June 22, 1965 E. A. CHRISTENSEN 3,190,376

BORING HEAD

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Fig. 1

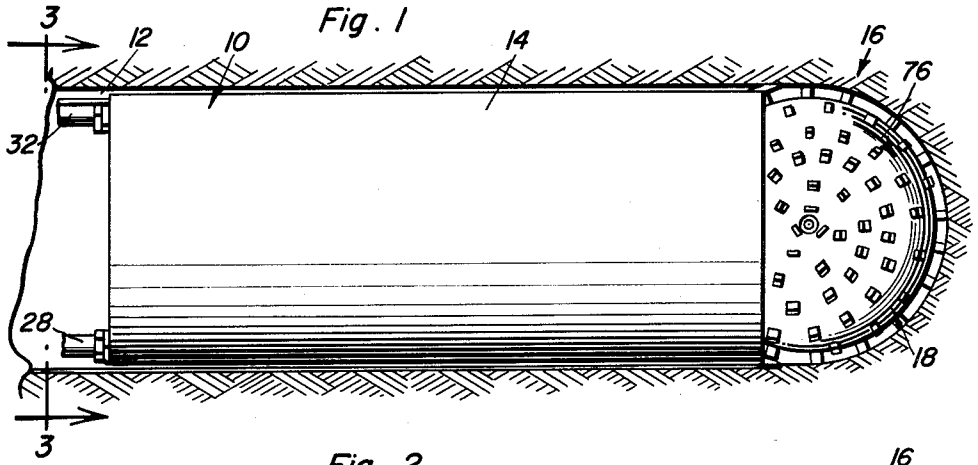


Fig. 2

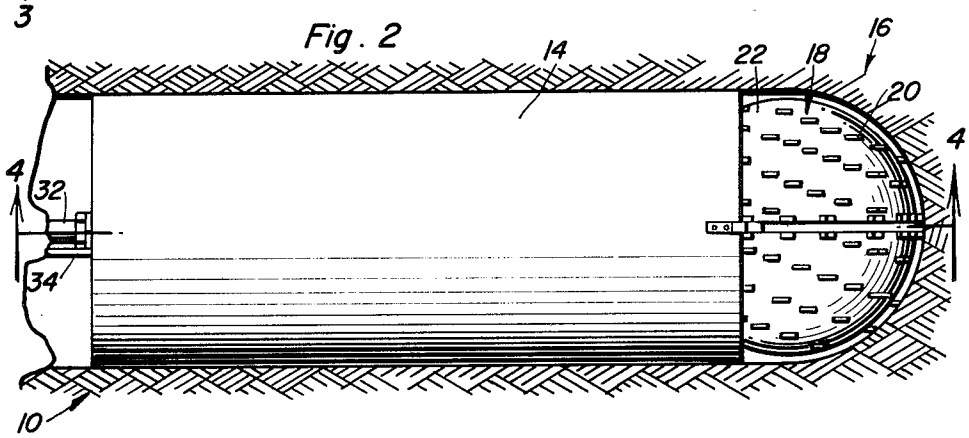


Fig. 3

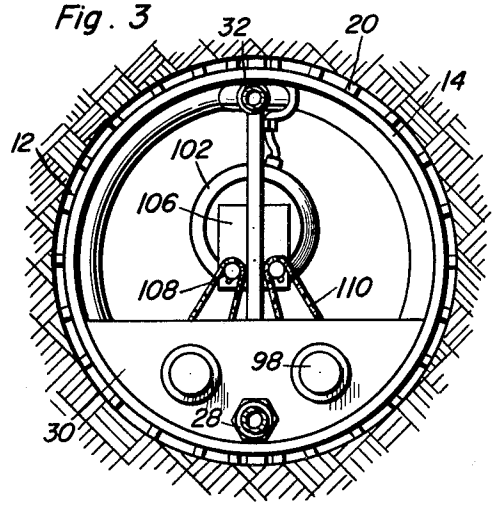
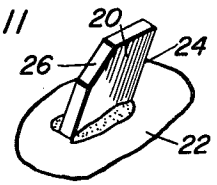


Fig. 11



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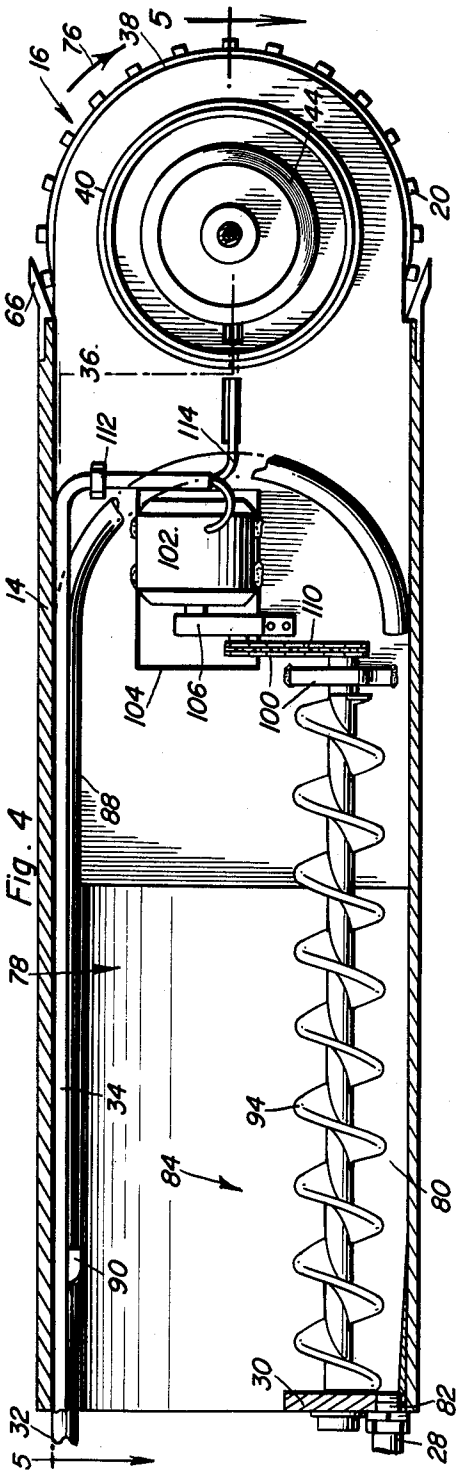


Fig. 4

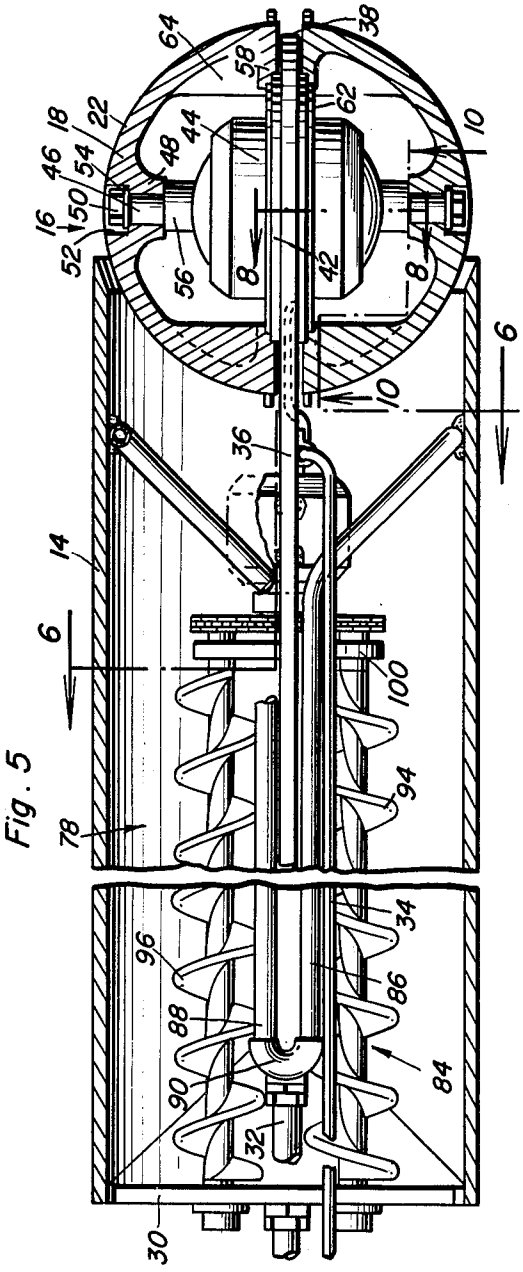


Fig. 5

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Fig. 6

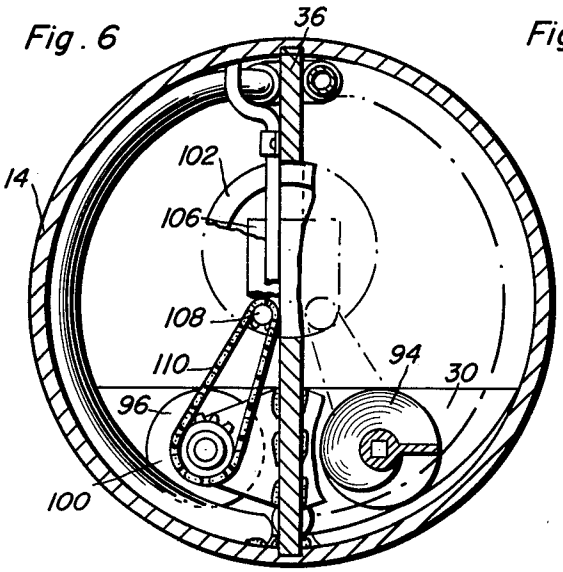


Fig. 12

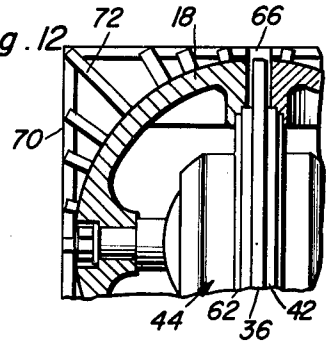


Fig. 13

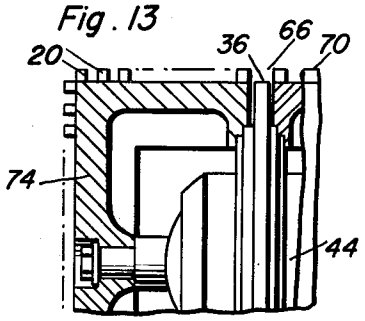


Fig. 10

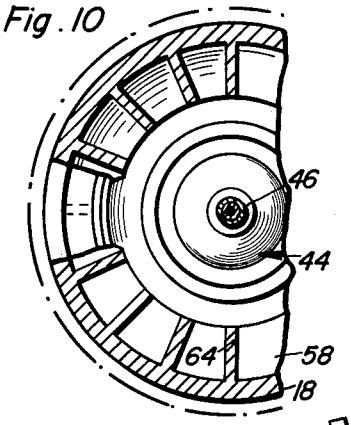


Fig. 8

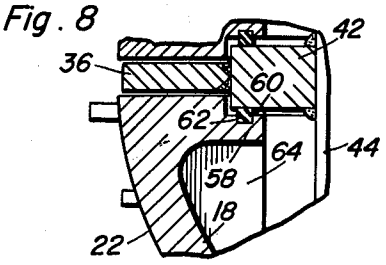


Fig. 9

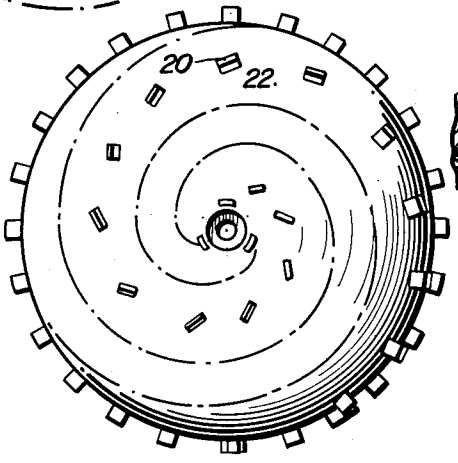
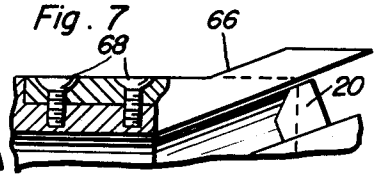


Fig. 7



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3,190,376

BORING HEAD

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Filed Jan. 30, 1962, Ser. No. 169,833
17 Claims. (Cl. 175—102)

This invention relates to an earth boring device of the rotary type and is particularly concerned with the formation of tunnels or passageways in a horizontal direction as for example under roadways so as to avoid the digging of open ditches thereacross.

In accordance with the purpose for the earth boring device of the present invention, it is a primary objective of the present invention, to provide an earth boring device operative in a novel manner to more rapidly and more efficiently form passageways through the earth of any desired cross-sectional shape.

Another object of the present invention, is to provide an earth boring tool which is inherently less likely to become damaged because of impact loads or overloads.

A further object of this invention in accordance with the foregoing objects, is to provide an earth boring device which is more efficiently operative because of a direct connection between its power source and the boring head and further because of a reduced back-up pressure of the earth dislodged and displaced by the boring head.

An additional object of this invention in accordance with the foregoing objects, is to provide a boring device which is operative to more rapidly remove solid, particulate material such as the earth excavated in forming the passageway or tunnels by conditioning the dislodged and displaced earth for more rapid removal by rendering said earth more fluent prior to removal thereof through the earth boring device. In accordance with this latter attribute of the present invention, more rapid removal is made possible by the utilization of suction pressure and further by virtue of the direct connection between the boring head motor and the boring head thereby operating at higher speeds.

A still further object of the present invention is to provide a boring device operative in accordance with the foregoing principles, and capable by the proper selection of certain parts thereof, to form passageways of any desired cross-sectional shape.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a side elevational view of one form of earth boring device in operative position excavating a horizontal tunnel.

FIGURE 2 is a top plan view of the earth boring device illustrated in FIGURE 1.

FIGURE 3 is a rear end view of the earth boring device as viewed from a plane indicated by section line 3–3 of FIGURE 1.

FIGURE 4 is a longitudinal sectional view of the earth boring device taken through a plane indicated by section line 4–4 of FIGURE 2.

FIGURE 5 is a sectional view through the earth boring device taken through a plane indicated by section line 5–5 in FIGURE 4.

FIGURE 6 is a transverse sectional view taken substantially through a plane indicated by section line 6—6 in FIGURE 5.

FIGURE 7 is an enlarged partial sectional view of a portion of the boring device.

FIGURE 8 is an enlarged partial sectional view taken substantially through a plane indicated by section line 8–8 in FIGURE 5.

FIGURE 9 is an enlarged diagrammatic view illustrating the arrangement of cutting teeth on a boring head hub rotor.

FIGURE 10 is a partial sectional view taken substantially through a plane indicated by section line 10–10 in FIGURE 5.

FIGURE 11 is an enlarged perspective view of a cutting tooth element utilized on the boring device.

FIGURE 12 is a partial front transverse sectional view illustrating a modified form of earth boring device.

FIGURE 13 is a partial sectional view similar to that of FIGURE 12 illustrating a second modified form of earth boring device.

Referring now to the drawings in detail, an earth boring device generally referred to by reference numeral 10 is illustrated in FIGURES 1, 2 and 3 in the process of forming a horizontal tunnel or passageway 12 beneath the surface of the earth. The earth boring device 10 includes therefore an outer casing member generally referred to by reference numeral 14, the cross-sectional shape of which corresponds to the cross sectional shape of the tunnel 12 being formed. In the example illustrated, the tunnel 12 being formed is circular in cross section so that the casing member 14 will be cylindrical in shape. Accordingly, the casing member 14 mounts forwardly thereof a projecting boring head assembly generally referred to by reference numeral 16 which includes a pair of rotatable rotor hubs 18 mounted for rotation about a horizontal axis fixed with respect to the casing member 14 but disposed forwardly thereof and extending at an angle transversely to the longitudinal axis of the casing member. The rotor hub members 18 in the illustrated embodiment, are substantially semispherical in shape and have externally mounted thereon a plurality of earth cutting means 20 one of which is more clearly shown in FIGURE 11. The teeth 20 may accordingly be welded to the external surface 22 of its rotor and includes a radially extending straight leading edge 24 with respect to the rotational direction of the hub member 18 and a trailing edge including a beveled surface portion 26. In the illustrated embodiments of FIGURES 1, 2 and 3, all of the cutting teeth elements 20 will be of equal radial length in order to form the passageway 12 which is circular in cross section. Also, extending through the passageway rearwardly of the earth boring device 10, is an earth removal suction hose 28 which is connected by a suitable fitting to a material retaining plate member 30 connected to the rear end of the casing member 14 across the bottom portion thereof and as more clearly seen in FIGURE 3. Also, extending into the casing member 14 diametrically opposite the suction hose 28, is a water inlet hose 32 by means of which water under pressure is supplied to the device 10 for purposes to be hereafter explained. Located adjacent to the water inlet hose 32, and also extending into the tubular casing member 14, is an electrical conduit cable 34. It will be appreciated that the hose conduit 28 and 32 as well as the electrical cable 34, are flexible and extend a considerable distance for connection to apparatus located above ground including suction generating equipment to which the suction hose 28 is connected, water pumping mechanism to which the water supply hose 32 is connected and an electrical power supply to which the electrical cable 34 is connected.

Referring now to FIGURES 4 and 5 in particular, it will be observed that the boring head assembly 16 disposed forwardly of the tubular casing member 14, includes a vertically disposed mounting plate 36 which is

welded internally of the tubular casing member 14 throughout a substantial longitudinal length thereof, and projects forwardly therefrom terminating in a semi-circular edge portion 38. A circular opening 40 is formed adjacent the forward end of the mounting plate member 36 and receives therewithin a gusset plate 42 as more clearly seen in FIGURE 8. The mounting plate member 36 is welded to the gusset plate 42 which in turn is welded to the outer casing of a boring head motor 44 thereby fixedly mounted by the mounting plate 36 forwardly of the tubular casing member 14. Extending from both axial ends of the motor 44, is a motor shaft 46 to which the rotatable boring hubs 18 are connected. It will be observed, that the boring hubs 18 being substantially semi-spherical in shape, are closely spaced from each other on opposite sides of the mounting plate member 36 and extend partially into the tubular casing member 14 to completely enclose therebetween the boring head motor 44 and form an annular inlet passage at the forward end of the casing member. Accordingly, each of the boring hubs 18 includes an internally projecting boss portion 48 rigidly connected by any suitable keying means to the projecting motor shaft 46, the remote ends of which are threaded to receive an assembly nut 50 spaced from the seat of a central recess 52 in the external surface 22 of the hub 18 by means of the washer element 54. The internally projecting boss portion 48 accordingly is shouldered against the bearing portions 56 of the motor 44. Accordingly, energization of the motor 44 will cause rotation of the boring hub 18 about a horizontal axis spaced forwardly of the tubular casing member 14 and extending in perpendicular intersecting relation to a longitudinal axis through the tubular casing member 14. Further, in order to maintain the motor 44 protected within the enclosure of the hub members 18, the hub members are provided with annular confronting rim portions 58. The annular rim portions 58 are therefore provided with an annular recess portion 60 which mount an annular seal ring 62 as more clearly seen in FIGURE 8 for wiping engagement with the gusset plate 42 fixed to the outer casing of the motor 44. Accordingly, the motor 44 will be enclosed in a fluid tight manner within and between the boring hub members 18, the annular rim portions 58 of which are closely spaced from each other on opposite sides of the mounting plate member 36. Also, projecting radially inwardly and internally within the boring hub members 18 are a plurality of spaced cooling fins 64 as more clearly seen in FIGURES 5, 8 and 10 operative to more efficiently dissipate the heat generated by operation of the electric motor 44.

As more clearly seen in FIGURES 4 and 7, the forward end of the tubular casing member 14 is provided with a pair of recesses to which a pair of scarfing tooth elements 66 are secured by any suitable fasteners 68. The scarfing tooth elements 66 are thereby aligned in the plane of the mounting plate member 36 for overlying the space between the boring rotors or hubs 18. The scarfing tooth elements 66 are thereby operative to excavate the earth between the rotor hubs 18 inasmuch as no cutting teeth elements 20 will be available for such purpose. The scarfing tooth elements 66 are however angled radially outwardly so as to just clear the projecting teeth element 20 inasmuch as said scarfing elements 66 should preferably overlap the spacing between the rotor hub members 18. It will also be observed from FIGURE 9 in particular, that the earth cutting teeth elements 20 are located on the external surface 22 of the rotor hub member 18 in a spiral arrangement with respect to the rotational axis. This arrangement will reduce the possibility of the boring head assembly 16 in being subjected to undue impact loads, tending instead to displace the entire boring device 10.

In the foregoing description of the boring head assembly, it will be observed that the semi-spherical shape of the rotor hub members 18 mounting cutting teeth of equal radial length, will be operative to cut a tunnel which is circular in cross-section corresponding to the circular cross-section of the tubular casing member 14. It will be appreciated, however, that tunnel passages may be formed of other cross sectional shapes including ovals and geometrically flat sided shapes. For example, as shown in FIGURE 12, the cylindrical type tubular casing 14 may be replaced by a tubular casing 70 that is square in cross-section. Accordingly, when utilizing a semi-spherical boring hub 18, the earth cutting teeth 72 will necessarily be of different radial lengths so as to cut the cross sectionally square formation. It will be further appreciated from FIGURE 12, that different variations in the length of the cutting teeth 72 may produce oval variations of the circular cross-section as described with respect to the device 10 illustrated in FIGURES 1, 2 and 3. In FIGURE 13, the same tubular casing member 70 may be utilized in association with earth cutting teeth 20 of equal length, mounted however on cylindrical type of hub rotors 74. Thus, the earth boring device of the present invention may be modified by replacement of the tubular casing member with any desired cross sectional shape associated either with cutting teeth of equal length mounted on the appropriately shaped boring hub or by mounting of cutting teeth of different lengths upon the boring hub. The wide flexibility in the cross sectional shapes of the tunnel to be bored is thereby made possible by the practice of the present invention.

As indicated by the arrows in FIGURES 1 and 4, the boring head assembly 16 is rotated in a clockwise direction so that earth will be dislodged and displaced into the tubular casing member 14 along the bottom thereof, as the boring device is moved forwardly by any suitable means as is well known in the art, such as a hydraulic jack or the like through the horizontal tunnels or passageway 12 being cut. It will be appreciated that it is essential not only to remove the displaced earth dislodged by the boring head assembly 16 so as to maintain the passageway 12 clear, but it is also necessary to remove such dislodged earth at a sufficiently rapid rate so as to prevent the back pressure thereof from impeding operation of the boring head assembly 16. Accordingly, mounted within the tubular casing 14 rearwardly of the boring head assembly 16, is an earth conditioning removal mechanism generally referred to by reference numeral 78 as more completely illustrated in FIGURES 4 and 5. The earth conditioning mechanism 78 therefore includes a mixing trough 80 disposed along the bottom portion of the tubular casing member 14 and defined forwardly of the material retaining member 30. The displaced earth will accordingly enter the trough portion 80 from the restricted, annular inlet passage at the forward end of the casing member, and be mixed with water therein and conveyed rearwardly toward the outlet opening 82 in the material retaining member 30 to which the suction hose 28 is connected. Mixing of the displaced earth not only produces a fluent mixture that may render removal of the earth by a suction hose possible but will also relieve the load and reduce the power requirement otherwise necessary in connection with earth removing conveyor assembly 84. Accordingly, water under pressure is supplied for mixing with the displaced earth by means of a pair of water supply conduits 86 and 88 which are connected by a Y-coupling 90 to the water supply hose 32. The water supply conduits 86 and 88 are therefore mounted within the tubular casing member 14 along the upper portion thereof so as to not interfere with the mixing and rearward conveyance of the earth by the conveyor assembly 84. The water supply conduit 86 and 88 extend forwardly of the tubular casing 14 on opposite sides of the mounting plate member 36 to diverge therefrom in a horizontal direction as indicated in FIGURE 5 against the side walls of the tubular casing 14 while said conduits curve downwardly, terminating at a lower end along the bottom of

the tubular casing member 14 and spaced just forwardly of the earth conditioning mechanism 78. Two jet streams of water under pressure will accordingly be discharged into the earth conveying assembly 84 on opposite sides of the mounting plate member 36. The water so discharged will not only assist in further displacing the earth rearwardly but also provide a medium with which the earth may be mixed by the conveyor assembly 84 resulting in a fluent mixture capable of being withdrawn by the suction hose 28 at the rear end of the tubular member 14.

The conveyor assembly 84 comprises a pair of auger mechanisms 94 and 96 rotatably mounted in opposite sides of the mounting plate member 36 by bearing assemblies 98 mounted in the material retaining member 30 and in the laterally extending brackets 100 welded to opposite sides of the mounting plate member 36. The auger mechanisms 94 and 96 are therefore both power driven in a direction causing displacement of materials rearwardly of the casing member 14 and will also be effective to mix the water and earth within the trough portion 80.

The auger mechanisms 94 and 96 are powered by means of an auger drive motor 102 that is fixed as by welding within a cut-out portion 104 in the mounting plate member 36 disposed above the trough portion 80 so as not to be unduly contaminated by the displaced earth. As more clearly seen in FIGURES 3, 4 and 6, the output shaft of the auger drive motor 102 is connected by a reduction gear box 106 to two output sprockets 108 each of which is drivingly connected by chain gearing 110 to the auger mechanisms 94 and 96 for rotation thereof in the proper direction. Electrical power for energizing the auger drive motor 102 is furnished through power line conductors sheathed within the electrical conduit 34 that extends rearwardly into the tubular casing member 14 adjacent to the water supply conduit 86 and is suitably anchored to the mounting plate member 36 by bracket elements 112. Also extending from the electrical conduit 34 at its forward end, is a power line conductor 114 which extends through the mounting plate member 36 to the driving motor 44 for the boring head assembly 16.

From the foregoing description, operation and utility of the novel earth boring device will be apparent. It will therefore be appreciated, that because of the absence of gearing for connecting the boring head motor to the rotor elements, damage due to unexpected impact load or overload will be avoided. Also, because of the spiral tooth arrangement and reduction in any back-up pressure of dislodged earth, resulting from the rendering of the earth fluent, less power and more efficient operation will be possible. Also, because of the more rapid removal of the dislodged earth, more rapid boring is possible. Finally, greater flexibility in the cross sectional shape of the passageway bored is possible by the selection of the casing and boring hub or tooth length.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What I claim as new is as follows:

1. An earth boring device comprising tubular casing means, mounting plate means fixed to the casing means and projecting forwardly therefrom, motor means mounted by the plate means for rotation about an axis spaced forwardly of the casing means, rotatable hub means connected to the motor means in complete enclosing relation thereto on opposite sides of the plate means and extending into and out of said casing means to form therewith an annular inlet passage, and earth cutting means externally mounted on the rotatable hub means for dislodging and displacing earth rearwardly into said casing means through said inlet passage in response to rotation of the hub means by the motor means.

2. The combination of claim 1, wherein said earth cutting means comprises a plurality cutting teeth projecting radially from the external surface of the rotatable hub means and fixed on said external surface in a spiral arrangement with respect to said rotational axis of the hub means.

3. An earth boring device for forming a sub-surface passageway comprising, tubular casing means, boring head means mounted in said casing means and projecting forwardly therefrom for dislodging and displacing earth rearwardly of said casing means along a bottom portion thereof, earth conditioning means mounted in said casing means rearwardly of the boring head means for rearwardly conveying and rendering the displaced earth fluent and earth removal means operatively connected to said casing means rearwardly of the earth conditioning means for removal of fluent earth from said casing means and the passageway formed rearwardly thereof, said boring head means comprising, mounting plate means fixed to the casing means and projecting forwardly therefrom, motor means mounted by the plate means forwardly of the casing means, rotatable hub means directly connected to the motor means in complete enclosing relation thereto on opposite sides of the plate means and extending into said casing means, and earth cutting means externally mounted on the rotatable hub means for dislodging and displacing earth rearwardly into said casing means in response to rotation of the hub means by the motor means.

4. The combination of claim 3, wherein said earth conditioning means comprises, material retaining means connected to a rear end of the casing means to form a trough along said bottom portion of the casing means, said removal means being connected to said retaining means, fluid supply means mounted in the casing means above said trough and discharging fluid rearwardly into the trough from a location between said boring head means and the earth conditioning means and conveyor means mounted in said trough for mixing and propelling the fluid and dislodged earth rearwardly displaced by the boring head means, to supply a fluent mixture to the removal means at said rear end of the trough.

5. The combination of claim 4, wherein said conveyor means comprises a pair of auger mechanisms rotatably mounted by the retaining means and mounting plate means on opposite sides of the mounting plate means within the trough, and a conveyor motor mounted by the mounting plate means above the trough and drivingly connected to said auger mechanisms.

6. The combination of claim 5, wherein said fluid supply means comprises a pair of fluid conduits extending forwardly into said casing means above said trough and on opposite sides of said mounting plate means, said conduits including fluid discharge portions extending downwardly adjacent a forward end of the casing means to terminate forwardly of said conveyor means to discharge water under pressure thereinto.

7. The combination of claim 6, wherein said earth removal means comprises a suction hose connected to said material retaining means.

8. The combination of claim 7, wherein said rotatable hub means comprises closely spaced rotors in fluid sealed relation to said mounting plate means for rotation about a rotational axis extending transversely of and disposed forwardly of said casing means, said rotors having an external surface curvature operative in association with said casing means and earth cutting means to form a passageway having a predetermined cross-sectional shape.

9. The combination of claim 8, including scarfing teeth fixedly mounted on the casing means and projecting forwardly therefrom in alignment with said mounting plate means and between said spaced rotors.

10. The combination of claim 9, wherein said earth

cutting means comprises a plurality of cutting teeth projecting radially from the external surface of the rotatable hub means and fixed on said external surface in a spiral arrangement with respect to said rotational axis of the hub means.

11. An earth boring device comprising, tubular casing means, mounting plate means fixed to the casing means and projecting forwardly therefrom, motor means mounted by the plate means forwardly of the casing means, rotatable hub means directly connected to the motor means in complete enclosing relation thereto on opposite sides of the plate means and extending into and out of said casing means, and earth cutting means externally mounted on the rotatable hub means for dislodging and displacing earth rearwardly into said casing means in response to rotation of the hub means by the motor means, said rotatable hub means comprising closely spaced rotors in fluid sealed relation to said mounting plate means for rotation about a rotational axis extending transversely of and disposed forwardly of said casing means, said rotors having an external surface curvature operative in association with said casing means and earth cutting means to form a passageway having a predetermined cross-sectional shape.

12. An earth boring device comprising tubular casing means, mounting plate means fixed to the casing means and projecting forwardly therefrom, motor means mounted by the plate means forwardly of the casing means, rotatable hub means directly connected to the motor means in complete enclosing relation thereto on on opposite sides of the plate means and extending into said casing means, earth cutting means externally mounted on the rotatable hub means for dislodging and displacing earth rearwardly into said casing means in response to rotation of the hub means by the motor means, and scarfing teeth fixedly mounted on the casing means and projecting forwardly therefrom in alignment with said mounting plate means.

13. An earth boring device for forming a sub-surface passageway comprising, tubular casing means, boring head means mounted in said casing means and projecting forwardly therefrom for dislodging and displacing earth rearwardly of said casing means along a bottom portion thereof, earth conditioning means mounted in said casing means rearwardly of the boring head means for rearwardly conveying and rendering said displaced earth fluent and earth removal means operatively connected to said casing means rearwardly of the earth conditioning means for removal of fluent earth from said casing means and the passageway formed rearwardly thereof, said earth conditioning means comprising, material retaining means connected to a rear end of the casing means to form a trough along said bottom portion of the casing means, said removal means being connected to said retaining means, fluid supply means mounted in the casing means above said trough and discharging fluid rearwardly into the trough from a location between said boring head means and the fluid conditioning means, and conveyor means mounted in said trough for mixing and propelling the fluid and dislodged earth rearwardly displaced by the boring head means, to supply a fluent mixture to the removal means at said rear end of the trough.

14. The combination of claim 13, wherein said conveyor means comprises a pair of auger mechanisms rotatably mounted by the retaining means within the trough, and a conveyor motor mounted above the trough and drivingly connected to said auger mechanisms.

15. An earth boring device for forming a sub-surface passageway comprising tubular casing means, boring head means mounted in said casing means and projecting forwardly therefrom for dislodging and displacing earth rearwardly of said casing means along a bottom portion thereof, earth conditioning means mounted in said casing means rearwardly of the boring head means for rearwardly conveying and rendering said displaced earth fluent and earth removal means operatively connected to said casing means rearwardly of the earth conditioning means for removal of fluent earth from said casing means and the passageway formed rearwardly thereof, said earth conditioning means comprising, material retaining means connected to a rear end of the casing means to form a trough along said bottom portion of the casing means, said removal means being connected to said retaining means, fluid supply means mounted in the casing means above said trough and discharging fluid rearwardly into the trough from a location between said boring head means and the fluid conditioning means, and conveyor means mounted in said trough for mixing and propelling the fluid and dislodged earth rearwardly displaced by the boring head means, to supply a fluent mixture to the removal means at said rear end of the trough, said fluid supply means comprising a pair of fluid conduits extending forwardly into said casing means above said trough and on opposite sides of said mounting plate means, said conduits including fluid discharge portions extending downwardly adjacent a forward end of the casing means to terminate forwardly of said conveyor means to discharge water under pressure therein.

16. A boring device comprising tubular casing means having a longitudinal axis, mounting means fixed to the casing means, motor means mounted by the mounting means, rotatable hub means mounted in spaced relation to the casing means to form a restricted inlet passage therewith, means drivingly connecting the motor means to the hub means for rotation thereof about an axis extending forwardly of the casing means at an angle to the longitudinal axis thereof, and cutting means externally mounted on the rotatable hub means for dislodging and displacing earth rearwardly into said casing means through said inlet passage in response to rotation of the hub means by the motor means, said hub means comprises two hemispherical shells disposed in back to back relationship whereby said inlet passage is annular in cross section.

17. In a boring device having a tubular casing, a motor fixedly mounted by the casing, a pair of closely spaced rotors, means fixed to the casing for rotatably mounting the rotors in positions projecting forwardly from the casing to form a restricted annular inlet passage therewith, means drivingly connecting the rotors to the motor for rotation of the rotors about an axis extending transversely of the casing, cutting means externally mounted on said rotors for movement rearwardly into the casing through said inlet passage, said rotors having an external surface curvature from which the cutting means project to cut a passageway of a predetermined cross-sectional shape.

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CHARLES E. O'CONNELL, *Primary Examiner.*