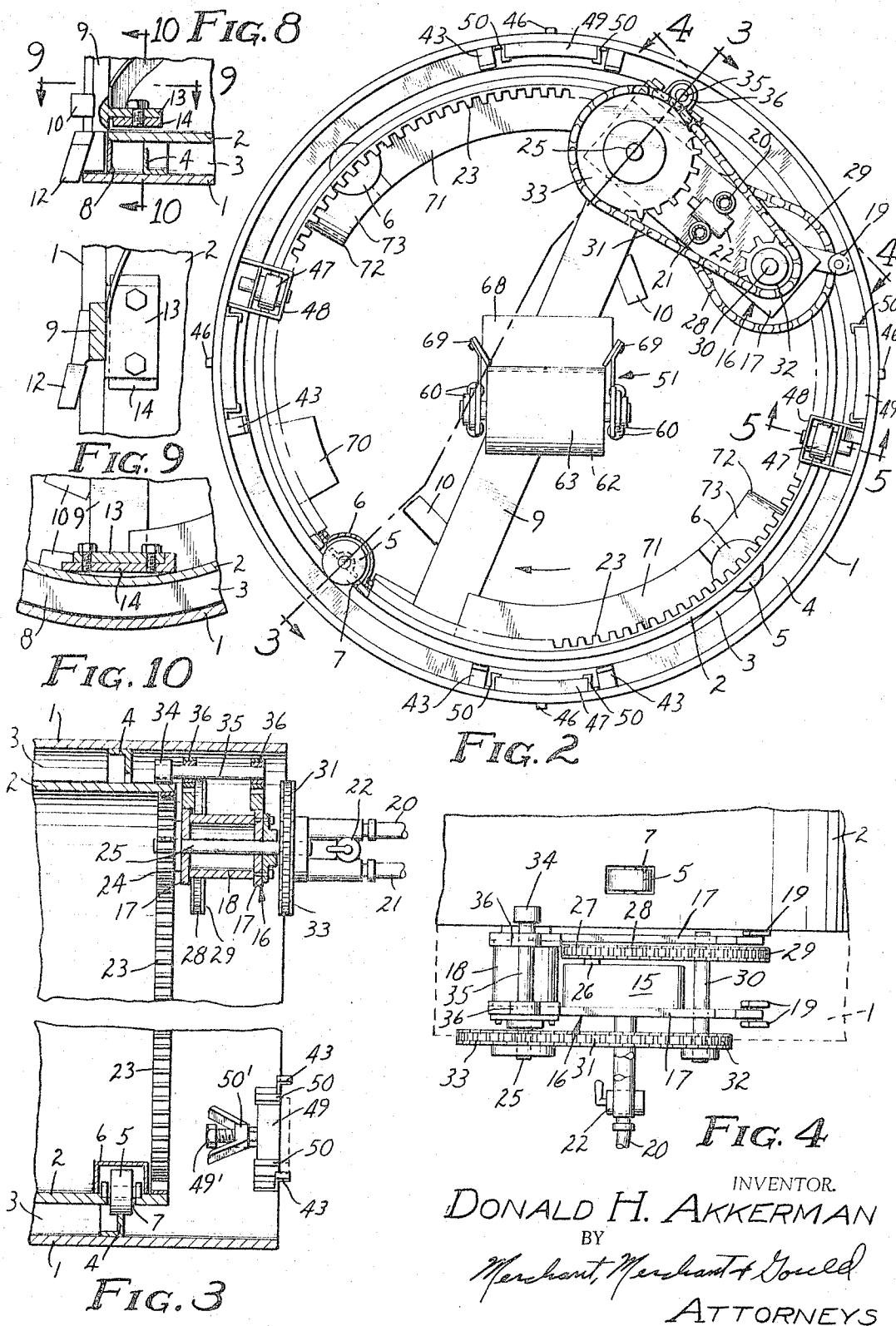
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TUNNELLING MACHINE HAVING CYLINDRICAL ROTOR AND CENTRAL CONVEYOR

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Filed June 22, 1964, Ser. No. 376,893

6 Claims. (Cl. 299—56)

My invention relates generally to earth-boring machines, and more particularly, to improvements in such boring machines for boring generally horizontally through embankments or the like for the purpose of installing culverts, tiles or like tubular conduits below ground level.

In the boring or tunnelling of the earth for the above purposes, I provide a tubular cylindrical casing having boring means at one end thereof and which is adapted to be pushed through the earth by suitable means such as jacks or the like. As the machine progresses in its subterranean movement, conduit sections, made of concrete or other suitable material, are placed behind the casing in substantial axial alignment therewith and the pressure of the jacks is applied to the last conduit section in the line to force the conduit sections and the boring machine into the tunnel cut by the boring means.

Frequently, obstructions such as large stones are encountered, these sometimes being of a size which, though they may be removed through the conduit sections, are too large to pass through the boring means at the head or front end of the boring machine casing. An important object of this invention is therefore, the provision of a boring machine having a boring bar and conveyor means which may be quickly and easily removed and replaced, and which, when the boring bar and conveyor means are removed, provides a passage for removal of such relatively large obstructions.

Another object of this invention is the provision of a boring machine which is arranged to permit easy access by the operator to the head of the tunnel being bored whereby, should an obstruction of such large size as to prevent its passage through the machine be encountered, the operator can easily apply powered rock-breaking equipment or the like to such obstruction to reduce the same to pieces of removable size.

Another object of this invention is the provision of an earth-boring machine having means whereby the direction of movement thereof through the earth may be accurately controlled.

Another object of my invention is the provision of an earth boring machine which is self-cleaning, whereby to prevent foreign material from coming between relatively movable and relatively stationary parts.

Still another object of my invention is the provision of a boring machine having means for maintaining substantially axial alignment therebetween and the conduit section immediately following the machine.

Other objects of this invention include the provision of an earth-boring machine that is relatively simple and inexpensive to produce, which is highly efficient in operation, and which is rugged in construction and durable in use while being relatively light in weight. The above, and still further highly important objects and advantages of this invention, will become apparent from the following detailed specification, appended claims, and attached drawings.

Referring to the drawings, which illustrate a commercial embodiment of the invention, and in which like reference characters indicate like parts throughout the several views:

FIG. 1 is an axial section of a boring machine produced in accordance with my invention, and illustrating its use;

FIG. 2 is an enlarged view in end elevation of my boring machine as seen from the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary section taken on the irregular line 3—3 of FIG. 2, some parts being removed;

FIG. 4 is a fragmentary section taken substantially on line 4—4 of FIG. 2;

FIG. 5 is a fragmentary section taken on the line 5—5 of FIG. 2;

FIG. 6 is an enlarged efragmentary view in end elevation as seen from the line 6—6 of FIG. 1, some parts being broken away and some parts being shown in section;

FIG. 7 is a fragmentary section taken on the line 7—7 of FIG. 6;

FIG. 8 is a fragmentary section taken substantially on the line 8—8 of FIG. 6;

FIG. 9 is a view partly in plan and partly in section, taken on the line 9—9 of FIG. 8; and

FIG. 10 is a fragmentary section taken on the line 10—10 of FIG. 8.

In the preferred embodiment of the invention illustrated, an earth-boring machine is shown as including an open ended tubular cylindrical casing 1 and an open-ended tubular cylindrical rotor 2 disposed concentrically within the rotor 1, the casing and rotor cooperating to define an annular space 3 therebetween. The cylindrical casing 1 is provided with a pair of axially spaced radially inwardly projecting annular flanges 4, each of which is disposed adjacent an opposite end of the rotor 2. The flanges 4 serve as strengthening members for the cylindrical casing 1 and as annular rails that engage peripheral surface portions of circumferentially spaced rollers 5 that are journaled within housings 6 bolted or otherwise rigidly secured to opposite end portions of the rotor 2, the rollers 5 projecting radially outwardly through openings 7 in the rotor 2, see particularly FIGS. 2 and 3. At its front end, the rotor 2 is provided with a radially outwardly projecting annular flange 8, the outer peripheral edge of which is closely spaced from the inner surface of the casing 1, the spacing therebetween affording only working clearance. The flange 8 is effective in excluding foreign matter from entering the annular space 3 during the boring operation of the machine.

An elongated generally rectangular boring bar 9 extends diametrically across the front end of the rotor 2, and has welded or otherwise rigidly secured thereto a plurality of longitudinally spaced boring teeth or bits 10, a pair of central teeth 11 and end teeth 12, the end teeth 12 describing a circle having a diameter substantially equal to the outer diameter of the casing 1. Adjacent its opposite ends, the boring bar 10 is provided with rearwardly projecting anchoring flanges 13 that are bolted or otherwise releasably anchored to cooperating pads 14 welded or otherwise rigidly secured to the front end portion of the rotor 2.

Means for imparting rotation to the tubular rotor 2 and boring bar 9 relative to the casing 1, comprises a motor 15 that is mounted in a frame 16 including a pair of spaced parallel platelike arms 17 and a tubular connector 18 welded at its opposite ends to the arms 17 at one end thereof. At their opposite ends, the arms 17 are pivotally secured to mounting brackets or ears 19 that are welded or otherwise rigidly secured to the inner surface of the casing 1 rearwardly of the rear end of the rotor 2. It will be noted that the rear end of the rotor 2 is disposed axially inwardly of the adjacent end of the casing 1, see FIGS. 1 and 3—5. For the purpose of the present example, the motor 15 is a conventional hydraulic motor, being connected to a source of fluid under pressure, not shown, by a fluid conduit 20, and to a fluid reservoir, not shown, by a return conduit 21. A conventional control valve 22

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is utilized to control operation of the motor 15. At its rear end, the rotor 2 is provided with an internal gear or the like 23, that has intermeshing engagement with an externally toothed drive member, such as a gear 24 that is mounted fast on one end of a shaft 25 suitably journaled in the frame 16 and extending through the tubular cross member 18. The motor 15 has an output shaft 26 on which is mounted a sprocket wheel 27 over which is entrained an endless link chain 28 that runs over a second sprocket wheel 29 fast on a jackshaft 30 that is journaled in the arms 17 of the frame 16. A second endless link chain 31 is entrained over a sprocket 32 fast on the shaft 30 and a cooperating sprocket wheel 33 fast on the opposite end of the shaft 25. It will be noted that the axes of the shafts 25, 26 and 30 are parallel to the common axis of the casing 1 and rotor 2, as is the axis of pivotal connection of the frame 16 to the gears 19, the frame 16 being so disposed that upon swinging movements thereof about the axis of its connection to the ears or brackets 19 will cause the gear 24 to move into or out of meshing engagement with the internal teeth 23. A roller 34 is mounted on one end of a shaft 35 that is journaled in bearings 36 on the frame 16 above the cross member 18, the roller 34 having rolling contact with the outer surface of the rotor 2 at its rear end portion to hold the gear 24 in meshing engagement with the gear teeth 23 of the rotor 2.

As shown in FIG. 1, any suitable means may be utilized to impart forward movement to the boring machine during the boring operation. For the purpose of the present example, I provide one or more fluid pressure operated jacks 37 involving a cylinder 38 and a cooperating piston-equipped plunger rod 39 which may be interposed between the rear end of the casing 1 and a suitable base of resistance shown more or less diagrammatically at 40. Although only one jack 37 is shown, it may be assumed that any desired number thereof may be circumferentially spaced about the rear end of the cylinder 1 to impart forward tunneling movements thereto through the earth, as indicated by reference character 41. As the machine advances a predetermined distance into the earth, the jacks 37 are retracted and a culvert section 42 is interposed between the rear end of the casing 1 and the jacks 37. The jacks 37 are then re-applied to the rear end of the conduit or culvert section 42 and the same is pushed forwardly into the earth with the boring machine. As shown particularly in FIGS. 2 and 5, a plurality of circumferentially spaced clips or brackets 43 are welded or otherwise rigidly secured to the rear end of the casing 1 for engagement with the adjacent end of the culvert section 42 to maintain the casing 1 and culvert section 42 substantially in axial alignment. As is common with culvert sections of this type, the front end of the culvert section 42 is provided with a diametrically reduced portion 44, the rear end thereof being formed to provide a recessed portion 45 for nestingly receiving the reduced front end portion of a succeeding portion, not shown.

Inasmuch as the motor 15 is mounted in the casing 1, rotary power applied to the rotor 2 and the load exerted thereagainst by the digging action of the boring bar 9, tends to impart counter rotation of the casing 1, which counter rotation is at least partially hindered by frictional engagement of the surrounding earth against the outer surface of the casing 1. As an aid is positively holding the casing against counter rotation, I provide a plurality of circumferentially spaced longitudinal skid rails 46 that are welded or otherwise rigidly secured to the outer surface of the casing 1 and which operate as keys to hold the casing against rotation in the earth. Further, to counteract the rearward axial thrust against the rotor 2 as the machine is moved forwardly through the ground, I provide a plurality of circumferentially spaced thrust roller bearings 47 that are journaled in bearing brackets 48 welded to the inner surface of the casing 1 rearwardly

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of the rotor 2, the rollers 47 engaging the rear end of the rotor 2, see particularly FIGS. 2 and 5.

A plurality of circumferentially spaced abutment elements or blocks 49 are axially slidably mounted between guide rails 50 at the rear end portion of the casing 1 and are adapted to engage circumferentially spaced portions of the reduced front end 44 of a following culvert section 42. Each abutment element 49 is backed-up by an adjustment screw or the like 49' that is screw threaded through a nut element 50' welded or otherwise rigidly secured to the inner surface of the casing 1 adjacent the rear end thereof. The front end 44 of the following culvert section 42 operatively engages the rear end of the casing 1 through the abutment elements 49 to impart advancing movement to the earth boring machine as the culvert section 42 is moved forwardly by operation of the jacks 37. As shown by full and dotted lines in FIG. 3, each adjustment screw 49' may be adjusted to move its respective abutment element 49 forwardly or rearwardly with respect to the casing 1. Hence, by adjusting selective ones of the abutment elements either forwardly or rearwardly, the casing 1 may be made to veer upwardly or downwardly, or to the right or left as desired, during movement thereof through the earth. Thus, correction may be made for any deviation which might occur during the tunnelling operation.

As the rotor 2 and the boring bar 9 rotate to cause the boring bits 10-12 to dig into the earth, the loosened earth falls into the interior of the cylindrical rotor 2 and is removed by endless belt conveyors 51 and 52. As shown in FIG. 1, as many conveyors 52 as required, are utilized, these being arranged in tandem with each other and with the conveyor 51. Each conveyor 52 comprises a frame 53 having a supporting base 54 at its front end, a pair of front and rear rolls 55 and 56 respectively and an endless conveyor belt 57 entrained over the rolls 55 and 56. The conveyor rolls 56, one of which is shown, are preferably driven by independent hydraulic motors 58 of conventional design. Each of the conveyor frames 53 are provided at their front ends with brackets 59 upon which rest the rear end of a preceding conveyor 52, the rear end of the conveyor 51 resting on the bracket 59 of the foremost conveyor 52 of the series thereof.

The conveyor 51 comprises a frame 60 having front and rear rollers 61 and 62 respectively journaled at the front and rear ends thereof, and an endless conveyor belt 63 entrained over the rollers 61 and 62. Although not shown, it may be assumed that the roller 62 is driven by an independent hydraulic motor in the same manner as are the conveyor belts 57. At its front end, the conveyor frame 60 includes a pair of forwardly and upwardly projecting arms 64 connected by a cross member 65 from which forwardly projects a trunnion 66 that is journaled in a tubular bearing boss or the like 67 projecting rearwardly from the central portion of the boring bar 9 on the axis of casing 1 and rotor 2. A transverse rearwardly and downwardly sloping guide plate 68 is secured to the cross member 65 to guide material toward the upper flight of the conveyor belt 63, and side retainer plates 69 are provided on the conveyors 51 and 52 to prevent material from being dislodged from the several conveyor belts 57 and 63 during removal of said material. It will be noted that the rear ends of the conveyors 51 and 52 each overlie the front end of an adjacent one of the conveyors 52 so that each thereof delivers material directly on to the next rearwardly disposed conveyor. When it is desired to remove the conveyor 51, it is only necessary that the rear end thereof be raised from engagement with the bracket 59 of the next rearwardly disposed conveyor 52 and move the conveyor 51 rearwardly to disengage the trunnion 66 from the tubular bearing boss 67. This done, the boring bar 9 may be removed by unscrewing the bolts which anchor the flanges 13 to their underlying pads 14. Thus the operator may gain free access to the earth 41 at the forward end of the tunnel made by the

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boring machine, for removal of large obstructions or for any other required purpose.

For the purpose of delivering material to the conveyor 51, I provide a pair of relatively short radially inwardly projecting feeding vanes 70, a pair relatively longer radially inwardly projecting vanes 71, the vanes 70 and 71 being rigidly secured to the inner surface of the rotor 2 and extending in a generally helical direction therein. Further, I provide a pair of longitudinal feeding vanes 72 that extend for the greater part of the length of the rotor 2 and which carry material upwardly responsive to rotation of the rotor 2, and dump the same on to the upper flight of the conveyor belt 63. Preferably, the feeding vanes 70-72 are disposed in circumferentially spaced relationship relative to each other, the vanes of each pair thereof being substantially diametrically opposed. During the digging operation, most of the material dug by the boring bits 10 is delivered to the guide plate 68 by the vanes 70 and 71 and the forward end portions of the vanes 72, the rear ends of the vanes 72 being curved as at 73 to prevent the excavated material from reaching the internal gear teeth 23.

During the boring operation, it is possible that some of the finer particles of the dug material might enter the annular space 3 between the outer edge of the flange 8 and the surrounding portion of the casing 1 where the material might reach the forwardly disposed rollers 5 and cause undue wear thereof. For the purpose of removing such material, I provide a scraper blade 74 welded or otherwise secured at one end to the rotor 2 adjacent the forward ends thereof, see particularly FIGS. 6 and 7. The scraper blade extends angularly outwardly through an opening 74' in the rotor 2, the outer end of the blade 74 engaging the inner surface of the casing 1 between the flange 8 and the adjacent flange 4. A hood 75 overlies the opening 74' and opens rearwardly with respect to the direction of rotation of the rotor 2 to permit material picked up by the blade 74 to be disposed radially inwardly of the rotor 2 and to prevent excavated material from entering the annular space 3 radially outwardly through the opening 74'.

With reference to FIG. 1, it will be seen that a conventional shackle 76 is pivotally secured to the casing 1 for swinging movements through an opening 77 therein between an inoperative storage position shown by full lines, and an operative position shown by dotted lines. The shackle 76 may be attached to any suitable means such as a hoist or the like, not shown, whereby the machine may be easily moved to the point of operation, or transported away therefrom.

From the above, it will be seen that, by mounting a drive motor 15 for the rotor 2 at one side of the casing 1 and at the rear end of the rotor 2, the interior of the rotor 2 is left open and provides a maximum of room for entry into the rotor by the operator, even when the conveyor 51 is in place in the rotor. Thus, during the boring operation, the operator may sit or lie in a culvert section 42 immediately behind the boring machine and observe and control the operation of the machine, with the aid of suitable lighting means and control mechanism for the motor 15, said lighting means and control mechanism being conventional and not shown. Hence, in the event of trouble, or when the boring machine emerges from an embankment at the end of the boring operation, the operator can immediately stop the motor 15 before damage occurs to the machine. However, should the boring bar 9 or the teeth thereof be damaged during the boring operation, it is a relatively simple matter for the operator to enter the rotor 2 and remove the conveyor 51 and the boring bar 9 for replacement of the boring bar 9, without the necessity of removing the entire machine from the tunnel made thereby.

While I have shown and described a commercial embodiment of my earth boring machine, it will be understood that the same is capable of modification without

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departure from the spirit and scope of the invention, as defined in the claims.

What I claim is:

1. In an earth boring machine:

- (a) a cylindrical open ended casing disposed on a generally horizontal axis,
- (b) an open ended cylindrical rotor of slightly less diameter than said casing disposed concentrically within said casing and having a front end disposed adjacent one end of said casing and a rear end axially inwardly spaced a short distance from the other end of said casing,
- (c) means mounting said rotor for rotation in said casing on the common axis thereof,
- (d) a boring bar extending diametrically of said rotor and releasably anchored at its opposite ends to the front end of said rotor for common rotation therewith,
- (e) a plurality of boring bits on said boring bar projecting forwardly of the adjacent end of said casing,
- (f) rotor driving means mounted on said casing in close proximity to the inner surface of said casing and remotely of the axis thereof adjacent the rear end of said rotor for imparting rotation to said rotor and boring bar relative to said casing,
- (g) a conveyor including a relatively stationary frame extending longitudinally of said casing and rotor,
- (h) means on said frame and said boring bar centrally of its ends releasably pivotally supporting the adjacent end of said stationary frame independently of said casing and rotor,
- (i) and means disposed longitudinally outwardly of said rear end of the rotor for supporting the opposite end of said conveyor frame.

2. The earth boring machine of claim 1 in which said means releasably pivotally supporting said adjacent end of the conveyor frame comprises a tubular member and a stub shaft one on said boring bar and the other on said frame, said stub shaft being axially slidably and rotatably received in said tubular member.

3. In an earth boring machine:

- (a) concentric open-ended outer and inner cylindrical tubular members normally disposed on a generally horizontal axis and comprising respectively a casing member and a rotor member having adjacent front ends,
- (b) said rotor member having a rear end axially inwardly spaced a short distance from the adjacent rear end of said casing member,
- (c) said members cooperating to define an annular space, one of said members having an annular flange at its front end portion substantially closing said annular space at one end thereof and having working clearance with the other of said members,
- (d) a plurality of rollers mounted on one of said members in said annular space and operatively engaging the other of said members to support said rotor member for rotation relative to said casing member on the axis of said members,
- (e) a boring bar extending diametrically of said rotor member and releasably anchored at its opposite ends to the front end of said rotor member for common rotation therewith,
- (f) a plurality of boring bits on said boring bar projecting forwardly of the adjacent end of said casing,
- (g) rotor driving means mounted on said casing member adjacent the rear end of said rotor member for imparting rotation to said rotor member and boring bar relative to said casing member,
- (h) a conveyor including a relatively stationary frame extending longitudinally of said casing member and rotor,
- (i) means on said frame and said boring bar centrally of its ends releasably pivotally supporting the adja-

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cent end of said stationary frame independently of said casing and rotor members,

- (j) and means disposed longitudinally outwardly of the rear end of said rotor member for supporting the opposite end of said conveyor frame.

4. The earth boring machine of claim 3 in which said rotor driving means comprises:

- (a) a motor,
- (b) a toothed wheel driven by said motor,
- (c) circumferentially spaced internal teeth on the rear end portion of said rotor member,
- (d) mounting means including a pivot mounting said motor and toothed wheel on said casing member intermediate the rear ends of said casing and rotor members for movements of said toothed wheel toward and away from meshing engagement with said internal teeth,
- (e) and a roller mounted on said mounting means and engaging the outer surface of said rotor member to hold said toothed wheel in meshing engagement with said internal teeth.

5. The earth boring machine of claim 3 further characterized by a scraper element on said rotor member and

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disposed within said annular space adjacent said annular flange, said rotor member having an opening therethrough adjacent said scraper element, said scraper element being responsive to rotation of said rotor member to engage material entering said space through said working clearance and discharge said material through said opening in the rotor member.

6. The earth boring machine of claim 3 in which said rollers are operatively journaled on said rotor member, said casing member including a pair of radially inwardly projecting annular flanges providing tracks for said rollers and stiffening portions for said casing member intermediate the ends of said rotor member.

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