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Hunter

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[54] **APPARATUS AND METHOD FOR DRILLING AN ARCUATE BORE FROM GROUND SURFACE UNDER AN OBSTRUCTION TO GROUND SURFACE**

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[52] **U.S. Cl.** **175/61,** 175/75, 175/173

[51] **Int. Cl.** **E21b 7/08**

[58] **Field of Search**.....175/61, 62, 73–75, 175/79, 173, 171, 220

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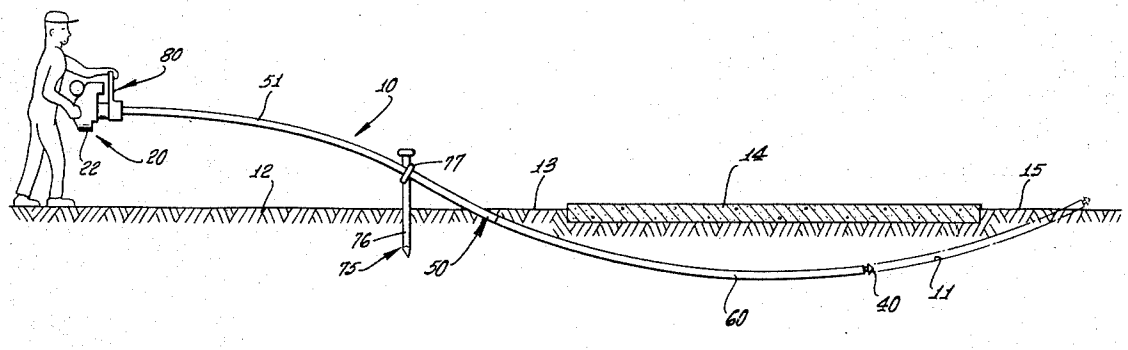
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[57] **ABSTRACT**

The earth boring apparatus has a motor driving a flexible drive shaft assembly located in a flexible tubular casing including a rear straight portion and a forward curved portion which guides a drill bit mounted on the end of the drive shaft assembly to, upon rotation of the drill bit, automatically drill an arcuate bore from the ground surface on an adjacent side of an obstruction, thereunder, to the ground surface on the opposite side of the obstruction while a water housing adapter around the rear end of the casing receives water from a hose for manually controlled intermittent feeding of the water down the casing to pass out the drill bit.

8 Claims, 8 Drawing Figures



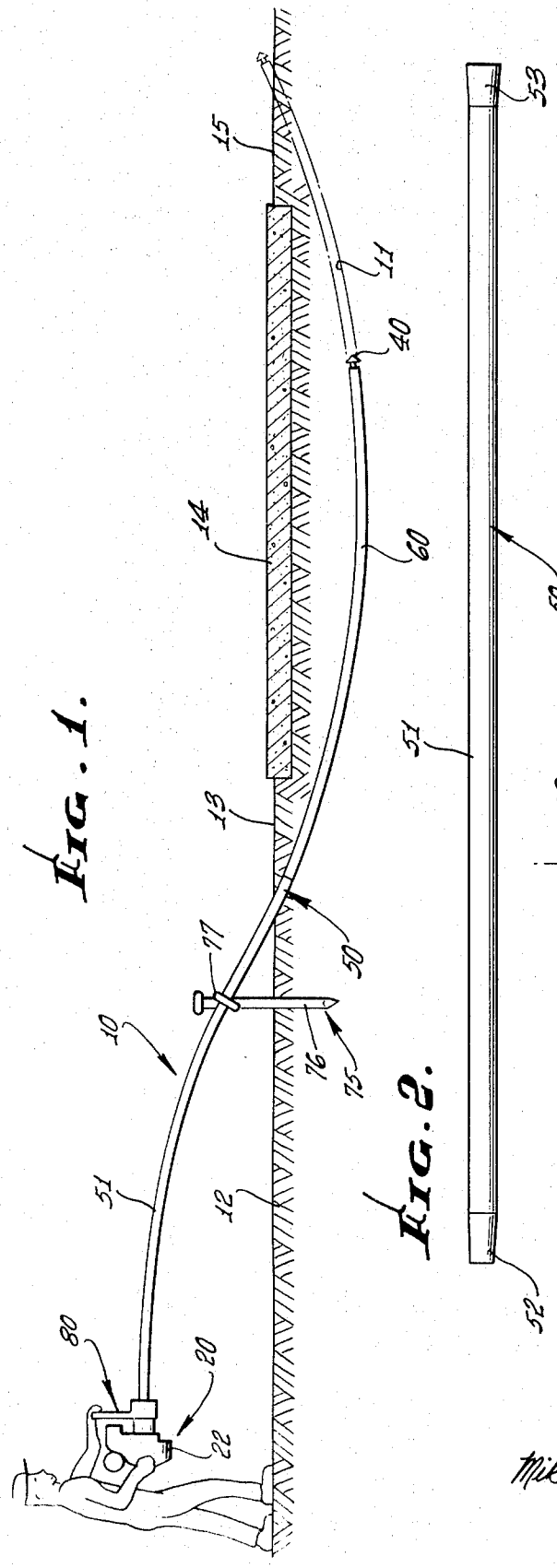


FIG. 1.

FIG. 2.

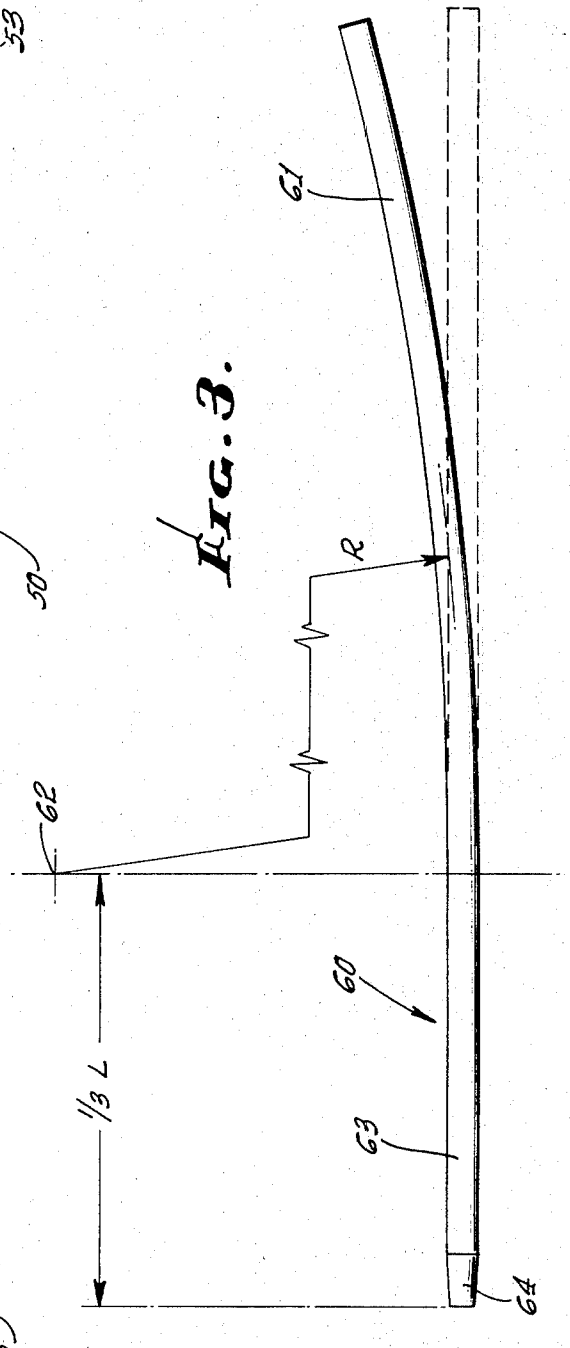


FIG. 3.

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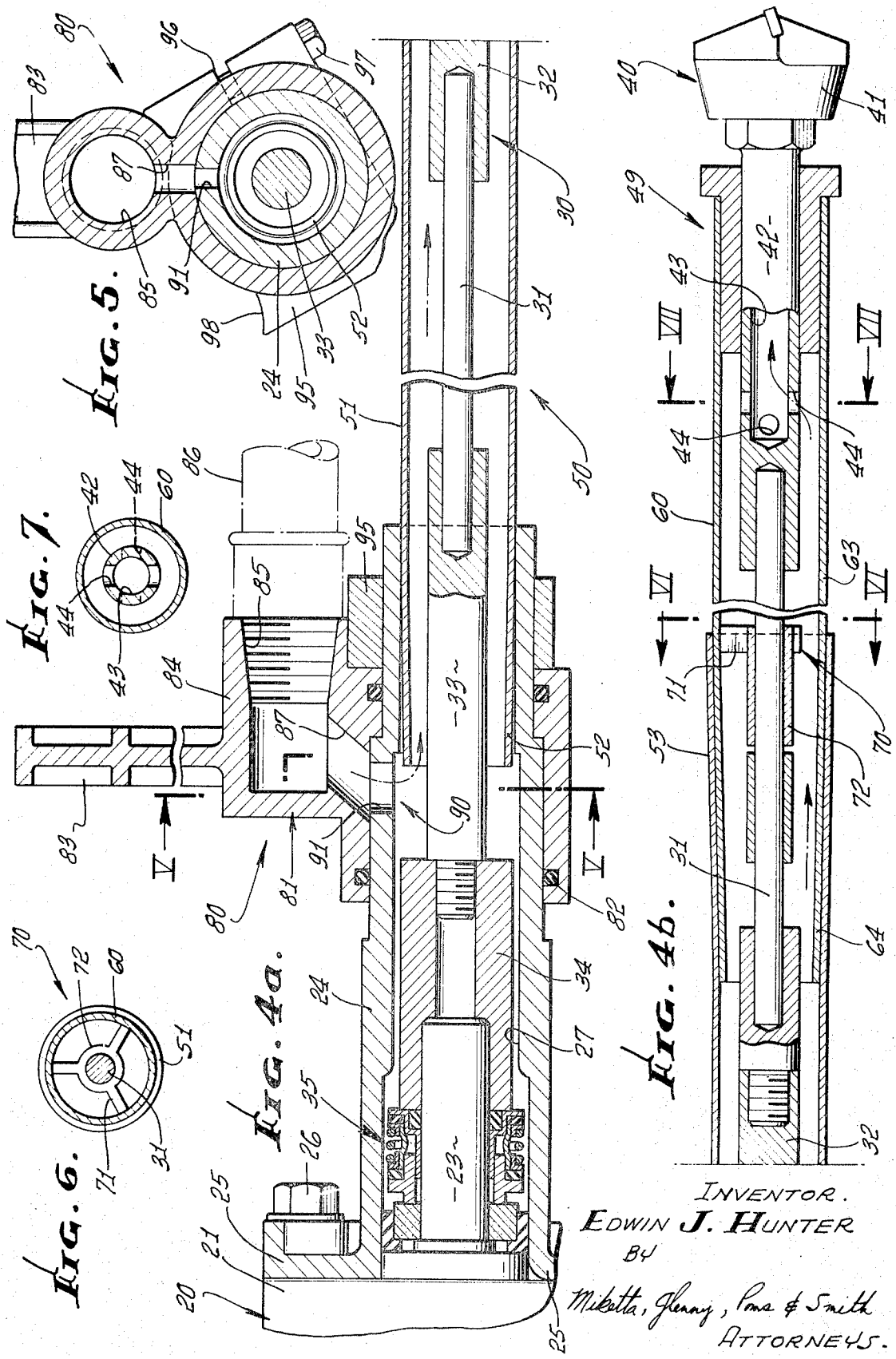


Fig. 5.

Fig. 7.

Fig. 4a.

Fig. 6.

Fig. 4b.

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APPARATUS AND METHOD FOR DRILLING AN ARCUATE BORE FROM GROUND SURFACE UNDER AN OBSTRUCTION TO GROUND SURFACE

BACKGROUND OF THE INVENTION

This invention relates to earth boring and more particularly to a method and apparatus for drilling an arcuate bore from the ground surface on one side of an obstruction, under the obstruction, to the ground surface on the other side thereof.

In the laying of pipe, it is frequently desirable to be able to drill a bore underneath an obstruction which it is not practically possible to circumvent. The need for the provision of such a bore under an obstruction is particularly acute during the installation of underground sprinkler systems because the piping therefor must pass under existing obstructions such as sidewalks, driveways, patios, etc. to join the pipes of each grassy area into a common watering system.

Heretofore, a successful method of providing piping under the obstruction was to dig a pair of the trenches on opposite sides of the obstruction. The trenches would be deeper than the depth of the obstruction and a tool would be drilled or forced from one trench under the obstruction to the other trench to form a bore thereunder by using a machine such as is shown in U.S. Pats. No. 2,902,832 and No. 3,182,732. The tool would then be withdrawn and the pipe would be inserted in the bore.

Another successful method of providing the necessary piping was to break up the obstruction where the pipe was to be laid. A trench was dug in which the pipe was laid after which the trench was filled. The obstruction would then be reconstructed if necessary, as it would be with a driveway, sidewalk, etc.

Both of these prior art methods are not satisfactory. A better method would be to drill an arcuate bore from the ground surface under the obstruction to the ground surface on the other side of the obstruction. Such a method would not require the digging of any side trenches nor require the disturbing the obstruction itself. Some fairly short length curved bore drilling has been accomplished heretofore by use of a continuously curved or 180° arcuate tool having a motor driven drill bit. However, that approach is completely impractical in attempting to drill under fairly wide obstructions, such as a driveway, since the curved tool configuration must be so large that it becomes unwieldy and impractical for a single workman to operate it from ground level, particularly if the motor drive is provided at one end of the 180° arcuate tool and the drill bit at the other.

BRIEF DESCRIPTION OF THE INVENTION

Therefore, it is the primary object of this invention to provide a novel earth boring apparatus and method for drilling an arcuate bore from ground surface under an obstruction to the ground surface on the opposite side of the obstruction.

Other and additional objects of this invention are to provide such an earth boring apparatus and method which require no side trenches, which require no disturbing of the obstruction, which may be used easily by a single workman operating from ground surface, which drill under various sizes of obstructions, and

which automatically provide an arcuate bore of predetermined desired configuration through the ground under the obstruction upon rotation of the drill bit.

Generally stated, the earth boring apparatus, with the improvement according to this invention for automatically drilling an arcuate bore from a first surface to a second surface includes a motor, a flexible drive shaft driven by the motor and driving a drill bit, and a flexible tubular casing means about the drive shaft and mounting the drill bit for guiding it, upon rotation thereof, to drill the arcuate bore, with the casing means including a forward portion initially deformed to a predetermined arcuate configuration and a rear portion of generally linear configuration. The casing means may be composed of a plurality of sections with at least one section having curved and straight portions. The radius of curvature of the curved portion is preferably slightly greater than the width of the obstruction under which the arcuate bore is being drilled. A water receiving means may be provided for receiving water under pressure and valve means may be provided for controlling the flow of water down between the casing means and the drive shaft assembly to the drill bit.

The method of drilling an arcuate bore under an obstruction using a motor and a drill bit, according to the present invention, generally stated, includes the steps of providing a driving guide tool with an initially straight portion and an initially curved portion joined thereto, connecting the end of the initially straight portion to the motor, mounting the drill bit on the end of the curved portion, placing the drill bit on the surface of the ground on one side of the obstruction, starting the motor to rotate the drill bit while the initially curved portion of the driving guide tool causes the drill bit to drill an arcuate bore into the ground under the obstruction, feeding the guide tool into the arcuate bore with the straight portion bending to follow the arcuate bore, and stopping the motor after the drill bit breaks the surface of the ground on the opposite side of the obstruction. The method may also include the steps of supplying tool sections and connecting the sections together; orienting the drill bit to enter the ground at generally 30° thereto; driving a stake into the ground and inserting the guide tool through a guide ring thereon; and/or intermittently supplying water to the drill bit by connecting a hose from a supply of water to a valve and manually moving the valve between its positions to regulate the flow of water to the drill bit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a landscape showing the earth boring apparatus, according to this invention, being used to drill an arcuate bore from ground surface under a driveway to the ground surface on the opposite side of the driveway.

FIG. 2 is a side view of a rear straight section of casing for the boring apparatus.

FIG. 3 is a side view of front section of casing for the boring apparatus, showing the initially straight portion and the initially curved portion thereof.

FIGS. 4*a* and *b*, together, are a fragmentary side cross section view of the earth boring apparatus, showing the internal construction of the major parts thereof.

FIG. 5 is a fragmentary end cross-sectional view showing the water housing adapter in open position relative the motor adapter and against the valve stop on the motor adapter.

FIG. 6 is an end cross-sectional view taken along the plane VI–VI of FIG. 4 showing a spider bearing centering a drive line within the casing.

FIG. 7 is an end cross-sectional view taken along the plane VI—VI of FIG. 4 showing the sleeve mounting the cutter adapter in the casing of the earth boring apparatus, according to this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT:

Referring now to the drawings and particularly to FIG. 1, an earth boring apparatus, with the improvements according to this invention, is generally denoted by the number **10**. The earth boring apparatus **10** is for drilling an arcuate bore **11** in the ground **12** from an adjacent surface **13** of the ground **12** under an obstruction **14** to the surface **15** of the ground **12** on the opposite side of the obstruction **14**. The obstruction **14** will typically be a driveway, sidewalk, patio, etc., which has a depth in the ground which is minimal in comparison to its width. The arcuate bore **11** is drilled to receive water pipe (not shown) or other conduit to extend a system such as a water sprinkler system across the obstruction **14** without disturbing it.

Typically, an earth boring apparatus **10** has an engine or motor unit **20** rotatively driving a flexible drive shaft assembly **30** mounting a drill bit **40**. The improvement, according to this invention in the earth boring apparatus **10**, includes the provision of a flexible tubular casing means **50**, with an initially curved portion **61** and an initially straight portion **63**, around the drive shaft assembly **30** with bearing means **70** therebetween, and with restraint guide means **75** therearound for automatically drilling a suitable arcuate bore **11** upon rotation of the drill bit **40**. The apparatus **10** may include a water receiving means **80** for receiving water from a hose and valve means **90** for selectively passing water from the water receiving means **80** down the space between the casing means **50** and the flexible drive shaft assembly **30** to the drill bit **40** to wash the bit **40**.

The motor unit **20**, illustratively shown in FIG. **1**, is a hand held unit, typically having a frame **21** on which the motor **22** is mounted. The motor **22** may be a self-contained source of power such as a gasoline engine or may require an external source of power such as an electric motor or pneumatic motor but will have an output shaft end **23** for connection to the drive shaft assembly **30**. As best seen in FIG. **4**, the motor unit **20** also typically includes a motor adapter **24** which is generally tubular in shape. One end of the motor adapter **24** has ears **25** through which bolts **26** pass to mount the adapter **24** to the frame **21** to locate the central bore **27** thereof over the output shaft end **23** for receiving the flexible drive shaft assembly **30**.

The flexible drive shaft assembly **30**, illustratively shown in FIG. **4**, includes a plurality of flexible drive shafts **31** of short length coupled together by male and female shaft couplings **32** into an assembly **30** of a required length. The motor end of the assembly **30** has a shaft extension **33** coupled to a shaft adapter **34** telescopingly mated around the output shaft end **23** of the motor **22**. A shaft seal assembly **35** is provided around the shaft end **23** between the motor **22** and the shaft adapter **34** at that end of the drive shaft assembly **30** while the other end thereof mounts the drill bit **40**.

The drill bit **40** includes a commercially available boring tool cutter **41** with a central hole and a threaded rearwardly extending boss. A cutter adapter **42** is threaded to the boss of the cutter **41** and joined to the end drive shaft **31**. The cutter adapter **42** has a central bore **43** communicating with the central hole of the cutter **41** and opening to the exterior of the adapter **42** adjacent the drive shaft end through radial hole **44** for a purpose which will appear later.

The drive shaft assembly **30**, though itself is old, is combined into the flexible driving guide tool or means **49**, according to this invention, by being located within the tubular casing means **50**. The flexible driving tool or means **49** is for causing the drill bit **40** to drill a suitable arcuate bore **11**. The flexible driving guide means **49** includes the component parts of the flexible drive shaft assembly **30**, already described, the tubular casing means **50**, and the bearing means **70**.

The tubular casing means **50** is for causing the drill bit **40** to drill a suitable arcuate bore **11** upon rotation of the drill bit **40**. As best seen in FIGS. **1**, **2** and **3**, the tubular casing means **50** of the illustrative embodiment includes a flexible rear generally straight casing section **51**. The section **51** has a tapered end **52** for being received in the bore **27** of the motor adapter **24** and has a flared end **53** for receiving a front curved casing section **60**. The casing sections **51** and **60** are preferably made of lightweight, flexible aluminum tubing, such as a 17 gauge (0.058) wall tube of about one inch diameter.

The front curved casing section **60** includes both the forward initially curved portion **61** and the rearward initially straight portion **63**. As best seen in FIG. **3**, the curved casing section **60** has the straight portion **63** over approximately one third of its length and has the curved portion **61** over the balance of its length. I have found that the straight portion **63** should extend over at least one third of the length of casing **60** where a fairly large radius of curvature, i.e. 20–30 feet, is employed. Shorter straight portions may be employed where the radius of the curvature is smaller, i.e. 5 to 10 feet.

The initially curved portion **61** may be provided by bending an initially all straight casing section past its elastic limit to a desired radius of curvature **62**, as is shown in FIG. **3**. I have found that if the radius of curvature **62** of the curved portion **61** is slightly greater than the width of the obstruction **14**, the arcuate bore **11** will be drilled automatically to extend from the near surface **13** completely under the obstruction and to the far surface **15** with the trailing straight portions **63** and casing section **51** following through the bore and deforming to its shape.

The radius of curvature for the curved section generally will range between about **15** and **30** feet for boring under obstructions from sidewalks to driveways. The desirable minimum length for the curved portion **63** varies in direct proportion to the radius of curvature value and preferably ranges between about 5 and 8 feet for the aforementioned range of radii.

The front curved casing section is completed with the provision of a tapered end 64 on the straight portion 63 which mates with the flared end 53 of the generally straight casing section 51. The flexible drive shaft assembly 30 is coaxially located in the casing sections 51 and 60 by the bearing means 70.

The bearing means 70 are for coaxially locating the drive shaft assembly 30 in the tubular casing means 50 for rotation of the drive shaft assembly therein. As best seen in FIGS. 4 and 6, the bearing means 70 include a plurality of spider bearings 71, each having a sleeve 72 for receiving therethrough an individual drive shaft 31 and having three radially outwardly extending arms 73 which extend to the casing means 50. A suitable number of spider bearings 71 are provided to ensure that the drive shaft assembly 50 follows the curvature of the casing means 50. The bearing means 70 is completed by the provision of a bushing 74 around the cutter adapter 42 and extending into the drill bit end of the casing means 50 to coaxially locate the drill bit 40 with respect to the casing means 50.

The earth boring apparatus 10 also requires a restraining guide means 75 for locating the drill bit 40 on the adjacent surface 13 so as to enter the ground 12 at the proper angle, which I have found to be approximately 30°. Thereafter, the restraining guide means 75 is for guiding the feeding of the flexible driving guide means 49 into the arcuate bore 11 after the drill bit 40. In the illustrative embodiment as seen in FIG. 1, the restraining guide means 75 includes a stake 76 driven into the adjacent surface 13 of the ground 12 to locate a ring 77 thereon, to provide a guide opening for receiving the driving guide means 49 therethrough.

As best seen in FIGS. 4 and 5, the earth boring apparatus 10 also includes a water receiving means 80 for receiving a supply of water under pressure from a source (not shown). In the preferred embodiment the water receiving means 80 includes a water housing adapter 81 received about the motor adapter 24, with the juncture therebetween closed by seals 82. The water housing adapter 81 has a handle 83 joined to a body 84 in which is located a receptacle 85 for threadably receiving one end of a hose 86. The body 84 also has passage 87 running from the receptacle 85 to the juncture of the body 84 with the water housing adapter 24 between the seals 82 for cooperating with the valve means 90.

The valve means 90 is for controlling the flow of water from the water receiving means 80 into the space between the casing means 50 and the drive shaft assembly 30 to flow out the drill bit 40. The valve means 90 of the illustrative embodiment, includes the provision of a hole 91 in the motor adapter 24 which in a certain position of the water housing adapter 81 is aligned with the passage 87 to allow water to flow from the hose 86 through the water housing adapter 81, through the motor adapter 24 and around the end of the casing means 50 into the space between the casing means 50 and the drive shaft assembly 30. In the other position of the water housing adapter 81, the passage 87 is not aligned with the hole 91 so that the flow of water is interrupted.

The valve means 90 also includes the provision of a valve stop 95 around the motor adapter 24 which locates the water housing adapter 81 in either of the two positions while permitting movement therebetween by manually moving the handle 83. The valve stop is split at 96 with a bolt 97 closing the split to permit cutouts 98 thereon to be suitably located with respect to the motor adapter 24. The body 81 of the water housing adapter 81 will engage one of the cutouts 98 in each position thereof to be located thereby.

The frame 21 preferably has the motor 22, the motor adapter 24, the shaft seal 35, the water housing adapter 81 and the valve stop 98 attached thereto for transportation to the job site. The flexible drive shaft assembly 30 is preferably mounted within the front and rear casing sections 60 and 51 by the spider bearings 71 to be transported to the job site. The drill bit 40 also is preferably mounted on the front section 60 for transportation. Once at the job site, the rear section 51 is inserted into the motor adapter 24 to locate the shaft adapter 34 around the output shaft end 23 and to locate the tapered casing end 52 in the motor adapter 24. The tapered casing end 64 is inserted into the flared casing end 53 while the adjacent shaft couplings 32 are joined. The hose 86 may then be threaded into the receptacle 85 to complete the assembly of the earth boring apparatus 10. The stake 76 is driven into the ground 12 to locate the ring 77 a specified distance thereabove. The tapered end 64 of the front section 60 may then be fed through the ring 77 until the drill bit 40 is located on the adjacent surface 13 of the ground 12 at the desired location of the start of the arcuate bore 11.

Since only some five to eight feet of the forward casing section 51 is curved and the remaining portions of casing 50 are flexible, according to my present invention, the operator may stand on the ground surface, holding the motor unit 20 at a convenient height above the ground to operate its associated controls and water valve, with most of the guide casing extending generally parallel to the ground, but flexing to allow the far or forward curved end to depend through the stake guide ring at approximately a 30° angle to the ground preparatory to initiating the drilling or boring operation without any predrilled holes or predug trenches.

Upon energizing of the motor 22, the drive shaft assembly 30 rotates inside the casing means 50 to rotate the drill bit 40. The rotation of the drill bit 40 starts the bore 11 with the initially curved casing portion 61 of the forward section 60 following into the bore and guiding the drill bit 40 to begin and continue to drill the bore in an arcuate configuration under the obstruction 14. The initially straight, flexible rear section 51 is initially generally parallel to the ground 12 and, together with initially straight portion 63 of casing 60, elastically bends to follow the curvature of the arcuate bore 11 as the drilling proceeds. As seen in FIG. 1, the drill bit 40 and the initially curved portion 61 continue drilling the bore 11 in an arc beyond the length of portion 61 under the obstruction 14 until the drill bit 40 opens the bore 11 to the far surface 15 on the opposite side of the obstruction 14. All during the drilling, water can be continuously or intermittently fed to the drill bit 40 to clean it and soften the dirt, by manual movement of the handle 83 of the water housing adapter 81 between its open and closed positions. The water from the hose 86 passes down the space between the casing means 50 and the drive shaft assembly 30 through the arms 73 of

the spider bearings **71**, through the hole **44** and into the bore **43** of the cutter adapter **42** to pass out of the hole in the cutter **41**. Once the drill bit **40** surfaces, the drill bit **40** and the driving guide means **49** are withdrawn leaving the bore **11** open to receive pipe or other conduits.

Thus the improvement according to this invention enables the earth boring apparatus to automatically drill an arcuate bore of predetermined configuration from an adjacent surface of the ground under an obstruction to the far surface of the ground on the opposite side of the obstruction with the single operator at all times in control of the motor unit and walking along on the ground surface toward the obstruction. The drilling or boring of fairly long arcuate bores is thus greatly facilitated and rendered practical for ease of installation of conduits under preexisting obstructions by this invention.

I claim:

1. In an earth boring apparatus having a motor driving a flexible drive shaft in turn driving a drill bit, an improvement for drilling an arcuate bore in the earth from a first surface area to a second surface area comprising the provision of:

a flexible tubular imperforate casing means about said drive shaft and mounting said drill bit for guiding said bit upon rotation to drill an arcuate bore through the earth, said flexible casing means having a forward portion, adjacent said bit, permanently deformed into a predetermined arcuate configuration corresponding generally to a segment of the arc of the bore to be drilled, and a rearward flexible portion of generally linear configuration capable of elastic deformation into an arcuate configuration to follow said forward position through the bore.

2. A guide casing means for use with a boring tool having a drill bit, a flexible drive shaft and a motor for drilling an arcuate bore from the ground surface, under an obstruction and back to the ground surface on the opposite side of the obstruction, said guide casing means comprising:

an initially curved portion for mounting the drill bit on one end thereof, and

an initially straight portion joined to the curved portion, said drill bit being mounted on the end of the initially curved portion to, upon rotation, be guided by the initially curved portion for drilling an arcuate bore into the ground under the obstruction, wherein a plurality of individual flexible driving guide sections constitute the portions, a section adjacent said bit including said initially straight portion over approximately one third of its length and said initially curved portion over the rest of its length to said bit said other sections being initially straight and joined to each other in a line and joined to the initially straight portion of the section adjacent said bit.

3. An earth boring apparatus for drilling an arcuate bore from ground surface under an obstruction to ground surface on the opposite side of the obstruction, said apparatus including a drill bit, and a motor unit with a motor for rotatively driving the drill bit, and comprising:

flexible driving guide means mounted to the motor unit and mounting the drill bit for rotation thereof, said means having an initially curved portion adjacent the drill bit joined to an initially straight portion, said curved portion causing the drill bit upon rotation thereof to drill an arcuate bore, said initially straight portion conforming to the arcuate bore as the initially straight portion moves therein to continue to drill the arcuate bore under the obstruction, wherein the driving guide means is made up of a plurality of flexible individual driving guide sections, all of said sections being generally straight except for the one section adjacent said bit, said one section including both the straight portion and the curved portion, said straight portion being joined in a line to the other sections and extending over at least one third of the total length of the one section.

4. The invention as in claim **3** wherein two individual driving guide sections are provided, one generally straight and the other having the initially straight portion and initially curved portion.

5. An earth boring apparatus for drilling an arcuate bore from ground surface under an obstruction to ground surface on the opposite side of the obstruction, said apparatus including a drill bit and a motor unit with a motor for rotatively driving the drill bit, comprising:

flexible driving guide means mounted to the motor of the unit and mounting the drill bit for rotation thereof, said means having an outer tubular casing having an initially curved portion adjacent the drill bit joined to an initially straight portion, said curved portion causing the drill bit, upon rotation thereof, to drill an arcuate bore, said initially straight portion conforming to the arcuate bore as the initially straight portion moves therein to continue to drill the arcuate bore under the obstruction:

an inner flexible drive shaft on the casing and having the front end thereof mounting the drill bit and the rear end thereof drivingly mounted to the motor to be rotated thereby; and

bearing means between the drive shaft and the casing for centering the drive shaft in the casing and for permitting rotation of the drive shaft within the casing to rotate the drill bit thereby;

wherein the motor unit includes a stationary frame to which the motor is mounted, said frame having a tubular motor adapter mounted thereto;

wherein the inner end of the tubular casing is mounted to the tubular motor adapter;

wherein the drive shaft is mounted to the motor to be rotated thereby, and additionally comprising;

means for receiving water in communication with the space between the casing and the drive shaft and valve means for controlling the flow of water from the receiving means into the space between the casing and the drive shaft to flow out the drill bit.

6. The invention as in claim **5** wherein the means for receiving water includes a water housing adapter, said housing adapter having a receptacle for connection to a water hose and passages from the receptacle and wherein the valve means includes the mounting of the housing adapter around the motor adapter for rotation

between two positions, said motor adapter having a hole therein communicating with the passage of the housing adapter when the housing adapter is in one position and not communicating therewith when the housing adapter is in the other position, whereby water is supplied to the casing when the housing adapter is in the one position and is closed off from the casing when the housing adapter is in the other position.

7. A method of drilling an arcuate bore under an obstruction using a motor driven drill bit comprising the steps of:

providing a guide tool with an initially straight portion and an initially curved portion joined thereto,

associating the end of the straight portion with the motor and mounting the drill bit on the end of the curved portion for rotation relative thereto by said motor;

placing the drill bit on the surface of the ground on one side of the obstruction,

rotating the drill bit and guiding it by the initially curved portion of the guide tool to drill an arcuate bore in the ground under the obstruction, and

feeding the initially straight portion of the guide tool into the arcuate bore and bending it through the arcuate bore until the drill bit breaks the surface of the ground on the opposite side of the obstruction.

8. The method as in claim 7 wherein the step of placing the drill bit on the ground includes the step of orienting the drill bit to enter the ground at a generally 30° angle thereto.

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