APPARATUS FOR DRILLING LARGE DIAMETER HOLES

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My invention relates to novel apparatus for drilling of cylindrical openings of a given depth in the earth's crust, for numerous purposes such as underground silos or storage compartments, concealed gun mounts, imbedded missile pads and the like.

When drilling or forming openings for missile silos and the like, the variations in hardness and kind of earth and rock formations (such as sand, soft shale, limestone, hard rock, etc.) which may be located within the proposed opening often present problems which hinder the efficient drilling of the opening. Since portions of the relatively heavy drilling head may be resting upon relatively soft ground and other portions thereof may be on hard rock or the like, one of such problems is that the support for the drilling head must be constructed so as to resist bending moments and stresses imparted thereto by portions of the heavy drilling head which are effectively cantilevered with respect to the support.

The primary object of my invention is the provision of novel apparatus of the type immediately above described which overcomes the above noted problems and which may be used to drill a cylindrical opening in the rock formations of the earth's crust of a greater diameter than heretofore thought possible, and with a minimum of power and expense.

A further object of my invention is the provision of apparatus of the type above described which is not unduly expensive to produce and which may be installed in an operative position and removed from a drilled opening with a minimum of skill and experience.

A still further object of my invention is the provision of apparatus of the type above described which is rugged and durable in construction and which requires but a minimum of maintenance.

The above and still further objects of my invention will become apparent from the following detailed specification, appended claim and attached drawings.

Referring to the drawings wherein like characters indicate like parts throughout the several views:

FIG. 1 is a schematic view in vertical section, illustrating preliminary steps in the practicing of my invention;

FIG. 2 is a view corresponding to FIG. 1 but showing my novel equipment in side elevation and still illustrating further steps in the practice of my invention;

FIG. 3 is an enlarged detailed vertical section of FIG. 2;

FIG. 4 is a view in horizontal section taken on the line 4—4 of FIG. 3;

FIG. 5 is a fragmentary view in section taken on the line 5—5 of FIG. 4; and

FIG. 6 is an enlarged fragmentary sectional view taken on the line 6—6 of FIG. 3.

Referring with greater particularity to the drawings, the first step in my method comprises the drilling of a vertical pilot hole A in the earth's crust X, and for this purpose it is obvious that any suitable rotary rock drill bit may be utilized. For a purpose which will hereinafter be explained, it will be noted, by reference to FIG. 1, that the depth of the pilot hole A is greater than that of the proposed opening B to be drilled by my method and with my novel apparatus.

The next step in my method comprises placing into the vertical pilot hole A an elongated, preferably cross-section cylindrical axis 1 the diameter of which, as shown in FIG. 1, is considerably smaller than that of the pilot hole A. Furthermore, it will be noted that the axial dimensions of the axis 1 are such, with respect to the pilot hole A, that the upper end 1a thereof projects considerably above the surface of the ground X for a purpose which will hereinafter become apparent. After centering the axis 1 within the pilot hole A, so as to define an annular space 2 therebetween, the next step in my method resides in the incising of the axis 1 into hole A. This may be done by the filling of said space 2 with concrete or grout 3, said grout 3 extending completely from the bottom 4 of the pilot hole A to the surface of the earth X. In this manner the axis 1 is securely anchored within the earth X for the carrying out of the remaining steps of my method with my novel apparatus each of which is hereinafter described.

After suitable hardening of the grout 3, my novel drilling head, identified in its entirety by letter 5, is inserted over the extended upper end 1a of the axis 1, as shown in FIG. 2. By reference to FIG. 2, the problems presented by the portions of the drilling head 5 resting on relatively soft ground may well be appreciated. Drilling head 5 includes an annular horizontally disposed base plate 6, upstanding outside frame members 7, and upstanding central tubular bearing sleeve 8, loosely encompassing the axis 1, and upper frame members or braces 9 connecting the upper end portions of the outer frame members 7 of the bearing sleeve 8. Suitable journaling in bearing brackets 10 depending from the under surface 11 of the annular base plate 6, on axes radiating from the axis 1, are circumferentially spaced elongated roller bits 12 formed to provide a plurality of generally axially extended circumferentially spaced spaced members 13. Rotary movements are imparted to roller bits 12 by any suitable means but preferably through a pair of motors or power units 14 mounted on the upper surface 15 of the base plate 6. Since the particular design of the power units 14 is not an important feature of this invention, further showing and description thereof is unnecessary. Rotary movements of the roller bits 13 obviously impart rotary movements to the drilling head 5 in its entirety.

It will be noted by reference particularly to FIGS. 3 and 4 that the power driven rotary bits 12 terminate at their axial inner end portions 16 in spaced relation to the axis 1 whereas their axial outer end portions 17 terminate in spaced relation to the outer peripheral limits 18 of the drilling head 5. For the purpose of providing an uninterrupted cut between opposite side portions of the axis 1 and the outer peripheral edge 18 of the drilling head 5, I provide circumferentially spaced pairs of inner gauge bits 19 and outer gauge bits 20. As shown, the pairs of inner and outer gauge bits 19, 20, are spaced 180° with respect to each other and 90° from the roller bits 12. The inner and outer gauge bits 19, 20, are likewise mounted for rotation on axes radiating from the axis 1, and are provided with similar cutting teeth 13. The inner gauge bits 19 overlap the cutting void between the axially inner ends 16 of the power driven roller bits 12 and the axis 1, whereas the outer roller bits 20 overlap the cutting void defined by the axially outer end portions of the roller bits 12 and the outer peripheral edge 18 of the drilling head 5. Gauge bits 19, 20, are preferably idlers.

Supplementing gravity so as to cause the drilling head 5 to exert the desired amount of downward pressure upon the rock strata in which the drilling head 5 is being worked, I provide means to exert a downward pressure on the drilling head 5 relative to the anchored axis 1, and it will be appreciated that the axis 1 must therefore be well anchored to resist the relative pull thereon by such means. Said means is illustrated as comprising an adjustable anchoring collar 21 which is slidable receiveable over the upper end 1a in overlying relationship to the drill head 5. Anchoring collar 21 may be locked to the
axle 1, in a given set position, through any suitable means such as circumferentially spaced set screws of the like 22. Preferably, the anchoring collar 21 is provided with a depending tubular bearing member or sleeve 23 which, as shown particularly in FIG. 3, is snugly receivable over the axle 1 and is telescopically slidable receivable within the bearing sleeve 3 associated with the drill head 5, and journals head 5 for rotation. An annular thrust bearing 24 underlies and collar 21. The annular bearing 24 is journaled for rotation on the tubular bearing sleeve 23 and rotatively engages the under surface 25 of the anchoring collar 21. Interposed between the thrust bearing 24 and the drill head 5 are circumferentially spaced expandable and retractable elements which are shown as well known double-acting fluid pressure cylinder mechanisms, represented generally by 26, the same being provided so as to exert a generally downwardly directed pressure on the drill head 5. As shown, the elements 26 include cylinders 27, the lower ends of which are secured to the drill head 5, preferably and as shown through the medium of the cross braces 9 thereof, as indicated at 28.

Elements 26 likewise include pistons 29, the push rods of which are identified by 30. The upper ends of the rods 30 are connected to the thrust bearing 24 as indicated at 31. Fluid under pressure is introduced into the lower ends of the cylinders 27, through suitable conduits 32 extending between the lower ends of the cylinders 27 and suitable well known hydraulic reservoir and pump means, the latter of which is partially shown at 33 in FIG. 3, as being mounted on and carried by the drill head 5. It is noted that the reservoir and pump means partially shown at 33 in FIG. 3, is independent of the power units 14, the former however not being an important feature of this invention and therefore being only briefly described herein.

Escape of fluid under pressure from the upper portions of the cylinders 27, so as to permit upward movements of the cylinders 27 and relative retracting movements of the plungers 39 thereby, is achieved through the medium of suitable tubes 34. The control of the operation of the fluid pressure cylinder mechanism 26 may be by any suitable and well known means, not shown.

Operation

A drilling operation with my novel apparatus, assembled as shown in FIGS. 2 and 3, is as follows: With the push rods 30 retracted within their respective cylinders 27, the anchoring collar 21 is lowered into engagement with the annular thrust bearing 24, and the collar 21 is locked in said position through the medium of set screws 22. Fluid under pressure is then introduced into the cylinders 27 by way of the pump means 33 and the inlet tube 32, whereby to exert a predetermined amount of downward pressure of the drill head 5 against the underlying rock strata comprising the earth's crust immediately surrounding the axle 1. Rotary movements are then imparted to the roller bits 12 through the medium of the power units 14, whereby to impart rotary movements to the drill head 5, as well as to the inner idler gauge bits 19, 20. In this manner an uninterrupted cut is effected between the axle 1 and the axially outer limits 35 of the gauge bits 20. It will be understood that a constant amount of pressure is maintained within the cylinders 27 so that a desired and constant downward pressure will be exerted by the drill head 5 upon rock strata being drilled, as the drill head 5 works its way downward therethrough. Obviously the precise amount of such pressure will vary with the density of the rock strata being drilled.

Removal from the bottom of the pit or opening B of the chips and rock dust loosened by the roller bits 12, 19, 20 may be effected by any suitable and well known means. For instance, water may be introduced into the bottom of the opening B to form a slurry, and removal of said slurry effected by a suction hose or the like, not shown.

It will be noted, primarily by reference to FIG. 5, that the primary function of inner roller gauge bits 19 is to drill and abrade away through the concrete or grouting 3 about the axle 1. Thus, when the desired depth of the opening B has been reached, the axle I is firmly supported in a vertical position by means of the concrete or grouting 3 encompassing the lower end of the axle 1, below the bottom of the opening B.

While I have shown and described a workable form of my invention, I wish it to be specifically understood that the same may well be modified without departure from the scope and spirit of the appended claim.

What I claim is:

Apparatus for drilling into the earth's crust a cylindrical opening of a given depth for the formation of an underground silo or the like, said apparatus comprising an elongated axle of constant diameter and the axial dimension of which is considerably greater than that of the proposed opening, said axle being adapted to be placed and secured within a previously drilled centrally located vertical pilot hole of a vertical depth greater than that of the proposed opening and with the upper end portion of said axle projecting above the upper elevation of said opening, a drilling head slidably rotatably received upon the projecting upper end portion of said axe and having a drilling diameter corresponding to the desired diameter of said opening, power operated means for imparting rotation to said head about said axle, and means for applying a generally downwardly directed pressure on said drilling head relative to the upper end portion of said axle, said means for applying a downward pressure on said drilling head comprising a vertically adjustable anchoring collar slidably received upon and releasably and retractedly secured to said axle in overlying relationship to said drilling head, and a generally vertically extensible and retractable device interposed between said drilling head and said anchoring collar.

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