United States Patent

Smith, Jr. et al.

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[45] **Mar. 28, 1972**

[54] METHOD OF AND APPARATUS FOR BORING HOLES UNDER STREETS, HIGHWAYS OR THE LIKE

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[73] Assignee: **said Smith, by said Koen**

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[52] **U.S. Cl.** **173/24**, 175/53, 175/62

[51] **Int. Cl.** **E21c 11/02**, E21c 19/00

[58] **Field of Search** 175/62, 53, 122; 173/24

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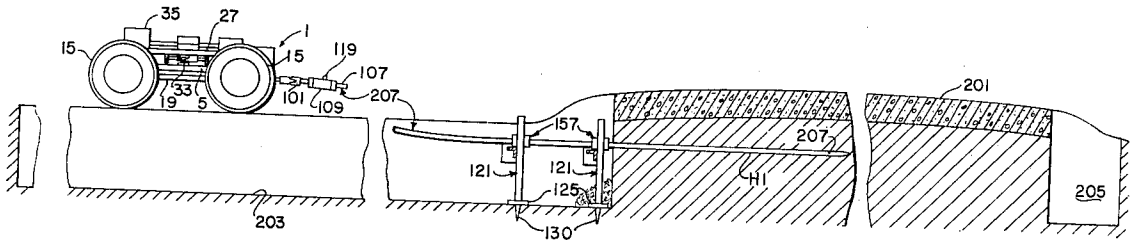
Primary Examiner—James A. Leppink

Attorney—Koenig, Senniger, Powers, and Leavitt

[57] **ABSTRACT**

Apparatus for boring a hole generally horizontally through the ground underneath an existing structure such as a highway, street, railroad line, building, etc., operating from above ground level at one side of the structure, involving a vehicle having an engine for its propulsion and for rotating a string of boring rod.

8 Claims, 16 Drawing Figures



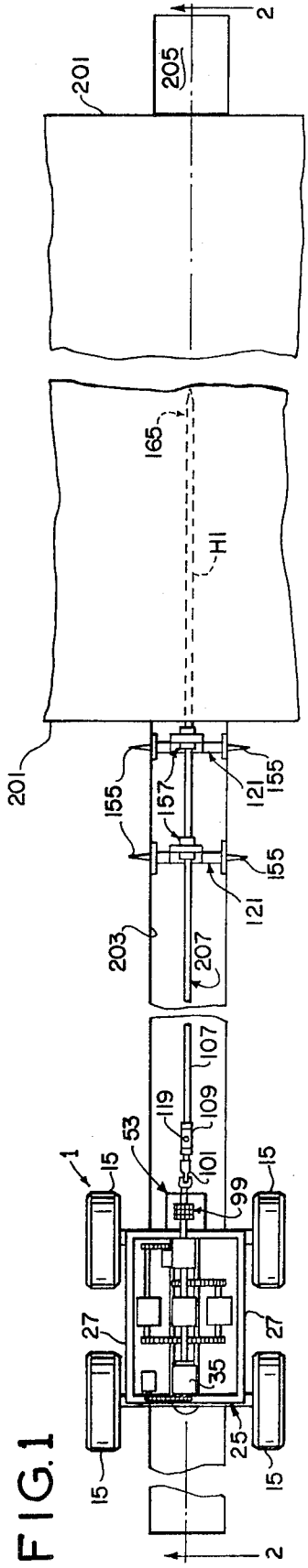


FIG. 1

FIG. 3

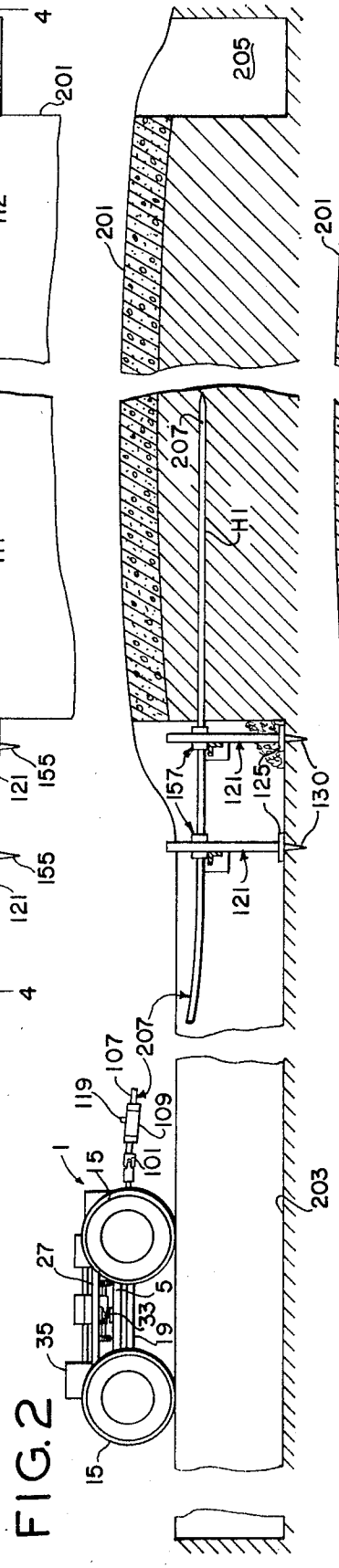


FIG. 2

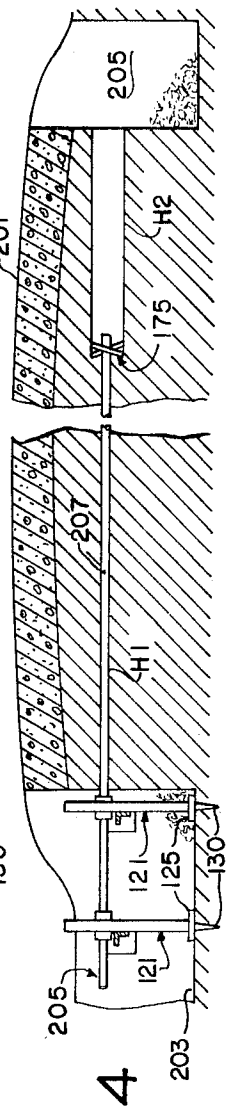


FIG. 4

FIG. 5

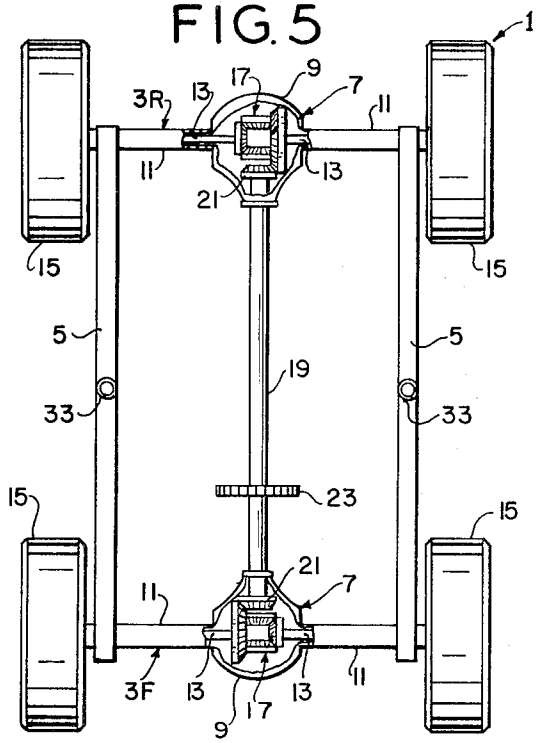


FIG. 6

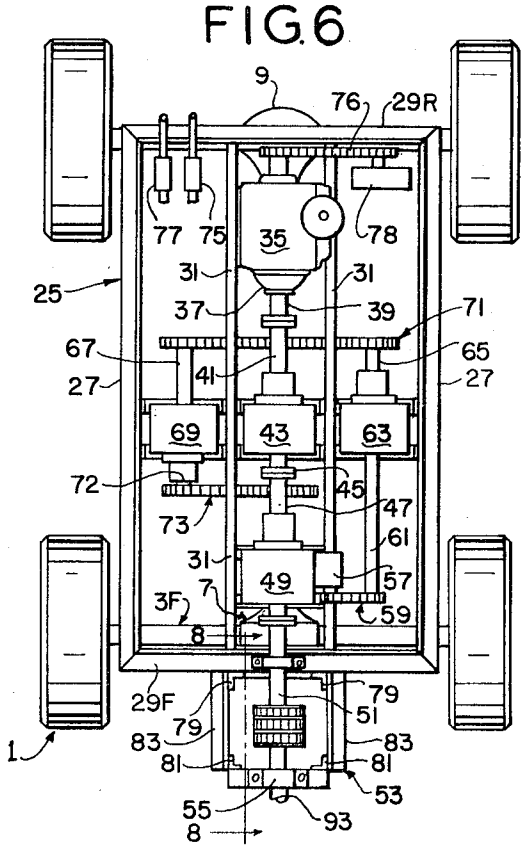


FIG. 7

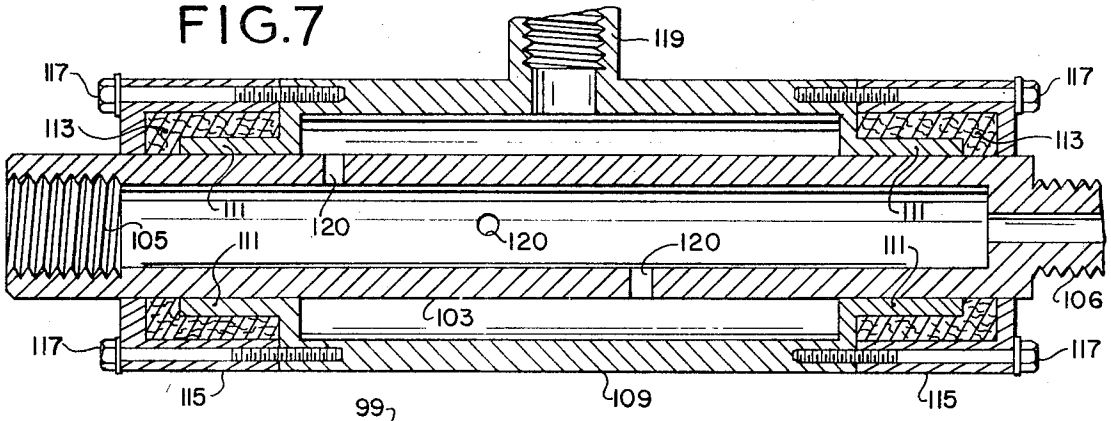


FIG. 8

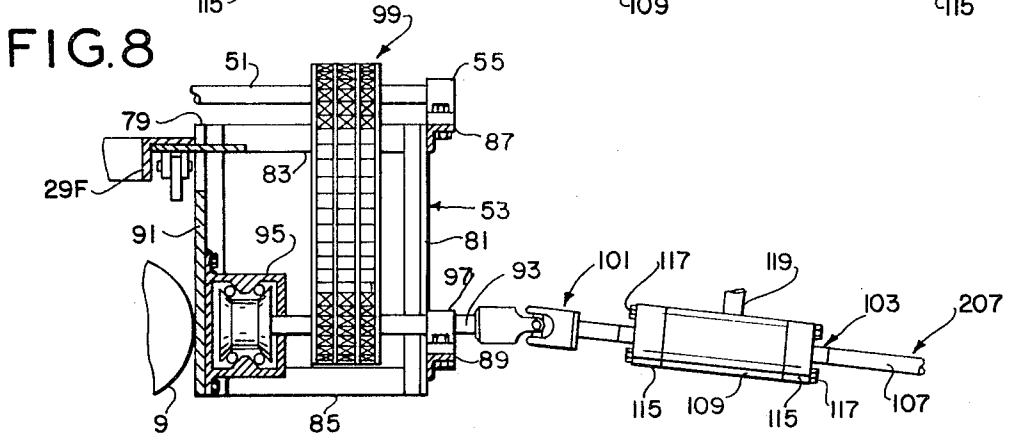


FIG. 9

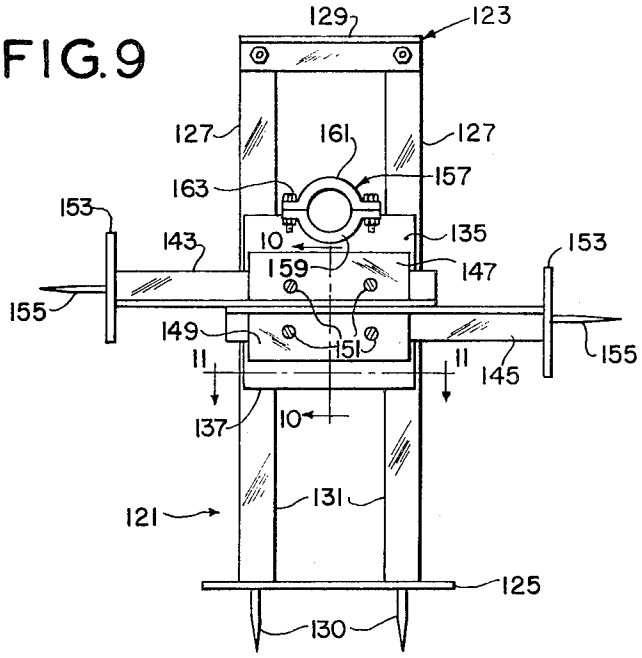
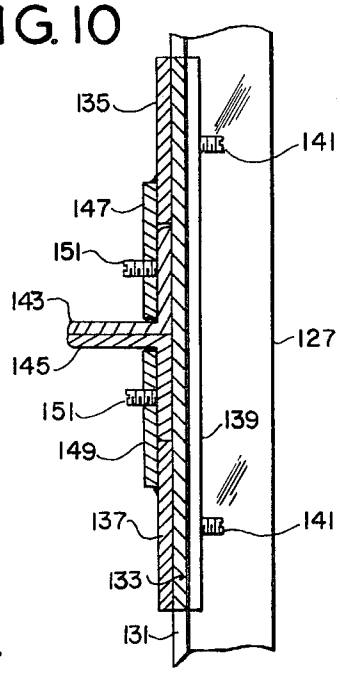


FIG. 10



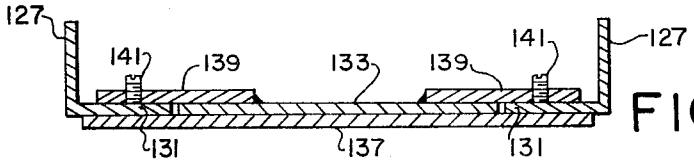


FIG. 11

FIG. 12

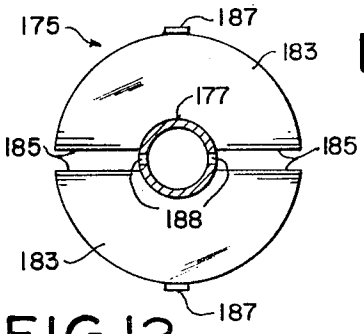


FIG. 13

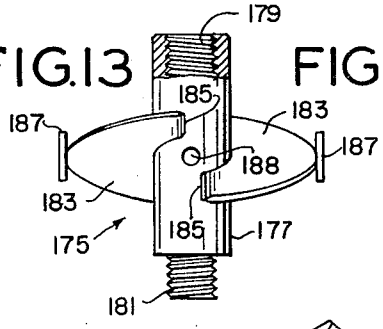


FIG. 16

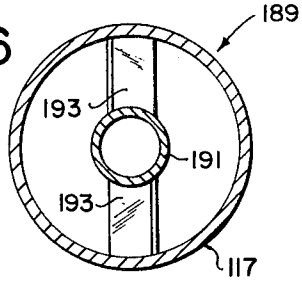


FIG. 14

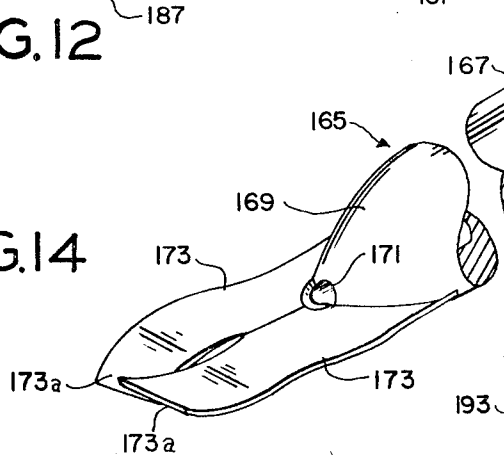
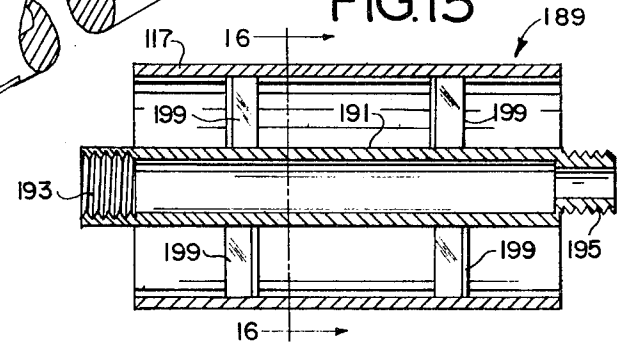


FIG. 15



METHOD OF AND APPARATUS FOR BORING HOLES UNDER STREETS, HIGHWAYS OR THE LIKE

BACKGROUND OF THE INVENTION

This invention relates to apparatus for boring holes generally horizontally through the ground underneath an existing structure such as a highway or street pavement, a railroad line, a building, or the like, and more particularly to such apparatus for boring such a hole operating from one side of the structure above ground level.

The invention is generally in the same field as that of U.S. Pat. Nos. 1,835,191, 2,165,666 and 2,752,122, showing machines for drilling holes under streets, highways, etc.

SUMMARY OF THE INVENTION

Among the several objects of the invention may be noted the provision of an improved apparatus for boring holes generally horizontally through the ground underneath an existing structure, such as a highway or street pavement, etc., enabling operation from one side of the structure at ground level with a minimum of excavation; the provision of such apparatus adapted for accurately boring a straight hole; and the provision of such apparatus readily adapted for boring holes of widely varying diameter and considerable length (e.g., holes from 2 inches up to 24 inches or more in diameter and up to 300 feet or more in length.

The invention utilizes the flexibility of a string of boring rod (tubular boring rod), generally involving digging a trench in the ground extending laterally outward from one side of said structure in the desired vertical plane of the hole, guiding a string of boring rod from one end thereof constituting its outer end and which is above ground level and spaced outward from said one side of said structure into the trench and thence forward into the ground underneath said structure, said string having a boring bit at its inner end, and rotating the said string and driving it forward from above ground level at its said outer end. Apparatus of this invention involves a vehicle adapted to span the trench, means for driving the vehicle comprising an engine and transmission means on the vehicle, a shaft extending forward from the vehicle above ground level at its front end and journaled for both rearward and forward thrust on the shaft, means for driving said shaft from said engine, and a boring rod coupling means connected to the forward end of said shaft by a universal joint. The coupling means is adapted for connection thereto of a string of boring rod for rotation of the string by said shaft and lengthwise movement of the string by the vehicle, the universal joint permitting angling of the rearward end portion of the string relative to said shaft. Other objects and features will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view illustrating apparatus of the invention and its use in boring a hole underneath a pavement;

FIG. 2 is a vertical section generally on line 2—2 of FIG. 1;

FIG. 3 is a fragmentary plan view similar to FIG. 1 illustrating a subsequent step in the method of the invention;

FIG. 4 is a vertical section generally on line 4—4 of FIG. 3;

FIG. 5 is a plan of the chassis of a vehicle constituting a part of the apparatus of the invention, with the vehicle body frame removed;

FIG. 6 is a plan of the vehicle with the body frame thereof in place;

FIG. 7 is an enlarged longitudinal section of a boring rod coupler of the apparatus shown in FIG. 8;

FIG. 8 is an enlarged vertical section on line 8—8 of FIG. 6;

FIG. 9 is a view in front elevation of a boring rod guide unit used in carrying out the invention;

FIGS. 10 and 11 are enlarged sections on lines 10—10 and 11—11, respectively, of FIG. 9;

FIGS. 12 and 13 are views illustrating a boring bit of relatively large diameter such as may be used in carrying out the invention;

FIG. 14 is a perspective (on a much larger scale than FIGS. 12 and 13) of a relatively small diameter (pilot) boring bit such as may be used in carrying out the invention;

FIG. 15 is a longitudinal section of a boring rod string stabilizer such as may be used in carrying out the invention; and

FIG. 16 is a transverse section on line 16—16 of FIG. 15.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. 1, 2 and 5–8, there is generally indicated at 1 a boring rod drive vehicle of this invention. As shown best in FIG. 5, this vehicle 1 comprises two conventional automotive rear axle assemblies 3F and 3R connected to form a vehicle chassis by side frame members 5, with 3F as the front axle assembly of the vehicle 1 and 3R as the rear axle assembly of the vehicle 1. As will be readily understood, each of the axle assemblies comprises an axle housing 7 having an enlarged central differential housing section 9 and tubular axle housing sections 11 extending outward at opposite sides of the section 9 housing the axle shafts 13 which carry the wheels 15. Housed in the differential housing section 9 is the usual differential gearing 17 comprising the usual differential side gears attached to the axle shafts 13, and differential pinion gears carried by the differential ring gear in mesh with the side gears. A drive shaft 19 extends between the differential housing sections 9 of the axle assemblies 3F and 3R, and has pinion gears 21 at its ends in mesh with the ring gears of the front and rear differentials 17 for driving the wheels. Shaft 19 carries a sprocket 23.

The chassis constituted by the two axle housings 7 and the side frame members 5 (which are rigidly secured to the axle housings 7 in any suitable manner) carries a rigid body frame 25 of the vehicle 1. This frame 25 comprises left and right side members each designated 27, front and rear end members 29F and 29R, and left and right intermediate longitudinal members each designated 31 (see particularly FIG. 6). It is mounted in any suitable manner on the front and rear axle assemblies 3F and 3R for up and down movement, and is spring-supported on the chassis side bars 5 as indicated at 33.

An automotive engine 35 is mounted between frame members 31 adjacent the rear of the vehicle with a gear reduction and clutch housing 37 at the front. The clutch output shaft 39 is connected to the input 41 of a first four-speed transmission 43. The output 45 of transmission 43 is connected to the input 47 of a second four-speed transmission 49. The first and second transmissions 43 and 49, which together constitute a first transmission means, are mounted between the frame members 31 in tandem. The second transmission 49 has a horizontal output shaft 51 extending forward beyond the front end member 29F of frame 25 and above the upper end of a sub-frame 53 extending downward at the front of frame 25, the forward end of shaft 51 being journaled in a bearing 55 at the front and on top of frame 53. The second transmission 49 has a power take-off 57 on one side (its left side as viewed looking in the direction from the rear to the front of the vehicle) driving via a chain and sprocket drive 59 the input shaft 61 of a third four-speed transmission 63 mounted in frame 25 between the left-hand frame members 31 and 27. The output shaft 65 of transmission 63 drives the input shaft 67 of a fourth four-speed transmission 69 via a chain and sprocket drive 71, this fourth transmission being mounted in frame 25 opposite the third transmission between the right-hand frame members 31 and 27. The output shaft 72 of the fourth transmission 69 drives the vehicle drive shaft 19 via a chain and sprocket drive 73 including the sprocket 23. The third and fourth transmissions together constitute a second transmission means.

Each of the wheels 15 of the vehicle is provided with a conventional hydraulic brake. A hydraulic cylinder 75 for the brakes for the left-hand wheels is suitably mounted on the frame 25, and a hydraulic cylinder 77 for the brakes for the right-hand wheels is mounted on the frame 25 alongside the

cylinder 75. The vehicle is adapted to be driven in forward and reverse directions by means of engine 35 via the first and second transmissions 43 and 49, power take-off 57 from the second transmission, and the third and fourth transmissions 63 and 69. Steering of the vehicle is via braking of the wheels, the vehicle turning to the left on operation of the braking system for the left-hand wheels including cylinder 75 and to the right on operation of the braking system for the right-hand wheels including cylinder 77. The engine 35 also drives via a belt and pulley drive 76 a water pump 78 for supplying water for boring from a suitable water supply tank (not shown) when no other pressurized water supply is available. The water tank may be removably mounted on frame 25, being removed when a pressurized water supply is available.

The sub-frame 53 (see particularly FIGS. 6 and 8) extends down at the front of the vehicle from the frame 25 directly in front of the front differential housing section 9 to about the bottom of the latter. It is generally square in plan comprising two rear vertical corner bars each designated 79, two front vertical corner bars each designated 81, upper horizontal side bars 83 and lower horizontal side bars 85. It also includes a horizontal top front bar 87 on which bearing 55 is mounted, and a horizontal bottom front bar 89. A vertical plate 91 spans the rear vertical corner bars 79. A shaft 93 extends horizontally forward from within the frame 53 adjacent its lower end, being journaled at its rearward end in a double thrust bearing 95 mounted on the front of the plate 91 and adjacent its forward end in a bearing 97 on the bar 89. Bearing 95 is of any suitable type for taking both rearward and forward thrust of shaft 93. Plate 91, which carries the bearing 95, engages the front of the differential housing section 9. Shaft 93 (which is generally at the level of the center of the differential housing section 9) is adapted to be driven from shaft 51 via a triple chain and sprocket drive 99.

Secured on the forward end of shaft 93 is the input of a universal joint 101, and secured to the output of this universal joint is a tubular boring rod coupling member 103 (see particularly FIGS. 7 and 8). This coupling member comprises a relatively short length of tubing which is internally threaded at one end (its rear end) as indicated at 105 for being threaded on the end of the universal joint output, and which has a reduced-diameter extension 106 at its other end (its forward end) for threading thereon a boring rod 107 which may be of the same diameter as the coupling member 103. A water jacket 109 is provided on coupling member 103 having reduced-diameter ends 111 in rotary engagement with the coupling 103. Packing is provided as indicated at 113 for sealing against leakage of water from within the jacket 109 while permitting the coupling 103 to rotate in the jacket, glands 115 being drawn up against the packing at the ends of the jacket by means of screws 117 threaded endwise in the jacket for effecting a water-tight seal as between the packing, the coupling 103 and the jacket. The latter has a water inlet 119, which may be supplied from the pump 78, or from a pressurized source when available. The coupling member has holes such as indicated at 120 for passage of water from within the jacket to the bore in member 103.

Reference numeral 121 denotes a boring rod guide unit or stand (see FIGS. 1–4 and 9–11) comprising a rectangular frame generally designated 123 comprising a horizontal bottom or foot plate 125, a pair of side members 127 extending vertically upward from the foot plate, and a top crossbar 129. The foot plate has prongs or spikes 130 extending downward therefrom for penetrating into the ground. The side members are angle irons arranged with their legs 131 directed inward toward one another. A plate 133 is vertically slidable between the angle iron legs 131, having upper and lower front plates 135 and 137 projecting laterally therefrom in front of the legs 131 and back side plates 139 extending laterally therefrom in back of the legs 131. Set screws 141 threaded in tapped holes in the back side plates 139 are engageable with legs 131 to lock the plate 133 in vertically adjusted position. Side stays designated 143 and 145 are laterally slidable on the face of plate 133 between the upper and lower plates 135 and 137 for laterally staying the frame. Each of these stays is constituted by an angle iron, the upper stay 143 being disposed with one leg extending vertically upward on the face of plate 133 and its other extending horizontally outward. The lower stay 145 is disposed with one leg extending horizontally outward directly below the horizontal leg of the upper stay and its other leg extending vertically downward on the face of plate 133. A plate 147 projects down from plate 135 in front of the vertical leg of the upper stay 143 and a plate 149 projects up from plate 137 in front of the vertical leg of the lower stay 145 to hold the stays in place while allowing lateral sliding movement thereof. The plates 147 and 149 have set screws such as indicated at 151 threaded in tapped holes therein for locking the stays in laterally adjusted position. Each stay has an outer end plate 153 with a prong or spike 155 thereon for piercing the ground at the sides of a trench in which the stand 121 is placed. At the top of the plates 133 and 135 is a boring rod guide eye 157. This is made up of a lower semicircular half 159 secured to the plates 133 and 135, and an upper semicircular half 161 bolted to the lower half as indicated at 163.

FIG. 14 illustrates a boring bit 165 for boring a hole of relatively small diameter, e.g., a pilot hole. As shown, this bit, which may be referred to as the pilot bit, is made of a short length 167 of tubular boring rod (e.g., 1¾ inch diameter rod) internally threaded at one end as indicated at 168 for being threaded on the end of the end boring rod of a string of boring rods, and having a bullet-shaped nose 169 provided with a central hole 171 for exit of water. Extending forward from the bullet-shaped end of rod 167 on opposite sides of the hole 171 are cutting blades 173 having their forward ends 173*a* oppositely bent as shown for boring a hole generally of the same diameter as the external diameter of the boring rod. The blades 173 are welded together part of the way from the tip of 167 with the hole 171, and are slightly skewed for functioning in auger fashion.

FIGS. 12 and 13 illustrate a bit 175 for boring a hole of larger diameter than the bit 165 (e.g., for enlarging a pilot hole bored by 165). As shown, bit 175 (which may be referred to as the enlarging bit) consists of a short length of boring rod 177 internally threaded at one end as indicated at 179 for being threaded on a reduced-diameter threaded extension at one end of a boring rod 107 and having an externally threaded reduced-diameter extension 181 at its other end. Welded on 177 are two semicircular steel blades each designated 183, these blades being in oppositely angled planes relative to 177. The radial edges 185 of these blades are hardened and sharpened or provided with a carbide cutting edge, and have straight cutting blades such as indicated at 187 extending generally normal to their semicircular edges for dressing the wall of a hole being bored. Holes for exit of water are indicated at 188.

FIGS. 15 and 16 illustrate a boring rod stabilizer 189 which may be used to prevent a long string of boring rod from whipping in an enlarged hole. As shown, this stabilizer comprises a short length of boring rod 191 internally threaded at one end as indicated at 193 and having a reduced-diameter externally threaded extension 195 at the other end, and a cylinder 197 surrounding rod 191 concentric therewith on skewed spokes 199.

Now referring back to FIGS. 1 and 2, the vehicle 1 is shown in its mode of use according to the invention for boring a relatively small diameter hole horizontally through the ground underneath a pavement 201, e.g., a highway pavement. As illustrated therein, a trench 203 is dug in the ground extending laterally outward from the pavement 201 from one side thereof (its left side as shown) in the desired vertical plane of the hole to be bored. A pit 205 is also shown as being dug on the opposite side of the pavement in said plane. The trench 203 may be dug about a foot or more deeper than the desired depth for the hole to be bored, for example, and generally need not be more than 1½ to 2 feet wide. The trench 203 may be dug to extend from 40, 50, 60 feet or more out from the

pavement **201**, and may, if desired, be sloped up toward ground level at its outer end.

The vehicle **1** is driven to a starting position at the outer end of the trench **203** and a string **207** of boring rods **107** is attached at one end to the outer end of the boring rod coupling member **103**. The boring rods used in making up the string are lengths of tubular rod each internally threaded at one end and having an externally threaded reduced-diameter extension (similar to **105** and **106**) at the other adapted for being threaded into the internally threaded end of the next rod. The string **207** is attached to the outer end of coupling member **103** by threading the internally threaded end of the end rod of the string on extension **106** of the coupling member. The boring rods **107** used are smooth on the outside and the string thereof is of uniform diameter (e.g., 1¾ inches in diameter) throughout its length. The string **207** of boring rod used is long enough to be relatively flexible and capable of readily bending so as to be curved from the coupling member **103** to the first of two drilling rod guide stands **121** mounted in the trench **203** some distance from the inner end of the trench with its guide eye **157** at the level of and in the vertical plane of the hole to be drilled. The universal joint **101** permits the necessary angling of the rearward end portion of string **207** relative to the shaft **93**. The second of the stated to guide stands **121** is mounted in the trench between the first stand and the inner end of the trench with its guide eye **157** coaxial with the guide eye **157** of the first. Each stand **121** is firmly positioned in the trench with the prongs or spikes **130** on the foot plate **125** of the stand driven down into the ground, and the lateral stays **143** and **145** (after vertical adjustment of the plate **133** properly to locate the guide eye **157**) moved outward for penetration of their prongs or spikes **155** into the ground at the sides of the trench. The string **207** extends horizontally straight through the guide eyes **157** of the two stands **121** and has the bit **165** threaded at **168** on the extension of the endmost rod.

With the string **207** of boring rods disposed as above noted, the vehicle **1** is driven forward directly above the trench (which it spans) in a straight line toward the pavement **201**, and the string is rotated at an appropriate speed via engine **35**, transmissions **43** and **49**, shaft **51**, chain and sprocket drive **99**, shaft **93**, universal joint **101** and coupler **103**, thereby to drill a hole H1 horizontally underneath the pavement. Guide eyes **157** of the two stands **121** function to maintain the string **207** straight and horizontal from the outer guide eye through the inner eye and thence into the ground. The hole H1 is drilled of the same diameter as the boring rods **107** in the string **207**, so that once the bit **165** has penetrated some 20 or 30 feet into the ground under the pavement, the stands **121** may be removed, the hole H1 itself maintaining the string **207** straight and true for the remainder of the boring operation. The bit **165** is so constructed that loose dirt or rock bored out thereby is packed in the wall of the bored hole H1. Water is fed through the string **207** via water jacket **109** and coupler **103** through the holes **120** in the coupler and exits from the bit **165** through hole **171** to mix with the loosened material. After boring in for a few feet, the water and loose material cease being discharged from the hole H1, the loose material packing in the wall of the hole and the water being absorbed. As the boring operation proceeds, additional lengths of boring rod **107** may be added (if needed) to the string **207** at the coupler **103**. This work may be carried out at ground level without any necessity for getting down into the trench. Completion of boring is readily observed by exit of the bit **165** into the pit **205**.

The hole H1 drilled as above indicated may be of the final desired diameter, in which event, the string **207** is withdrawn by moving the vehicle **1** back away from the pavement **201** to pull the string out of the hole. Generally, however, the hole H1 is drilled as a pilot hole for subsequent enlargement to a hole H2 of a larger diameter. In the latter case, once the bit **165** has emerged in the pit **205**, it is removed, and the enlarging bit **175** is attached to the end of the string **207**. Then the string is pulled back through the hole H1 while rotating the string and the enlarging bit **175** by moving the vehicle **1** back away from the pavement **201**. Water is delivered through the string and out through part **177** to mix with the loose dirt and rock. After boring in the reverse direction with the enlarging bit **175** for about 6 to 8 feet, for example, the vehicle **1** is moved forward with the bit **175** continuing to rotate in the same direction as for cutting to push loose dirt and rock mixed with water out of the forward end of the hole H2 into the pit **205**. This is repeated until the entire hole is enlarged to form H2.

If desired, additional boring rods may be added to the string forward of the enlarging bit **175** (to the right of the enlarging bit as viewed in FIG. **4**) and the stabilizer **189** attached to the end of the string. This prevents the string from whipping in the enlarged hole and prevents the hole from becoming out of round or too large.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantages results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus for boring a hole generally horizontally through the ground underneath an existing structure, operating via a trench dug in the ground extending laterally outward from one side of said structure in the desired vertical plane of the hole, said apparatus comprising a vehicle adapted to span the trench, said vehicle having axle housings at the front and rear thereof, each axle housing having a central differential housing section with a differential therein and axle shafts extending from the differential to the outer ends of the housing, wheels on the ends of the axle shafts, a vehicle drive shaft extending between the two housings having pinions at its ends for driving the axle shafts of each housing, an engine on the vehicle, first transmission means on the vehicle driven by the engine, a boring drive shaft extending forward from the vehicle at the level of and in front of the central differential housing section of the front axle housing, means journaling said shaft for both rearward and forward thrust thereon, means for driving said shaft from the output of said first transmission means, a boring rod coupling means connected to the forward end of said shaft by a universal joint, said coupling means being adapted for connection thereto of a string of boring rod for rotation of the string by said shaft and lengthwise movement of the string by the vehicle, said universal joint permitting angling of the rearward end portion of the string relative to said shaft, a power take-off from said first transmission means, and second transmission means driven via said power take-off and connected to drive said vehicle drive shaft.

2. Apparatus as set forth in claim **1** wherein the vehicle has a braking system for the wheels on one side thereof and an independent braking system for the wheels on the other side thereof for steering the vehicle by braking the wheels on one side or the other.

3. Apparatus as set forth in claim **1** wherein said coupling means comprises a length of tubular rod attached at one end to the universal joint and adapted for attachment to its other end of the string of boring rod, a water jacket surrounding said length of rod, the latter being rotatable in the jacket and having openings for entry of water thereto from the jacket, the jacket having a water inlet.

4. Apparatus as set forth in claim **3** wherein the vehicle carries a water pump driven by the engine for pumping water to the jacket.

5. Apparatus as set forth in claim **1** further comprising two guide units for guiding the string in a straight line at the inner end of the trench, each guide unit comprising a frame adapted to be mounted in the trench having means insertable in the ground at the bottom of the trench and laterally movable lateral stays having means insertable in the ground at the sides of the trench, and a vertically adjustable guide eye for the string.

6. Apparatus as set forth in claim 5 wherein the lateral stays are vertically adjustable with the vertically adjustable guide.

7. Apparatus as set forth in claim 1 wherein said first transmission means comprises a first transmission and a second transmission mounted on the vehicle in tandem in line with the engine, the engine having its output shaft connected to the input of the first transmission, the first transmission having its output shaft connected to the input shaft of the second transmission, the second transmission having its output shaft above said boring drive shaft and connected thereto via a chain and sprocket drive.

8. Apparatus as set forth in claim 7 wherein said power take-off is from said second transmission, and wherein said second transmission means comprises a third transmission and a fourth transmission, the third transmission having its input powered from said power take-off and its output connected to the input of the fourth transmission, and the output of the fourth transmission is connected to said vehicle drive shaft.

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