The present invention relates to a process and apparatus for accurately drilling a hole in the earth and for placing a casing in the hole.

In the locating of large holes and conduits for sewers, power lines and similar purposes, it is particularly desirable that expense be kept as low as possible but that the hole or conduit be accurately located. It has been found that the larger the hole the more tendency there is for the drill to wander. Consequently, one object of the present invention is to provide a method and apparatus for accurately locating a hole or conduit at relatively low expense.

A further object of the invention is to provide improved method and apparatus for accurately drilling a hole.

Still another object of the invention is to provide improved method and apparatus for drilling a horizontal or near horizontal hole beneath an object such as a road.

A further object of the invention is to provide improved method and apparatus for drilling a hole at proper slope or grade.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims.

FIGS. 1–3 are side elevations of certain apparatus used in the process of the present invention showing said apparatus in the serial steps of the process.

FIG. 4 is an enlarged section taken along the line 4–4 of FIG. 3 in the direction of the arrows and showing certain details of the apparatus.

FIG. 5 is a vertical longitudinal section taken along the line 5–5 of FIG. 4 in the direction of the arrows and showing in greater detail a portion of the structure illustrated in FIG. 3.

FIG. 6 is an enlarged fragmentary detail view taken along the line 6–6 of FIG. 1.

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawing and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

Referring more particularly to FIG. 5, the apparatus of the present invention includes a hydraulic or electric motor 10 which is mounted upon a frame 11 and has its drive shaft 12 operatively connected to a transmission 15 by means of a belt and pulley arrangement 16. The transmission 15 is mounted upon the frame 11 and has its output shaft 17 coupled to a spindle 20 which is rotatably mounted within the bearing assemblies 21 received within bearing housings 22. The bearing housings 22 are fixedly secured to a further frame 25 which is fixed at its lower end to horizontally extending girders 26. Frame 25 also fixedly supports frame 11.

The girders 26 serve as runners which support the above described apparatus or carriage 28 for horizontal sidewise movement upon tracks 27 provided by I-beams 30. Girders 26A (only one shown) are secured to the opposite ends of the girders 26 and mount adjacent their opposite ends gib keys 26B which retain the carriage 28 on the track. Referring to FIG. 3, the I-beams 30 are each supported by a jack 33 which can be operated to raise or lower the forward end of the I-beams 30 and thus adjust the height and attitude of the I-beams and, in turn, the structure supported thereon.

The spindle 20 is retained within the bearing housings 22 by a nut 35 which bears against the inner race 36 of one of the bearing assemblies 21 and which is threadedly received upon the spindle 20. Longitudinal movement of the spindle 20 is also prevented by engagement of the enlarged portion 40 of the spindle with the inner race 38 of the other bearing assembly 31. A spindle adapter 37 is fixed to the enlarged portion 40 of the spindle and secures a cylindrical connecting member 41 to the spindle, said member having mounted thereon a paddle 43. At its distal end 42, the connecting member 41 is provided with a suitable keying and locking mechanism including the tooth 45, said mechanism functioning to fixedly connect the member 41 to the hollow cylindrical stem 46 of a hollow auger 47 for rotation therewith. Of course, any of various conventional connecting means can be used to couple the member 41 to the stem 46 of the hollow auger. In the particular illustrated embodiment of the invention, the hollow auger 47 is received within a casing 50 which is intended to line the final hole subsequent to drilling thereof. The casing 50 is supported upon a semi-circular support element 51 which is welded to a further support element 52 which is, in turn, coupled to a transversely extending I-beam 55. The I-beam 55 together with further I-beams 56 and 57 are secured together to form a pad or support assembly for the casing 50 and for a shield 60 fixed to the I-beam 57.

Also fixedly supported upon the I-beams 56 is a generally rectangular member 58 which has a central semi-circular cut-out 59. The member 58 which is fixedly supported on I-beams 56 and 57 by braces 58A and 58B, functions to push the casing 50 forwardly in the manner described below. The shield 60, also braced by member 58B, has a central opening 61 therethrough which the spindle 20 projects. The function of the shield is to protect the spindle and associated bearing structure as well as the transmission and drive mechanisms being damaged or buried within the earth moved through the casing 50 by the hollow auger 47.
The apparatus of the present invention will be further described in connection with the operation thereof and in the description of the process or method of the present invention. Referring to FIG. 1, the tracks or I-beams 30 have mounted on their forward ends a guide and support assembly 65 which can be used as illustrated in FIG. 1 to guide and support percussion stem 66 which is connected to a percussion head 67. The percussion head is conventional and might be constructed according to the disclosure of the patent to Ross Bussinger, 2,979,033, entitled, Fluid Actuated Impact Tool. Air pressure is supplied to the percussion head through the percussion stem 66 which is hollow. The percussion stem 66 is formed from a plurality of sections 65 each of which is threadedly connected onto the rearward end of a preceding section after the percussion head has been driven a predetermined distance into the earth 70. Referring to FIG. 6, the guide and support assembly 65 comprises a ring 69 fixed to radially extending bars 69A. The radially extending bars 69A are removably attached to semi-circular support element 69B by screws 69C. Support element 69B can be used to support the casing 50 in the manner illustrated in FIG. 3 by removing members 69 and 69A.

The particular embodiment of the process illustrated in FIG. 1 shows the invention being used to drill a hole beneath a roadway 71, said hole being intended, for example, for a gravity sewer. The rearward end of the percussion stem 66 is coupled to the spindle 20 by a conventional chuck or ERG which provides for connecting means 72. Depending upon the type of tool being used to drill the hole, the drive motor 10 can be used to rotate the percussion stem 66 and head 67 although in certain applications, such rotation will not be necessary.

It is necessary, however, to exert a constant forward force on the head 67 or at least to provide a stable base which will not be pushed rearwardly by the operation of the head 67. This stable base is provided by the percussion stem 66, the spindle 20, the frame 25, the I-beams 26 and the tracks 30. The I-beams 26 are operatively connected to the tracks 30 by means of hydraulic cylinders 75, the piston rods 74 of which are connected to the I-beams 26 by pins 76. The pins are moved into and out of place by small hydraulic cylinders 78. The pins 76 can be withdrawn and reprojected through various apertures 77 in the I-beams 30 depending upon the location of the carriage 28. The hydraulic cylinders 75 are used to maintain the position of the carriage 28 at a desired location for resisting the force of the percussion head 67 and also to move the hollow auger and casing into the hole as described below.

Referring again to FIG. 1, a further trench 82 is located on the other side of the roadway. The percussion drilling of the hole by percussion head 67 is continued until the condition illustrated in FIG. 2 is achieved with the percussion head 67 projecting into the trench 82 and with the percussion stem 66 extending beneath the roadway and projecting into the trench 82. The assembly 65 is then removed by means of the ring 69 and bars 69A, therefrom leaving the support element 69B.

A cutter head 85 consisting of an outer ring 86 and four radially inward extending cutter blades 87 fixed thereto is next placed upon the rearward end 90 of the percussion stem 66. The cutter head 85 further consists of an inner ring 88 which is fixed to the cutter blades 87 and is rotatably received on the percussion stem 66.

The hollow auger 47 is then threaded onto the rearward end 90 of the percussion stem 66 and moved into engagement with and fixed to the cutter head 85. The casing 50 is next placed about the hollow auger 47 and against the ring 86 with the auger and casing supported on the support element 69B. Alternatively, the hollow auger and casing may be positioned on the stem simultaneously. The hollow auger 47 and the casing 50 are, of course, provided in sections and as the process proceeds, additional sections are added. The various sections of the hollow auger are connected together by suitable conventional structure preventing relative rotation of the connected sections and including tapered threads. Said structure does prevent relative rotation of the connected sections but does not interfere with or obstruct the hollow interior of the hollow auger whereby the hollow auger can move smoothly onto the percussion stem. Each new casing section is welded onto the rearward end of the previous casing section as the process proceeds.

The hollow auger 47 is connected to the member 41 and is caused to rotate along with the cutter head 85 by power from the motor 40. The hollow auger is advanced on the percussion stem by action of the hydraulic cylinders 75 maintaining a forward force on the carriage 28 and hollow auger. The casing 50 is pushed but not rotated by the member 50 causing the casing to follow the cutter head 85 as it moves through the earth 70. The percussion stem 66 serves as a guide accurately positioning the axis of the hole drilled by the cutter head and the hollow auger moves, dirt passes along its flight 95 and out of the rearward end of the casing 50 where the paddle 43 distributes it away from the casing 50.

If the hole drill first by the percussion head 67 is inaccurately located, a new hole can be drilled at relatively low expense. If the larger hole were inaccurately drilled, the cost of redrilling would be much greater if redrilling could be accomplished at all. As is suggested above, the percussion stem 66 serves as a guide and accurately locates the axis of the larger hole. In the described embodiment, the casing 50 is positioned as a part of the process by causing the casing to directly follow the cutter head. Alternatively, the casing need not be used and the thus drilled hole may or may not be lined later with such a casing.

It can be appreciated that the present invention is particularly useful in the situation wherein a hole at a particular grade or slope is desired. The jacks 32 can be adjusted to raise or lower the front end of the I-beam 30 until the attitude of the device is proper for the grade or slope desired. If the resulting pilot hole drilled by the percussion head and stem is at the wrong grade or slope or not within tolerances, the hole can be redrilled.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention and the scope of the claims are also desired to be protected.

As an example of further alternative embodiments of the invention, the use of the percussion head and stem might be replaced by a jacking operation wherein the smaller cylindrical guide means is provided in the earth by the jacking of a tool directly into the earth by static pressure. Alternatively, the guide means can be a drill bit and stem which is drilled into the earth by rotation.

The invention claimed is:
1. Apparatus for drilling and accurately locating a hole comprising a percussion head and stem, means for supporting said percussion head and stem for movement thereof into the earth at the axis of the desired hole, a hollow auger and cutter head adapted for being rotatably received on said percussion stem, said supporting means being partially removable to leave a remaining portion operable to rotate and advance said cutter head and hollow auger on said percussion stem to bore the hole.
2. Apparatus for drilling and accurately locating a hole comprising a carriage, fluid cylinders and fluid cylinder motors for moving said carriage and tracks for moving said carriage on said tracks, means for supporting a percussion head and stem on said carriage, said means comprising a ring, a pair of radially ex-
tending horizontal bars fixed to the periphery of said ring, an upwardly opening semicircular shaped member fixed centrally thereof to the forward end of said carriage, said bars being removably fixed to the upper ends of said members with said ring coaxial thereof, a spindle rotatably mounted on said carriage for rotation about the axis of said semi-circular shaped member, means for retaining said spindle against longitudinal movement relative to said carriage, said spindle being adapted for connection to a percussion stem supported within said ring and also adapted for connection to a hollow auger supported within said semi-circular member when said ring and bars are removed, and means for rotating said spindle.

3. Apparatus for drilling and accurately locating a hole comprising a carriage, fixed tracks for said carriage, fluid cylinder motors connected between said carriage and tracks for moving said carriage on said tracks, means for supporting a hollow auger and casing on said carriage, said means comprising a pair of spaced semi-circular shaped members fixed centrally thereof one to the forward end of said carriage and the other rearwardly of said one, said semi-circular shaped members having an axis and being coaxial a spindle rotatably mounted on said carriage rearwardly of said supporting means for rotation about the axis, means for retaining said spindle against longitudinal movement relative to said carriage, a casing cradled in said supporting means, a hollow auger received within said casing, a paddle carrying member connecting said hollow auger and said spindle, an element fixed to said carriage and engaging said casing for the forward pushing thereof by said carriage, means for rotating said spindle and hollow auger, and shield means fixed to said carriage and protecting said last mentioned means from earth moving out of said casing.

4. The process of accurately locating a casing in a hole which comprises boring a first hole with a tool including a cylindrical stem, placing a hollow auger on the stem, said hollow auger having an inside diameter permitting it to freely but not loosely rotate on said stem, placing a cylindrical casing about said hollow auger, boring a larger hole with said stem at its axis by rotating said hollow auger and advancing it on said stem, and simultaneously advancing said casing with said hollow auger.

5. The process of accurately locating a casing in a hole which comprises boring a first hole with a percussion tool including a cylindrical percussion stem, placing a hollow auger and cutter head on the percussion stem, said hollow auger having an inside diameter permitting it to freely but not loosely rotate on said stem, placing a cylindrical casing about said hollow auger and behind said cutter head, boring a larger hole with said stem at its axis by rotating said hollow auger and cutter head and advancing them on said stem, and simultaneously advancing said casing with said hollow auger and behind said cutter head.

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